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Special Issue Reprint

Adopting Sustainable Dietary Patterns

Effects of Food Labeling, Food Choices, and Eating Behaviors

Edited by
Christopher P. F. Marinangeli

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Adopting Sustainable Dietary Patterns: Effects of Food Labeling, Food Choices, and Eating Behaviors

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Guest Editor

Christopher P. F. Marinangeli

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About the Editor

Christopher P. F. Marinangeli

Dr. Marinangeli has a PhD in food and nutrition science and is a registered dietitian. He is a scientist and food industry professional with 15 years of experience across consumer-packaged goods and the Canadian agriculture sector. He is experienced at leveraging human nutritional sciences to create new opportunities for differentiation and growth. He is a recognized expert in national and international food regulations and the effects of dietary components on cardiometabolic health. His expertise includes human nutrition science, regulatory affairs, and consumer insights and equity for developing effective strategies and tactics for dietary integration of healthy food options. Currently, Dr. Marinangeli leads the Centre for Regulatory Research and Innovation at Protein Industries Canada. His prior positions include senior nutritional and regulatory positions at Pulse Canada and Kellogg Canada. He has served on numerous advisory committees, including as a member of the Canadian Advisory Committee for ILSI North America, and Jury Member for Agriculture Agri-food Canada's Food Waste Reduction Challenge: Novel Technologies. He currently serves on the Scientific Advisory Committee for the Canadian Federation of Dietetic Research, and the Human Research Ethics Board for Agriculture Agri-Food Canada.

Preface

Food systems are undergoing a renaissance and re-positioning their value as proponents of sustainable dietary patterns. Industry stakeholders are incorporating measures of sustainability into their supply chain and innovation pipelines, so they can be leveraged as salient factors of differentiation to consumers. At the same time, government policies and regulations can affect how foods are produced and positioned in the marketplace. However, as the domains of sustainable food systems encompass health, the environment, sociocultural factors, and economic prosperity, there is a need to understand food environments and motivations of consumers to drive a value proposition for sustainability in food choices across the food value chain.

The sustainability of food systems has been characterized as a "wicked problem" that is met with broad and complex challenges without a single solution. While governments and industry prioritize sustainable food systems in strategic approaches to innovation, investment, and efficiency, not aligning with consumers and their needs can impede or even cause initiatives to fail.

This Special Issue focuses on the consumer–food interface within the context of sustainable dietary patterns. The disseminated research highlights various attributes of consumers and their food environments that can affect food choices and the tools that can be employed as facilitators of purchasing and eating behaviors.

I would like to acknowledge all of the authors who contributed to this Special Issue. Your work and dedication to this important topic is critical to the adoption of sustainable food systems. I would also like to thank the staff at MDPI for their assistance and support.

This Special Issue is dedicated to James and Monique. Always in my corner and always in yours.

Christopher P. F. Marinangeli
Guest Editor

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Editorial

Understanding Consumers to Enhance Demand for Sustainable Diets: Comment on "Adopting Sustainable Dietary Patterns: Effects of Food Labeling, Food Choices, and Eating Behaviors"

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The creation of sustainable food systems is a "wicked problem"; it is multifaceted with no single or one-size-fits-all solution [1]. Initiatives that aim to solve specific problems related to food system sustainability can differ between geopolitical regions, countries, and communities. Increasingly, sustainability is becoming an essential component of food systems and is generally measured against four domains: human health and nutritional adequacy, ecological preservation, social equity, and economic prosperity [2,3]. Each is critical for a food system to be both sustainable and successful in its own right. The interplay between these domains cannot be overlooked, as effects on one can affect others. The complexity of food systems requires that multiple stakeholders across producers, industry, and government work to leverage resources that create efficiencies, establish systems, and develop new technologies that affect outcomes related to sustainability. However, resource allocation affects how these domains are prioritized, which can accelerate or decelerate activities that affect metrics related to sustainability outcomes [4,5]. While many attributes of food system sustainability occur between the production and distribution of food in retail, the importance of consumers cannot be forgotten [6]. They are an integral stakeholder of food systems that can create demand for sustainable solutions.

This Special Issue on "Adopting Sustainable Dietary Patterns: Effects of Food Labeling, Food Choices, and Eating Behaviors" focuses on consumer-centric factors related to the adoption of sustainable dietary patterns. The ability to find solutions that align with consumer needs and values which are related to food choices can enhance the demand and value proposition for upstream sustainability efforts that occur prior to the point of purchase [7]. This Issue covers a range of topics that highlight the challenges and the need for tailored approaches to creating inclusive food environments for consumers while aligning with global objectives for sustainable food systems. They have important implications for the adoption of sustainable diets, including 1. the examination of the sociodemographic characteristics of food environments; 2. the nutritional profiling of plant-based diets and targeted consumer needs; 3. the role of policy and regulatory modernization in changing food behaviors; and 4. the importance of consumer beliefs and value systems that affect food choices. This Editorial provides a brief synopsis of the studies and reviews included in this Special Issue.

1. Food Environments and Socioeconomic Factors

Consumers and their food environments can be diverse. As such, understanding food environments and the unique problems that affect consumer food choices can allow the identification and prioritization of the areas where resources are needed in order to ensure the highest impact on sustainability outcomes. Lewis et al. evaluated the post-pandemic individual and household characteristics of those who regularly used corner/convenience

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stores as their main sources of food in Baltimore, Maryland. Most respondents had low incomes, were Black (62.2%), and did not own a home (66.9%). These individuals had a lower intake of calories from sugar-sweetened beverages compared to White participants, but also consumed fewer servings of fruit and vegetables (3.20 vs. 4.68 servings/day). Fiber intake was also higher (18.41 g/day) amongst White compared to Black individuals (12.71 g/day). Income, home ownership, and food security status also had differing effects on beverage, fruit and vegetable, and fiber consumption. The authors argue that consumers are critical in the "supply-and-demand" feedback loop that dictates food offerings in retail environments.Understanding their needs in complex urban environments can create demand and access to healthy foods. Forray et al. examined the adherence to Romanian dietary guidelines in the North-Western Regions of Romania based on sociodemographic characteristics. While most understood the link between nutrition and health, the majority of individuals (83.5%) did not adhere to the dietary recommendations, which was underpinned by a low consumption of fruit and vegetables, fish and seafood, and water intake. Interestingly, older individuals (OR = 0.98), unemployed individuals (OR = 0.40), retirees and those receiving social welfare (OR = 0.53), and those with illnesses (OR = 0.69) were the least likely to consume <5 servings of fruit and vegetables per day. It was suggested that access to affordable vegetables or the likelihood of growing their own fresh food could explain these results. The authors note the need for tailored approaches to addressing food security with linkages between food literacy and sociodemographic factors. Zhang et al. showed that, in rural China, women were the most likely to consume "traditional" (higher in vegetables/fruit and meat/seafood/eggs, and lower in milk, beans, and nuts) and "meat/animal protein" dietary patterns compared to a highly diverse "healthy" pattern. Non-obese participants had a 69% greater likelihood of consuming a "healthy" dietary pattern compared to the "meat/animal" pattern. Education level and income showed similar associations.

The results from these studies all underscore the regional specificity related to metrics of sustainable diets. They reinforce that the adoption of sustainable dietary patterns by consumers may require discrete approaches that are unique to the needs of specific food environments to affect the demand for specific dietary patterns.

2. Evaluating "Plant-Based" as a Sustainable Dietary Pattern

Global discussions around sustainable diets often default to the adoption of a plant-based dietary pattern. This is predicated on the simplified notions that plant-based diets and protein require fewer environmental resources to produce, can be nutrient-dense, and include higher and lower levels of fiber and saturated fat, respectively, than typical Western-type dietary patterns [8]. The fact is that a plant-based diet is an inclusive "term" that can encompass various patterns of eating, including veganism, vegetarianism (and its subcategories lacto-ovo- and pesco-vegetarian), and flexitarianism. The integration of healthy plant-based diets into dietary guidelines focuses on a high consumption of fruit and vegetables and whole grains, with the important distinction of sourcing most dietary protein from plant foods, which include legumes, nuts, seeds, and nutrient-dense processed foods such as high-protein fortified plant milks. If these patterns are integrated based on scientific evidence that support dietary guidelines, plant-based diets would be nutritionally complete and limit the consumption of nutrients of concern [9]. Innovation in the plant protein space is creating new food platforms but is heterogenous in terms of nutrient content. Studies have started to demonstrate that their use can facilitate a decrease in risk factors for cardiovascular disease [10]. Measurements of the nutritional merits of the proposed "plant-based" dietary paradigms require evaluation to ensure they align with the principles of sustainable diets.

In this Special Issue, Acosta et al. used an overall plant-based diet index (oPDI), healthful PDI (hPDI), and less healthful (lhPDI) to evaluate the nutrient and food group intakes of Canadian preschool-aged children. Their results demonstrated that different indices can be used to evaluate nutrient intakes and associated food groups. For the oPDI score, both healthy and unhealthy plant foods were scored positively. Healthy plant foods were scored positively for the hPDI, while unhealthy plant foods were scored negatively. The scoring was the opposite for the lhPDI. Animal foods were scored negatively for all indices. Using the oPDI, children in the highest tertile had higher (folate, iron, fiber) and lower intakes (calcium, vitamin D, vitamin B12) of nutrients and foods to encourage. Protein was also lower given the negative scoring for animal protein, as was as saturated fat intake. The diets that generated the highest hPDI scores showed higher intakes of fiber, folate, and iron, and a lower consumption of cholesterol and saturated fat compared to Tertile 1. Lastly, the lhPDI scores in Tertile 3 showed a greater intake of added sugar and carbohydrate alongside a lower intake of protein and various vitamins and minerals, including calcium, vitamin D, vitamin B12, folate, and iron. Across all indices, fruits and refined grains were the primary plant food groups consumed, with relatively minor contributions from legumes, nuts, and seeds. These indices can be used to identify nutritional gaps in plant-based dietary patterns to be addressed. Fulgoni et al. used the National Health and Nutrition Examination Study (2013–2018) to show that nutrition adequacy for some varied across age groups. For example, the highest quartile of plant protein amongst adolescents showed a decrease in calcium, potassium, and vitamin D adequacy and an increase in adequacy for copper and magnesium. For adults 19–50 years of age, protein and vitamin B12 adequacy decreased, but folate and iron adequacy increased. Furthermore, zinc and calcium adequacy were reduced for older adults ($\geq$51 years). These results emphasize that as plant protein is promoted to become a more prominent attribute of dietary patterns, care is needed to ensure nutrient intakes are sufficient. In order to achieve this, planning and shifts toward a greater incorporation of plant protein foods not typically prominent in typical US dietary patterns, such as legumes, nuts, and seeds, are required. Furthermore, depending on the level of animal proteins consumed in a diet, the fortification of manufactured foods could be a valuable tool for maintaining the adequate intake of some nutrients. Accurate dietary assessments and newly developed assessment tools can assist with the adoption of sustainable plant-based diets that are nutritionally adequate.

Sustainability efforts and targets can change across the lifespan, given that nutrient requirements can also change over time. Metabolic perturbations, health status, and socioeconomics can also affect nutrient needs and food accessibility. Wakayama et al. developed and validated the Meiji Nutritional Profiling System that can assess the nutritional density of innovative food products for adults $\geq$ 65 years in Japan. With shifts in dietary patterns being used to drive sustainability efforts, sufficient guidance and access to tools could be helpful for highlighting challenges for specific populations. This ensures that diets are nutritionally adequate by recommending specific foods and strategies that address individual needs.

3. Steering Consumers Toward Sustainable Food Behaviors with Regulation and Policy

The role of regulations and policies as facilitators of consumer food choices cannot be ignored. They create rules by which nutritional attributes can be communicated and can be used as tools to help address food system sustainability. Levis et al. summarized the results of a 7-day workshop organized by the Pan American Health Organization and World Health Organization in July 2022. The results generated a variety of objectives and population-focused tactics aimed at improving the nutrient density of diets and decreasing

the risks of non-communicable disease. The highlighted regulatory and policy initiatives included labeling, taxation and tax incentives, marketing, school programs, and conflict-of-interest mitigation. It was also emphasized that efforts should be coordinated to create efficiencies for implementation. Onyeaka et al. systematically evaluated the global policy and regulatory initiatives that have helped address food security and its effects on mental health. Integrated approaches have been successful in addressing both conditions, but tactics are regionally specific given the different challenges and infrastructures in place across food systems. The successful case studies discussed were targeted social safety net programs and tax reductions (West and Central Africa), humanitarian efforts through the FAO, World Trade Organization, and Group of Seven countries (Europe), the Supplemental Nutrition Assistance Program (US), Universal Childcare Benefit (Canada), community food programs as a replacement for food banks (UK and Canada), and the electronic Public Distribution System used to streamline the distribution of subsidized grain (India). The authors also state that food security policies that combine social, economic, and healthcare outcomes will address food security and have concomitant benefits on mental health. Regulation and policy outcomes should be continuously evaluated to reflect the present food system and create sustainable food environments for consumers.

4. Driving Sustainable Food Choices by Aligning with Consumer Beliefs and Values

Personal beliefs and values around food are an important consideration when it comes to food choices. It is these personal ideals and food behaviors that can affect the sustainability of food systems. Consumer insights are a useful tool that can be leveraged for successful food innovation, research, messaging, and merchandizing, as well as the implementation of effective regulations and policies that support sustainable food purchase. Yang et al. evaluated perceptions and support for front-of-pack labeling on menus in Canada. Most respondents indicated that they would like to see more health logos that outline healthier options (27% of respondents) and foods with high amounts of nutrients of concern (21% of respondents). However, when asked whether healthy logos would affect their eating behaviors, 44% of consumers indicated that logos would not affect whether they ate at a restaurant. Furthermore, 62% indicated that they would still consider buying a menu item associated with a health warning logo. Given that "health" was the fourth most important factor given for eating outside the home (after taste, price, and convenience), health logos may not have a strong value proposition for food items in restaurants. Other tactics could be more successful for facilitating healthier food choices when eating outside the home. The authors highlight that a multitude of factors affect food choices, including socioeconomic status, and that multidisciplinary approaches are required to facilitate the purchase of healthier foods inside and outside the home.

The results of Hayashi et al. highlight that consumer food beliefs can differ within the same population demographic. An analysis of the "Survey on Dietary Habits of the Younger Generation" (n = 1888) showed that amongst 18–35-year-olds in Tokyo, Japan, three attitudes toward healthy and balanced meals emerged: 1. "Valuable yet burdensome"; 2. moderate value, but "environment-reliant"; and 3. "low value due to hassle." Various attributes were associated with each attitude. For example, the group that viewed nutritious meals as having "low value due to hassle" was associated with having a lower income, and was more concerned with taste, price, and the effort required in preparing and consuming a balanced meal. Those who assigned the greatest value to the consumption of healthy, balanced meals had the skills and knowledge for ease of adoption. The authors emphasize that tactics aimed at improving diets should be dynamic and tailored to the knowledge, beliefs, attitudes, and socioeconomic indicators of the target group.

What drives purchase intent? Segmenting and understanding consumer food values can predict willingness to pay. Albornoz et al. investigated the effects of perceived value on the willingness to pay for healthy branded food using a sample (n = 518) of Peruvian consumers of the healthy brand "Union Brand". The results demonstrated that being health-conscious was associated with the perceived quality, social value, emotional value, and financial value of a food. Furthermore, all of these "perceived values", except for financial value, were associated with a willingness to purchase healthy foods. It was hypothesized that the non-association between financial value and willingness to pay was due to consumers placing higher value on quality. For consumers of healthy foods, perceived value can facilitate purchase decisions where the industry can tailor communication strategies toward successful sales. It could be worthwhile to apply the same methodology to other consumer demographics to find values to align with sustainability outcomes.

Although plant-based dietary patterns represent a fundamental construct around sustainable diets, adoption can be a challenge. For consumers identifying as vegan or vegetarian, there is little guidance for those who self-identify as flexitarian/or semi-vegetarian [11]. In alignment with some of the other results presented in this Issue, the primary drivers for food purchase decisions have consistently been taste > price > health > convenience > environment [12]. In the context of plant-based diets, there is value in understanding sustainability attributes and attitudes toward food choices.

Consavage Stanely et al. conducted a secondary analysis of the International Food Information Council's Food & Health Survey (2012–2022) to evaluate the perception, beliefs, and behaviors related to plant-rich dietary patterns. While environmental sustainability was perceived to be positive, it influenced less than half of purchase decisions. From 2020 to 2022, the proportion of respondents that reported eating somewhat or much more red meat increased from 13.1 to 18.7%. Furthermore, >50% of older consumers were more inclined to eat the same amount of red meat vs. <45% of younger consumers. Between 2019 and 2022, adherence to plant-based dietary patterns was low, with vegan and vegetarians making up an average of 4.6% of respondents. Flexitarian patterns ranged between 2.1 and 7.4%, while "plant-based" dietary adherence ranged from 4.0 to 11.8%. These results emphasize the "say-and-do" gap between food beliefs and behaviors. Understanding how consumers can translate their food beliefs into actional behaviors in the retail environment could be a valuable strategy for driving the adoption sustainable food behavior promotion.

5. Final Thoughts

The 12 papers presented in this Special Issue on "Adopting Sustainable Dietary Patterns: Effects of Food Labeling, Food Choices, and Eating Behaviors" report on a variety of consumer-centric topics related to sustainable diets. Given the complexity of consumers with diverse needs, food beliefs, and values, different tactics are required to encourage their interest in embracing sustainable diets. Also, it is important to acknowledge that consumers might not be interested in the sustainability attributes of their food. However, this does not preclude strategies from promoting foods associated with better sustainability characteristics by communicating on those attributes that do matter to those consumers. Analytical tools can assess the nutritional merits of diets, while regulation and policy can expedite efforts. Sustainability is a "wicked problem" and stakeholders across the food value chain will continue to design initiatives that advance it in various domains. However, by integrating approaches that target consumers, demand, and sustainable food behaviors, the success of these efforts across the food system can be magnified.

Conflicts of Interest: CPFM is an employee of Protein Industries Canada and former employee of Pulse Canada and Kellogg Canada.

List of Contributions

1. Lewis, E.C.; Xie, Y.; Sundermeir, S.M.; Poirier, L.; Williamson, S.; Lee, S.; Pei, X.; Stephenson, J.; Trujillo, A.J.; Igusa, T.; et al. Factors and Perceptions Associated with Post-Pandemic Food Sourcing and Dietary Patterns among Urban Corner Store Customers in Baltimore, Maryland. *Nutrients* **2024**, *16*, 2196.
2. Forray, A.I.; Coman, M.A.; Chereches, R.M.; Borzan, C.M. Exploring the Impact of Sociodemographic Characteristics and Health Literacy on Adherence to Dietary Recommendations and Food Literacy. *Nutrients* **2023**, *15*, 2853.
3. Zhang, L.; Chang, H.; Chen, Y.; Ruan, W.; Cai, L.; Song, F.; Liu, X. Socio-Demographic Factors Associated with Rural Residents' Dietary Diversity and Dietary Pattern: A Cross-Sectional Study in Pingnan, China. *Nutrients* **2023**, *15*, 2955.
4. Acosta, P.F.C.; Landon, O.A.; Ribau, Z.J.; Haines, J.; Ma, D.W.L.; Duncan, A.M.; Guelph Family Health Study. Plant-Based Dietary Indices in Relation to Nutrient and Food Group Intakes in Preschool-Aged Children. *Nutrients* **2023**, *15*, 4617.
5. Fulgoni, V.L.; Agarwal, S.; Marinangeli, C.P.F.; Miller, K. Impact of Plant Protein Intakes on Nutrient Adequacy in the US. *Nutrients* **2024**, *16*, 1158.
6. Wakayama, R.; Drewnowski, A.; Horimoto, T.; Saito, Y.; Yu, T.; Suzuki, T.; Takasugi, S. Development and Validation of the Meiji Nutritional Profiling System (Meiji NPS) to Address Dietary Needs of Adults and Older Adults in Japan. *Nutrients* **2024**, *16*, 936.
7. Levis, C.; Mejía Toro, C.; Patiño, S.R.G.; Villalobos-Daniel, V.E.; Spinillo, C.; Gomes, F.d.S. Building Capacity and Advancing Regulatory Measures to Improve Food Environments in the Region of the Americas. *Nutrients* **2024**, *16*, 1202.
8. Onyeaka, H.; Ejiohuo, O.; Taiwo, O.R.; Nnaji, N.D.; Odeyemi, O.A.; Duan, K.; Nwaiwu, O.; Odeyemi, O. The Intersection of Food Security and Mental Health in the Pursuit of Sustainable Development Goals. *Nutrients* **2024**, *16*, 2036.
9. Yang, Y.; Charlebois, S.; Music, J. Front-of-Package-Label-Style Health Logos on Menus—Do Canadian Consumers Really Care about Menu Health Logos? *Nutrients* **2024**, *16*, 545.
10. Hayashi, F.; Takemi, Y. Differences in the Values and Related Factors of Eating a Balanced Meal among the Younger Generation in Japan. *Nutrients* **2024**, *16*, 1855.
11. Albornoz, R.; García-Salirrosas, E.E.; Millones-Liza, D.Y.; Villar-Guevara, M.; Toyohama-Pocco, G. Using the Theory of Perceived Value to Determine the Willingness to Consume Foods from a Healthy Brand: The Role of Health Consciousness. *Nutrients* **2024**, *16*, 1995.
12. Consavage Stanley, K.; Hedrick, V.E.; Serrano, E.; Holz, A.; Kraak, V.I. US Adults' Perceptions, Beliefs, and Behaviors towards Plant-Rich Dietary Patterns and Practices: International Food Information Council Food and Health Survey Insights, 2012–2022. *Nutrients* **2023**, *15*, 4990.

References

1. Clark, M.; Macdiarmid, J.; Jones, A.D.; Ranganathan, J.; Herrero, M.; Fanzo, J. The Role of Healthy Diets in Environmentally Sustainable Food Systems. *Food Nutr. Bull.* **2020**, *41*, 31S–58S. [CrossRef] [PubMed]
2. Kraak, V.I.; Aschemann-Witzel, J. The Future of Plant-Based Diets: Aligning Healthy Marketplace Choices with Equitable, Resilient, and Sustainable Food Systems. *Annu. Rev. Public Health* **2024**, *45*, 253–275. [CrossRef] [PubMed]
3. Drewnowski, A.; Finley, J.; Hess, J.M.; Ingram, J.; Miller, G.; Peters, C. Toward Healthy Diets from Sustainable Food Systems. *Curr. Dev. Nutr.* **2020**, *4*, nzaa083. [CrossRef] [PubMed]
4. Gustafson, D.I.; Decker, E.A.; Drewnowski, A.; Hamm, M.W.; Hwang, J.; Merrigan, K.A. Making Healthy, Sustainable Diets Accessible and Achievable: A New Framework for Assessing the Nutrition, Environmental, and Equity Impacts of Packaged Foods. *Curr. Dev. Nutr.* **2022**, *6*, nzac136. [CrossRef] [PubMed]
5. Miller, K.B.; Eckberg, J.O.; Decker, E.A.; Marinangeli, C.P.F. Role of Food Industry in Promoting Healthy and Sustainable Diets. *Nutrients* **2021**, *13*, 2740. [CrossRef] [PubMed]
6. Fanzo, J.; Drewnowski, A.; Blumberg, J.; Miller, G.; Kraemer, K.; Kennedy, E. Nutrients, Foods, Diets, People: Promoting Healthy Eating. *Curr. Dev. Nutr.* **2020**, *4*, nzaa069. [CrossRef] [PubMed]
7. Kenny, T.A.; Woodside, J.V.; Perry, I.J.; Harrington, J.M. Consumer attitudes and behaviors toward more sustainable diets: A scoping review. *Nutr. Rev.* **2023**, *81*, 1665–1679. [CrossRef] [PubMed]
8. Alsaffar, A.A. Sustainable diets: The interaction between food industry, nutrition, health and the environment. *Food Sci. Technol. Int.* **2016**, *22*, 102–111. [CrossRef] [PubMed]

9. Tso, R.; Forde, C.G. Unintended Consequences: Nutritional Impact and Potential Pitfalls of Switching from Animal- to Plant-Based Foods. *Nutrients* **2021**, *13*, 2527. [CrossRef] [PubMed]
10. Crimarco, A.; Landry, M.J.; Carter, M.M.; Gardner, C.D. Assessing the effects of alternative plant-based meats v. animal meats on biomarkers of inflammation: A secondary analysis of the SWAP-MEAT randomized crossover trial. *J. Nutr. Sci.* **2022**, *11*, e82. [CrossRef] [PubMed]
11. Rolands, M.R.; Hackl, L.S.; Bochud, M.; Lê, K.A. Protein Adequacy, Plant Protein Proportion, and Main Plant Protein Sources Consumed Across Vegan, Vegetarian, Pescovegetarian, and Semivegetarian Diets: A Systematic Review. *J. Nutr.* **2024**. [CrossRef] [PubMed]
12. International Food Information Council. 2024 IFIC Food & Health Survey. Available online: https://foodinsight.org/wp-content/uploads/2024/06/2024-IFIC-Food-Health-Survey.pdf (accessed on 20 November 2024).

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Factors and Perceptions Associated with Post-Pandemic Food Sourcing and Dietary Patterns among Urban Corner Store Customers in Baltimore, Maryland

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Abstract: Objective. Diet-related disease is rising, disproportionately affecting minority communities in which small food retail stores swamp supermarkets. Barriers to healthy food access were exacerbated by the pandemic. We examined the following: (1) individual- and household-level factors in a sample of Baltimore community members who regularly shop at corner stores and (2) how these factors are associated with indicators of dietary quality. Design. Cross-sectional data were collected using an online survey to capture sociodemographics, anthropometrics, and food sourcing, spending, and consumption patterns. Concurrent quantitative and qualitative analyses were conducted in Stata 18 and ATLAS.ti. Setting. This study was set in Baltimore, Maryland, USA. Participants. The participants included adults (n = 127) living or working in Baltimore who identified as regular customers of their neighborhood corner store. Results. The respondents were majority Black and low-income, with a high prevalence of food insecurity (62.2%) and overweight/obesity (66.9%). Most (82.76%) shopped in their neighborhood corner store weekly. One-third (33.4%) of beverage calories were attributed to sugar-sweetened beverages, and few met the recommended servings for fruits and vegetables or fiber (27.2% and 10.4%, respectively). Being Black and not owning a home were associated with lower beverage and fiber intake, and not owning a home was also associated with lower fruit and vegetable intake. Food insecurity was associated with higher beverage intake, while WIC enrollment was associated with higher fruit and vegetable and fiber intakes. Open-ended responses contextualized post-pandemic food sourcing and consumption in this setting. Conclusions. This paper helps characterize the consumers of a complex urban food system. The findings will inform future strategies for consumer-engaged improvement of local food environments.

Keywords: urban; Baltimore; food sourcing; food environment; dietary quality; COVID-19; corner stores

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1. Introduction

Nearly 60% of United States adults are currently living with at least one chronic disease (e.g., obesity, cancer, diabetes), and this rate is projected to increase over the next three decades [1,2]. Diet contributes to the development of many chronic diseases, and the presence of at least one increases the risk for multimorbidity [3]. The chronic disease burden disproportionately affects minority populations because of the complexity of historical, social, economic, and environmental mechanisms [4]. Members of these populations are more likely to reside in under-resourced communities with high access to energy-dense

foods and sugar-sweetened beverages, which increase the risk for chronic disease, and low access to fruits and vegetables, which are protective for chronic disease [5]. These communities, often referred to as "food swamps", tend to be characterized by an abundance of small independently owned food retail stores ("corner stores") and prepared food sources ("carryouts"), and a lack of nearby supermarkets. Strong linkages have been made among inequitable food environments, food access (e.g., availability and affordability), and dietary quality as predictors of disease [5]. In recent years, the coronavirus disease of 2019 (COVID-19) pandemic further exacerbated existing inequities, as resources were stretched thin for many American families [6].

Many interventions, programs, and policies have sought to improve food access under usual and emergency (e.g., pandemic) conditions, although most have focused extensively on one level of the food system, failing to address root causes of diet-related health disparities. There has been a recent call to action for research to develop and implement strategies with a broader focus on the food system as a whole across local, state, and federal levels [7]. Several examples of successful multi-level multi-component intervention trials further support this requisition, some of which demonstrated particular promise in Baltimore, Maryland, prior to COVID-19 [8–11].

In 2020, the Baltimore Urban food Distribution (BUD) study received funding to improve the food distribution system for healthy, affordable foods and beverages among Baltimore corner stores and local farmers, producers, wholesalers, and distributors [12]. The BUD intervention leverages a digital tool—a timely innovation given the rise in the use of digital health technology during COVID-19—referred to as the BUD mobile application ("BUD app"). The app is designed to allow for a streamlined exchange of hyperlocal items between retailers and suppliers [13,14]. While the intervention primarily focuses on engaging retailers and suppliers in the supply-side proliferation of healthy foods, the app can be expanded to involve consumers in the demand-side feedback loop for reinforced stocking and purchasing of these foods in their community environments.

As of January 2024, the Maryland Food Bank estimates that grocery prices have increased by nearly 20% since January 2020 [15]. To that end, acquiring fresh, nutritious foods has become increasingly challenging for Baltimore residents, especially those navigating neighborhoods where generational disparities in food access and health persist. An updated understanding of who the consumers in this food system are, and how their food sourcing patterns and perceptions play a role in their diets, could inform future intervention strategies including the integration of consumer input in the BUD app and parameterization of an agent-based model to simulate chronic disease risk. Therefore, the present paper sought to explore the following research questions:

1. What are the individual- and household-level factors characterizing a sample of Baltimore community members who regularly shop in their neighborhood corner stores?
2. How are these individual- and household-level factors associated with indicators of dietary quality (i.e., sugar-sweetened beverage consumption, fruit and vegetable intake, and dietary fiber intake)?

2. Methods

2.1. Study Setting

Baltimore, Maryland, is an example of an inequitable urban food system that contributes to differential food access among residents. In 2018, it was estimated that nearly one-quarter of residents (23.5%) lived in areas deemed to be "Healthy Food Priority Areas"—more commonly recognized as food deserts or swamps—where healthy food availability, transportation, annual household income, and the presence of supermarkets are low [16]. Racial/ethnic minority residents are more likely to live in these areas and disproportionately lack adequate access to food compared to their White counterparts. While there were 47 supermarkets and 6 public markets in Baltimore prior to the pandemic, small independently owned corner stores and convenience stores are much more ubiquitous, amounting to over 700 locations

(525 corner stores and 183 convenience stores) citywide [16]. Given the absence of supermarkets in many neighborhoods, residents often frequent these smaller stores for food purchases.

2.2. Sampling

Respondents (n = 127) were adults who (1) live or work within a 0.5-mile radius of a corner store; (2) purchase food items at least once per week from a corner store; (3) are 21–75 years old; (4) plan to stay in Baltimore for at least the next 12 months; and (5) are not pregnant. The age range for eligible respondents was selected to capture adults who would be most likely to have high individual purchasing power at small stores. Recruitment was carried out via in-person flyers, social media, and word-of-mouth (e.g., snowball sampling), including follow-up emails sent to respondents encouraging the referral of local friends, family, and colleagues. A description of the original study protocol can be found in Gittelsohn and Colleagues (2022), although the data collection strategies described here reflect a later shift from in-person to online because of pandemic-related restrictions [12,17].

2.3. Materials and Measures

Data were collected between March and September 2023 using a modified online version of an Adult Impact Questionnaire (AIQ) fielded in previous studies in Baltimore [12,18]. The instrument consisted of 84 closed- and open-ended questions including dietary intake screeners selected to capture foods belonging to the categories promoted as part of the larger BUD trial including (1) beverages (2) fruits and vegetables, and (3) whole grains/fiber. The AIQ was administered using Qualtrics and made available for mobile and web through a secure Johns Hopkins University server. On average, respondents spent 50.76 min completing the survey.

2.3.1. Quantitative Measures

Individual factors. Sociodemographic information. Individual-level sociodemographic information was gathered including home address (to capture neighborhood and proximity to BUD-participating corner stores), age in years, gender, race/ethnicity, marital status, level of highest education, and employment status. Food sourcing. Patterns and behaviors related to food sourcing were collected through questions pertaining to how many times certain foods and beverages were bought over the last 30 days and from which types of food sources they were purchased. Psychosocial factors. Psychosocial questions pertaining to healthy eating were used to assess behavioral intentions, outcome expectancies, and self-efficacy. For example, selected items were used as prompts for future purchasing intentions, such as "The next time you purchase bread, which would you choose?" with pre-selected options (e.g., white bread, potato bread, 100% whole wheat bread). Anthropometry. Respondents were asked questions regarding their blood pressure, weight, and height. Body Mass Index (BMI) was calculated using self-reported height in inches and self-reported weight in pounds as measured by a medical professional or at home. If the respondent provided their weight as measured by a medical professional, that number was utilized. Using the formula: weight (lb)/[height (in)]^2 $\times$ 703, BMI was recorded in Excel Version 16.85 and categorized in Stata 18 as either underweight (BMI less than 18.5), normal (BMI between 18.5 and 24.9), overweight (BMI between 25 and 29.9), obese (BMI between 30 and 39.9), or severely obese (BMI of 40 or over) [19].

Household factors. Household-level information was assessed through questions pertaining to socioeconomic status (e.g., number of adults and children living in the household, annual household income, housing arrangement, and household participation in food assistance programs), as well as questions on food purchasing and food preparation. Household food security status was obtained using the U.S. Household Food Security Survey Module: Six-Item Short Form [20]. Responses to the six questions were scored to produce a sum total raw score ranging from 0 to 6. A raw score of 0–1 was considered "high or marginal food security", a raw score of 2–4 was considered "low food security", and a

raw score of 5–6 was considered "very low food security". In other words, respondents with a score from 2 to 6 were generally food insecure.

Dietary quality indicators. Beverage intake. Beverage intake was measured using the Beverage Intake Questionnaire (BEVQ-15) [21,22]. The questionnaire asks respondents to indicate approximately (1) how often and (2) how much each time, they drank fifteen researcher-selected beverages, including sugar-sweetened beverages, in the past month. Responses are scored into average daily fluid ounces, average daily calories, and average daily grams consumed for each beverage, and then these scores are summed to find the total average daily fluid ounces, total average daily calories, and total average daily grams for all beverages. Fruit and vegetable intake. Fruit and vegetable intake was measured using the Block Fruit/Vegetable/Fiber (FVF) Screener [23,24]. The screener includes 7 questions about fruit and vegetable intake and 3 questions about foods high in fiber. Responses are used to rank individuals with regard to their usual intake, producing scores ranging from 0 to 35 for fruits and vegetables (with a score of less than 11 being considered "low") and from 0 to 50 for fruits, vegetables, and beans, as well as a point estimate of total daily fruit and vegetable servings. Fiber intake. Fiber intake from fruits and vegetables, beans, and whole grains was also measured using the Block FVF Screener, which, in addition to producing a score associated with fruit and vegetable intake, produces point estimates for various daily nutrient intakes including vitamin C (mg), magnesium (mg), potassium (mg), and dietary fiber (mg).

2.3.2. Qualitative Measures

COVID-19 impact. Respondents were asked two qualitative open-ended questions as follows: (1) "In 1–2 sentences, can you tell us about how the COVID-19 pandemic has impacted how and where you food shop? What foods do you shop for? (Please respond with at least 10 words.)" and (2) "In 1–2 sentences, do you think the COVID-19 pandemic has changed how people in your community shop for food? What about how stores in your community sell food? (Please respond with at least 10 words)". The questions were designed to prime respondents for the thoughtfulness of both facilitators and barriers to food sourcing as they completed the AIQ, as well as to supplement the quantitative data with the shared lived experiences of respondents.

2.4. Data Checking

Given the nature of online data collection, extensive data checking was required because of the infiltration of bots and scammers. We developed a comprehensive two-part, three-reviewer protocol based on recommendations from Griffin and Colleagues (2022) who reported experiencing similar challenges [25].

2.5. Data Analysis

A concurrent nested triangulation approach to data analysis was used, whereby the quantitative and qualitative data were collected at the same time during the administration of the AIQ but analyzed separately with more weight given to the quantitative analyses [26]. Concurrent triangulation designs allow researchers to define relationships more accurately among variables of interest and to recontextualize theory in other populations and settings [27,28]. Descriptive and statistical quantitative analyses were conducted using Microsoft Excel for Mac (version 16.81) [29] and Stata (version 18) [30]. Thematic qualitative analysis was conducted using ATLAS.ti Web (version 24) [31].

Descriptive analysis. Respondent characteristics were analyzed using descriptive statistics in Stata. Variables were created to collapse or dichotomize measures of interest, if appropriate. All dietary data were scored based on guidelines provided by the developers of each screener tool. Independent samples *t*-tests and Wilcoxon–Mann–Whitney tests were used to compare the means of dependent dietary intake variables among dichotomous independent factors of interest. Chi-square tests and one-way analysis of variance (ANOVA) were used to examine associations among categorical sociodemographic variables.

Statistical analysis. A linear regression model-building approach was used to analyze the associations between categorical measures of interest, or factors, and continuous dietary intake outcomes. Three models were constructed beginning with sociodemographic factors, then adding additional individual-level factors, and finally, adding household-level factors. This was repeated three times for each of the three dietary outcomes of interest (daily beverage intake, daily servings of fruits and vegetables, and daily dietary fiber intake), which were each regressed on different independent variables. Assumptions of normality were investigated, as well as model specification and backward stepwise selection, and independent *t*-tests were used to select the final model of best fit for each outcome of interest, taking multicollinearity into account. The variance inflation factor (VIF) was employed to check for multicollinearity within each regression model with a tolerance (defined as 1/VIF) level set to 0.1. For all analyses, statistical significance was defined by a *p*-value of <0.05.

Thematic analysis. An inductive approach to coding was employed by a primary (Y.X.) and secondary (E.C.L.) coder. The coding process followed a similar process to that of Grounded Theory, such that codes were derived directly from the question responses first and then condensed into a shorter list of codes applied to each response [32]. Codes were further examined for those with few quotations and, in some instances, were combined with other codes. The codes were categorized into two overarching groups—"Individual-Level Changes" and "Store/Community-Level Changes"—based on the premises of the two open-ended response questions, and the resulting key themes were then analyzed in ATLAS.ti.

3. Results

3.1. Description of the Study Sample

Individual-level factors. The respondents (n = 127) ranged in age from 21 to 67 years old (mean (M) = 38.95 years, standard deviation (SD) = 11.27). The majority reported being female (65.4%) and Black or African American (51.2%). A little less than half (46.5%) were married, about one-quarter (23.6%) held a bachelor's degree, and around two-thirds (66.9%) were currently employed. Two-thirds (66.9%) were overweight or obese based on calculated BMI scores. Overall, 82.76% reported shopping at a neighborhood corner store at least once per week—while 16.55% reported daily corner store shopping, and only 66.90% reported shopping in a supermarket at least once per week. When asked about food purchasing intentions for staple items such as milk, bread, and rice, only one-quarter (25.20%) said they would choose 1% low-fat milk over higher-fat options (e.g., 2% milk, whole milk), one-third (34.65%) said they would choose 100% whole wheat bread over potato or white bread, and a little less than one-quarter (21.26%) said they would choose brown rice over white or yellow rice at their next purchase. About forty-five percent (44.83%) indicated intention to purchase the healthiest option for all three items.

Household-level factors. Most (63.8%) rented their household residence and had a mean annual household income of less than USD 40,000—and more than eighty percent (81.1%) reported an annual household income that was below the median annual household income level for Baltimore (USD 54,735) [33]. Regarding food spending, respondents spent, on average, USD 710.31 total on food in the last 30 days, of which an average of USD 238.05 came from food assistance, to feed a mean number of three people per household. Seventy-two percent (72.44%) reported having at least one (M = 1.21, SD = 0.98) child under 18 years of age living in the household. More than half (57.48%) reported that someone in their household had participated in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) within the past year, followed by 39.37% in free or reduced-cost school breakfast, 34.65% in the Supplemental Nutrition Assistance Program (SNAP), and 14.17% in free or reduced-cost school lunch. Almost two-thirds (62.2%) shared that their household had experienced food insecurity (low or very low food security) in the last year.

Relationships among factors. Being Black was significantly associated with food insecurity status ($F(2, 123) = 3.87$, $p = 0.023$). A Tukey post hoc test revealed that the

likelihood of being Black was significantly associated with low food security (0 = 0.043) or very low food security (p = 0.064) compared with high or marginal food security. Being Black was also significantly associated with BMI status (F(5, 120) = 3.83, p = 0.003), especially for those in obesity classes II (p = 0.003) and III (p = 0.046) compared with those considered normal weight, and for those in obesity class II compared with those considered overweight (p = 0.039).

Not surprisingly, the highest level of education obtained was significantly associated with employment status (F(2, 124) = 20.02, p = 0.0001) and annual household income (F(2, 124) = 25.61, p = 0.0001). WIC enrollment was significantly associated with food security status (F(2, 124) = 4.29, p = 0.016), and this was seen particularly for those who had very low food security compared with high or marginal food security (p = 0.012). Participating in the SNAP program, however, was not associated with food security in this sample.

Regarding dietary intake, the average daily caloric intake from beverages was 1372.68 calories (SD = 1240.004), 458.37 calories (SD = 423.47) of which were attributed to consumption of sugar-sweetened beverages (SSBs) on average. Estimated daily servings of fruits and vegetables was 3.78, on average (SD = 2.06), which is only 75.6% of the recommended daily serving size of 5 [34]. In fact, only 27.2% of the sample had a predicted daily serving size of 5 or more servings. Predicted daily intake of fiber was 15.13 g on average (SD = 7.09). This is similar to the national average for adults, which falls around 15 g of fiber per day, although the United States Department of Agriculture (USDA) recommends that adults up to age 50 consume 25 g for women and 38 g for men, per day, and those above 50 consume 21 g for women and 30 g for men [35]. In our sample, across all adults, only 10.4% were estimated to consume 25 g or more of fiber daily.

A summary of respondent characteristics across food and nutrient intakes can be found in Table 1.

Table 1. Daily food and nutrient intakes by individual- and household-level characteristics.

		Daily Food and Nutrient Intake		
		Beverages, Kcal	**Fruits and Vegetables, Servings**	**Total Fiber, Grams**
Characteristics	***n* = 127**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Individual level				
Gender				
Male	42	1514.36 (1162.00)	4.29 (2.15) *	19.65 (6.19) ***
Female $^{\nabla}$	83	1307.25 (1290.62)	3.52 (1.98)	12.84 (6.42)
Non-Binary	2	1113.04 (676.92)	-	-
Age (years)				
21–34 $^{\nabla}$	50	1319.68 (1118.45)	3.98 (2.22)	17.34 (6.62)
35–44	45	1611.52 (1424.05)	3.74 (1.75)	15.66 (6.50)
45–54	13	878.85 (765.54)	2.85 (2.37)	10.49 (7.95) **
55–64	17	1402.08 (1318.90)	3.88 (2.18)	11.22 (6.94) **
65–75	2	283.89 (294.32)	5.01 (1.18)	13.73 (1.05)
Race/ethnicity				
Black or African American $^{\nabla}$	65	1101.86 (1057.52)	3.20 (1.96)	12.71 (6.97)
White	49	1649.27 (1322.39) *	4.68 (2.06) ***	18.41 (6.81) ***
Other	13	1724.13 (1601.13)	3.40 (1.47)	14.95 (3.06)

Table 1. *Cont.*

		Daily Food and Nutrient Intake		
		Beverages, Kcal	**Fruits and Vegetables, Servings**	**Total Fiber, Grams**
Characteristics	***n* = 127**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Marital status				
Married ▽	59	1766.02 (1275.38)	4.69 (1.93)	19.24 (5.97)
Never Married	49	953.20 (1009.41) ***	2.79 (1.85) ***	11.14 (6.02) ***
Divorced	6	1746.00 (2257.14)	3.01 (1.31) *	12.00 (5.00) **
Other	13	996.33 (618.23) *	3.57 (1.99)	12.34 (6.31) ***
Education				
Less than 12th grade ▽	10	1899.49 (2010.92)	2.88 (1.55)	13.25 (7.25)
High School or GED	32	1112.63 (997.78)	2.84 (2.01)	11.59 (6.81)
Less than 2 years of college or vocational school	31	971.83 (639.77) *	3.65 (1.68)	14.02 (5.44)
Associate or bachelor's degree	42	1687.87 (1426.35)	4.65 (2.20) *	18.58 (7.17) *
Graduate School	10	1649.74 (1300.68)	4.36 (1.87)	17.48 (6.33)
Other	2	1108.17 (750.20)	4.96 (0.78)	17.67 (6.46)
Employment status				
Employed ▽	85	1619.11 (1386.16)	4.23 (2.08)	17.34 (6.62)
Unemployed	25	893.48 (545.58) **	2.83 (1.68) **	11.20 (5.86) ***
Disabled	12	673.99 (477.33) *	2.80 (1.95) *	9.35 (5.70) ***
Retired or other	5	1256.27 (1210.21)	3.47 (1.88)	11.95 (7.42)
Body Mass Index (BMI)				
Underweight ▽	3	903.87 (664.71)	2.86 (0.87)	14.09 (6.00)
Normal weight	39	1503.43 (1058.71)	4.75 (1.87)	18.49 (6.39)
Overweight	39	1537.17 (1449.35)	3.60 (1.76)	15.38 (5.97)
Obesity class I	9	1477.74 (1204.48)	4.56 (2.93)	16.40 (10.09)
Obesity class II	9	733.94 (673.18)	3.33 (2.01)	11.19 (5.82)
Obesity class III	28	1183.23 (1334.02)	2.67 (1.94)	11.06 (6.74)
Household level				
Annual household income (USD)				
Less than 40,000 ▽	62	1123.45 (1132.43)	3.27 (1.94)	12.23 (6.78)
40,001–80,000	51	1569.10 (1266.46)	4.08 (2.08) *	17.48 (6.13) ***
More than 80,000	14	1760.90 (1451.47)	4.95 (1.98) **	19.40 (6.75) ***
Housing arrangement				
Own Home ▽	30	1845.96 (1383.33)	4.95 (1.66)	19.01 (5.28)
Rent Home	81	1242.47 (1218.18) *	3.42 (2.03) ***	14.07 (7.25) ***
Live with Family	11	1280.89 (929.01)	3.84 (2.48)	14.74 (7.50)
Other	5	844.34 (573.61)	2.36 (1.24) **	9.61 (4.38) **

Table 1. *Cont.*

		Daily Food and Nutrient Intake		
		Beverages, Kcal	**Fruits and Vegetables, Servings**	**Total Fiber, Grams**
Characteristics	***n* = 127**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Household size				
One person ▽	11	778.03 (602.39)	2.94 (1.61)	11.49 (4.35)
Two people	27	1131.25 (1078.47)	2.97 (1.87)	10.97 (6.39)
Three people	36	1384.44 (1231.52)	4.29 (2.33)	17.34 (8.04) *
Four people	35	1669.35 (1504.20) *	3.76 (1.97)	15.42 (5.73)
Five people	10	1462.35 (1374.96)	4.31 (1.93)	17.56 (7.43) *
>Five people	8	1542.21 (754.39)	4.61 (1.76)	18.90 (6.18) *
Food assistance participation				
WIC Program ▽	73	1179.71 (1013.37)	3.39 (2.25)	13.29 (7.82)
SNAP Program	44	2292.84 (1312.08)	5.46 (1.55) *	20.69 (4.13) *
Free/reduced school meals	68	1460.69 (1370.62)	3.95 (2.17)	15.08 (7.94)
Other	9	1378.77 (1055.79)	4.77 (1.83)	16.84 (9.47)
Food security status				
High/marginal food security ▽	48	1323.22 (1149.14)	4.19 (2.18)	17.16 (6.98)
Low food security	26	1020.38 (1201.08)	3.15 (2.09) *	12.75 (7.18) *
Very low food security	53	1590.30 (1313.80)	3.72 (1.88)	14.44 (6.77)

▽ Reference group. * Statistically significant association (p-value < 0.05) compared with the reference group. ** Statistically significant association (p-value < 0.01) compared with the reference group. *** Statistically significant association (p-value < 0.001) compared with the reference group.

3.2. Associations with Beverage, Fruit and Vegetable, and Fiber Intake

Daily calories from beverages. In the final model, being Black (β = −456.74, CI: −891.73, −21.74, p = 0.040) and not owning a home (β = −349.67, CI: −695.64, −3.71, p = 0.048) were significantly associated with a lower daily intake of calories from beverages. Being at greater risk for food insecurity (β = 592.87, CI: 99.43, 1086.32, p = 0.019) and having at least one child under 18 years of age in the home (β = 541.48, CI: 66.87, 1016.08, p = 0.026) were significantly associated with higher daily intake of calories from beverages. WIC enrollment, annual household income, future intention for purchasing rice, and high blood pressure were not significantly associated with daily beverage intake.

Daily servings of fruits and vegetables. In the final model, not owning a home (β = −0.58, CI: −1.07, −0.09, p = 0.017) was significantly associated with lower daily servings of fruits and vegetables. Having a higher level of education (β = 0.51, CI: 0.12, 0.91, p = 0.012) and WIC enrollment (β = 1.07, CI: 0.37, 1.78, p = 0.003) were significantly associated with higher daily servings of fruits and vegetables. Being Black, overweight/obese, male, household size, and spending more food money on fruits and vegetables were surprisingly not significantly associated with daily fruit and vegetable intake.

Daily dietary fiber intake. In the final model, being Black (β = −2.40, CI: −4.39, −0.40, p = 0.019), being older (β = −2.40, CI: −4.38, −0.42, p = 0.018), and not owning a home (β = −1.77, CI: −3.19, −0.35, p = 0.015) were significantly associated with a lower daily intake of dietary fiber. Being male (β = 6.12, CI: 4.02, 8.22, p = 0.0001) and WIC enrollment (β = 3.22, CI: 1.16, 5.28, p = 0.003) were significantly associated with a higher daily intake of dietary fiber. Being overweight/obese, having a higher level of education, and spending more food money on fruits and vegetables were not significantly associated with daily fiber intake.

All factors included in each of the three final linear models can be found in Table 2.

Table 2. Factors associated with beverage, fruit and vegetable, and fiber intake.

Characteristics	Beverages, kcal	Fruits and Vegetables, Servings	Total Fiber, Grams
	β (95% CI)	β (95% CI)	β (95% CI)
Gender	-	−0.63 (−1.31, 0.05)	6.12 (4.02, 8.22) *
Age	-	-	−2.40 (−4.38, −0.42) *
Race/ethnicity	−456.74 (−891.73, −21.74) *	−0.63 (−1.31, 0.05)	−2.40 (−4.39, −0.40) *
BMI category	-	−0.61 (−1.32, 0.09)	−1.93 (−3.97, 0.11)
Marital status	-	-	-
Education level	-	0.51 (0.12, 0.91) *	1.08 (−0.09, 2.25)
Employment status	-	-	-
Annual income	255.58 (−136.83, 647.98)	-	-
Housing arrangement	−349.67 (−695.64, −3.71) *	−0.60 (−1.09, −0.11) *	−1.77 (−3.19, −0.35) *
Household size	-	0.19 (−0.07, 0.45)	0.84 (0.08, 1.61) *
Food security status	592.87 (99.43, 1086.32) *	-	-
Children in home	541.48 (66.87, 1016.08) *	-	-
Blood pressure	−379.16 (−863.57, 105.25)	-	-
Food spending	-	0.64 (−0.01, 1.28)	1.86 (−0.06, 3.77)
Food assistance			
SNAP	-	-	-
WIC	318.77 (−124.11, 761.66)	1.07 (0.37, 1.78) *	3.22 (1.16, 5.28) *
Food intentions			
Milk	-	-	-
Bread	-	-	-
Rice	422.73 (−88.34, 933.80)	-	-
Corner store shopping			
Daily	-	-	-
Weekly	-	-	-
Supermarket shopping	-	-	-

* Statistically significant (p-value < 0.05).

3.3. Perceptions of COVID-19 Impacts on Food Sourcing and Consumption

Twenty-two key themes were identified as representing community member perspectives of COVID-19 impacts on food sourcing and consumption. Examples of each theme can be found in Table 3 and are included in a discussion of the study findings in the following section.

Table 3. Key themes (n = 22) and relevant examples from respondent quotations.

Theme	Example
Staple foods	*"...pantry staples like rice, beans, flour, etc."*
Fresh foods	*"The closest corner [store] near me had no fresh produce at the height of the pandemic which forced me to have to go to the nearest supermarket which is at least a mile from my house."*
Online food shopping	*"I have observed that not only me tend to shop sometimes online that a lot more people in my neighborhood tends to do that now and all this came about due to the COVID-19 pandemic that limited one from going to the corner stores in person."*
Store operation changes	*"When I go out, my options are limited. Because so many places closed down or restricted business operations during the pandemic, there are fewer options for me to get what I need."*
Store cleanliness and sanitary practices	*"Pre COVID me didn't really care much about cleanliness and packaging of products but after COVID started, I look out for stores that are not known for taking due process in [cleanliness]."*
Concern for expiration of perishable foods	*"The food is really not good some is expired..."*
Money spent on food	*"We save the bigger grocery stores for larger trips only once or twice a month."*
Changes in price and affordability of food	*"We try to eat healthy but the prices have went up so much. It seems as if fruits and vegetables cost more than unhealthy foods."*
Use of food assistance programs and pantries	*"[I] saw an increase in people relying on food pantries and corner stores for quick, cheap, or free foods"*
Proximity to stores and access to transportation	*"[Corner stores] get food from other stores and sell it to us for a much higher price than at the original store [but] most of them are far to get to if you don't drive"*
Adoption of new cooking methods	*"I began trying out new recipes and cooking more meals at home due to restaurant closures."*
Reduced income and job loss	*"I was shopping in bulk to try to stretch my money and feed my family"*
Fear of COVID-19 infection	*"Makes me want to not shop around other people or just go to the nearest store for something fast."*
Food deserts	*"The pandemic has created another food desert in my community. The closest market was Save A Lot and they closed and replaced it with Dollar General. So no fresh fruits or veggies..."*
Customer foot traffic in stores	*"For me personally, I've had to make some pretty drastic changes to my grocery routine...now I'm finding that [some] stores are too crowded with people looking for deals."*
Relationship between store owners and their customers	*"We did not really pay much attention to the stores around our place before the pandemic and after the pandemic we started patronizing the stores around. Now we are known more by the [store owners]."*
Last resort measures to obtain food	*"People have to be more creative about how they access food."*
Community togetherness and support for local businesses	*"When I do go grocery shopping, I try to stick with local businesses where possible...this helps keep money circulating in our communities..."*
Changes to food sourcing and shopping patterns	*"I don't buy the things I want as much anymore just the things I need."*
Limited food variety and quality	*"I shop for meat bread water and fresh veggies if available [but] where I live there is not that many options."*
Increased awareness of health	*"[People] are more concerned about healthy purchases than they used to"*
No post-pandemic changes to food sourcing or consumption made	*"...the pandemic didn't really affect my grocery shopping habits. I shop for quick meals when I am on the go and groceries when I can get to the store."*

4. Discussion

This paper examines individual- and household-level factors and community member perceptions associated with dietary quality (beverage, fruit and vegetable, and dietary fiber intake) in the wake of pandemic-related disruptions to small urban food retailers. We found that one-third of daily average beverage consumption was attributed to sugar-sweetened beverages, and few adults met the recommended daily intakes for fruits and vegetables and fiber. Linear regression models revealed significant associations among factors such as being Black, home ownership, WIC program enrollment, and indicators of dietary quality.

Community member perceptions codified across 22 themes pointed to several implications for food sourcing and consumption patterns given recent shifts in the food system.

Most (82.8%) respondents reported shopping in their neighborhood corner store at least once per week, citing proximity and convenience as major factors in their selection of food retail sources. In regard to diet, one-third (33.4%) of daily average beverage calories consumed were attributed to sugar-sweetened beverages, less than 30 percent (27.2%) met the recommended amount of daily fruit and vegetable servings, and only 10 percent (10.4%) consumed the minimum recommended amount of dietary fiber per day. Mentions of COVID-19's impact on the selection of types and quality of foods pertained to a lack of fresh items and the need to shift towards more processed, shelf-stable, and canned goods. Importantly, processed and ultra-processed foods are commonly higher in added sugars and lower in fiber, protein, vitamins, and other nutrients compared with whole, nutritious foods [36]. Ultra-processed foods in particular may contribute towards empty calories, displacing more nutrient-dense foods and leading to a calorically dense yet undernourished diet [36].

Interestingly, among our sample, being Black and not owning a home were associated with lower daily beverage and fiber intake, and not owning a home was also associated with lower fruit and vegetable intake. Homeownership is an important indicator of wealth accumulation over time and may affect health through various mechanisms, especially for low-income households [37]. Individuals with greater wealth have been shown to experience lower mortality, higher life expectancy, and decreased risk of chronic diseases including obesity, hypertension, and asthma [38]. A 2018 report highlighted several key findings linking greater wealth with better health, including that wealth is associated with healthier living conditions and access to health care and is protective against chronic stress—which is known to negatively impact diet and mental and physical health [39]. Moreover, home ownership may suggest greater housing stability, which could be protective for dietary quality. In one study, housing instability was associated with lower vegetable consumption and lower overall dietary quality among an urban adult population [40]. However, the existing literature on specific mechanisms underlying home ownership and its impact on diet in the United States is mixed, with most studies focused on income and broader health outcomes. Given that not owning a home was associated with a lower intake of all three dietary groups assessed in our sample, further investigation of potential mechanisms is warranted, and local, state, and federal homeownership programs should be considered as part of future systems interventions aimed at improving healthy food access and diet.

Not surprisingly, food insecurity was associated with higher daily caloric intake from beverages—one-third (33.39%) of which came from sugar-sweetened beverages, on average—and WIC enrollment was associated with higher daily fruit and vegetable and fiber consumption. Previous studies in the literature have identified food insecurity as a potential driver of sugar-sweetened beverage consumption across child, adolescent, and adult populations [41–43]. This relationship has been observed both inside and outside of the home—a 2019 study found that the odds of purchasing a sugar-sweetened beverage at a small or top chain restaurant were higher in households with marginal and low food security, and the odds of purchasing a low-calorie beverage were lower in households with very low food security [44]. Previous studies also support the finding that WIC program enrollment is associated with increased consumption of fruits and vegetables and dietary fiber. Most recently, the increased WIC cash value benefit (CVB) was found to be associated with a greater amount and diversity of redeemed fruits and vegetables among participants of the program [45]. In addition, according to a 2021 report, WIC participants buy and eat more fruits and vegetables, as well as whole grains and low-fat dairy products [46]. However, national WIC enrollment rates remain low, with more than half of WIC-eligible recipients not enrolled in the program as of 2021 [47]. In Maryland, the enrollment rate for all eligible recipients dropped from 59.8% to 55.4% from 2020 to 2021 [47,48]. Therefore, future interventions in this setting should consider ways in which

to increase WIC enrollment and retention for eligible households. WIC benefits redemption could be explored in small independently owned corner stores and other small-box stores (e.g., dollar stores), as well, in order to improve the selection of healthy options given the program's minimum stocking requirements.

When asked about food sourcing and consumption in their communities, many respondents shared that their nearby stores lacked variety in the healthy items available, and stores that did offer them were often located further away or had higher prices. This seemed to be exacerbated by the pandemic, with some respondents mentioning shifts in their food shopping behaviors, such as sourcing shelf-stable canned fruits and vegetables and utilizing online food services that offer coupons or discounts. Respondents also expressed concerns regarding the quality of foods stocked in corner stores. Several sentiments placed the blame on corner stores, although others acknowledged the influence of broader food system challenges due to the pandemic. A desire for convenience, accessibility, and close proximity to stores was brought up frequently by community members, sometimes overriding the desire for healthy options. Interestingly, a few respondents mentioned having relationships with small store owners, and some highlighted the importance of community togetherness and supporting local businesses. Support from local food assistance programs, such as food pantries, tended to be associated with feelings of community togetherness, especially for those hit by harder times during the pandemic.

Coupled with our findings pertaining to dietary quality and associated characteristics, these respondent perspectives provided a deeper understanding of the complex food shopping experiences of those navigating a disrupted urban food environment. For example, it is possible that the lower overall fruit and vegetable intake could be partly explained by the challenges related to availability, variety, quality, and price discussed by respondents. In addition, lower intake of dietary fiber could be due in part to increased purchasing of canned and processed foods, which are more likely to be lower in fiber and other nutrients than fresh or frozen foods. Mention of relationships with small, neighborhood store owners could be leveraged in the BUD study—in fact, a consumer module (called "BUDConnect") of the BUD app is currently being developed and tested to provide a digital platform for relationship-building between store owners and their regular customers. Therefore, these findings will help ensure community members' needs are adequately met through BUDConnect, such as being able to request the stocking of desired healthy items and rate and review the quality and pricing across various neighborhood stores.

The present study had several challenges worth noting. Online recruitment required the need to develop and implement an added step to our data-checking protocol given the nature of online bots. In addition, the data collected were cross-sectional and included self-reported anthropometric measures, which were used to calculate BMI and may have introduced opportunities for bias. However, most recent studies agree that self-reported height and weight are sufficient for use in research [49]. Finally, daily caloric intake from beverages was high among one-fifth (18.9%) of the sample relative to the average estimated total daily caloric intake in the United States. This could be due in part to the self-report nature of the BEVQ-15 instrument, although we did not capture total daily caloric intake in our sample and were therefore limited in our ability to contextualize unexpectedly high average intakes of dietary components with regard to respondents' overall diet. Future research should take this into consideration, in addition to our sample, which was limited in size.

Given recent calls to action for research to develop and implement informed, broad-scale programs and policies for improved nutrition and health [7], our next steps will include parameterizing an agent-based simulation model. Simulation models have been used to represent flows and accumulated stocks of healthy foods using modern representations of urban food systems, including Baltimore [50]. In this case, the planned model will utilize our AIQ data and other existing data sources to represent the impact of food environment programs and policies on dietary behaviors, obesity, and cancer risk. Once calibrated and tested, this tool can provide policymakers with guidance in the selection

of evidence-based strategies for improving outcomes and reducing the burden of disease. To our knowledge, a model of this nature does not currently exist but could play a crucial role in future preparedness and response to both usual and emergency disruptions to the food system.

5. Conclusions

The pandemic exacerbated existing issues of food access and food security for vulnerable communities nationwide, introducing nuanced challenges for sourcing and consuming healthy foods and beverages. Diet-related chronic disease risk continues to rise, underscoring a critical need for effective and sustainable interventions, programs, and policies that target the consumer, retailer, and supplier levels of the food system simultaneously. Consumers play a particularly important role in the supply–demand feedback loop for stocking and purchasing in small food retail stores, and the factors implicated in this complex system require better understanding. The findings presented here fill a critical gap in the literature and help inform intervention strategies such as the design and testing of an app to engage consumers in the demand-side proliferation of healthy food access and a simulation model for policymakers to assess potential risks and benefits of future programs and policies.

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References

1. National Center for Chronic Disease Prevention and Health Promotion [NCCDPHP]. Chronic Diseases in America. 13 December 2022. Available online: https://www.cdc.gov/chronic-disease/data-research/facts-stats/index.html (accessed on 9 July 2024).
2. Ansah, J.P.; Chiu, C.-T. Projecting the chronic disease burden among the adult population in the United States using a multi-state population model. *Front. Public Health* **2023**, *10*, 1082183. [CrossRef] [PubMed]
3. Gropper, S.S. The role of nutrition in chronic disease. *Nutrients* **2023**, *15*, 664. [CrossRef] [PubMed]
4. Kaiser Family Foundation [KFF]. Key Data on Health and Health Care by Race and Ethnicity. 15 March 2023. Available online: https://www.kff.org/racial-equity-and-health-policy/report/key-data-on-health-and-health-care-by-race-and-ethnicity/ (accessed on 9 July 2024).
5. Cooksey Stowers, K.; Jiang, Q.; Atoloye, A.T.; Lucan, S.; Gans, K. Racial differences in perceived food swamp and food desert exposure and disparities in self-reported dietary habits. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7143. [CrossRef]
6. Park, J.; Kim, C.; Son, S. Disparities in food insecurity during the COVID-19 pandemic: A two-year analysis. *Cities* **2022**, *131*, 104003. [CrossRef] [PubMed]
7. Thorndike, A.N.; Gardner, C.D.; Kendrick, K.B.; Seligman, H.K.; Yaroch, A.L.; Gomes, A.V.; Ivy, K.N.; Scarmo, S.; Cotwright, C.J.; Schwartz, M.B.; et al. Strengthening US food policies and programs to promote equity in nutrition security: A policy statement from the American Heart Association. *Circulation* **2022**, *145*, e1077–e1093. [CrossRef]
8. Economos, C.D.; Hyatt, R.R.; Must, A.; Goldberg, J.P.; Kuder, J.; Naumova, E.N.; Collins, J.J.; Nelson, M.E. Shape Up Somerville two-year results: A community-based environmental change intervention sustains weight reduction in children. *Prev. Med.* **2013**, *57*, 322–327. [CrossRef]
9. Ewart-Pierce, E.; Mejía Ruiz, M.J.; Gittelsohn, J. "Whole-of-Community" obesity prevention: A review of challenges and opportunities in multilevel, multicomponent interventions. *Curr. Obes. Rep.* **2016**, *5*, 361–374. [CrossRef] [PubMed]
10. Gittelsohn, J.; Trude, A.C.; Poirier, L.; Ross, A.; Ruggiero, C.; Schwendler, T.; Steeves, E.A. The impact of a multi-level multi-component childhood obesity prevention intervention on healthy food availability, sales, and purchasing in a low-income urban area. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1371. [CrossRef]
11. Vo, L.; Albrecht, S.S.; Kershaw, K.N. Multilevel interventions to prevent and reduce obesity. *Curr. Opin. Endocr. Metab. Res.* **2019**, *4*, 62–69. [CrossRef]
12. Gittelsohn, J.; Lewis, E.C.; Martin, N.M.; Zhu, S.; Poirier, L.; Van Dongen, E.J.I.; Ross, A.; Sundermeir, S.M.; Labrique, A.B.; Reznar, M.M.; et al. The Baltimore Urban Food Distribution (BUD) app: Study protocol to assess the feasibility of a food systems intervention. *Int. J. Environ. Res. Public Health* **2022**, *19*, 9138. [CrossRef]
13. Ross, A.; Krishnan, N.; Panchal, J.; Brooks, J.K.; Lloyd, E.; Lee, T.-H.J.; Gittelsohn, J. Formative research for an innovative smartphone application to improve distribution of healthy foods to corner stores in Baltimore City. *Ecol. Food Nutr.* **2019**, *58*, 3–22. [CrossRef]
14. Lewis, E.C.; Zhu, S.; Oladimeji, A.T.; Igusa, T.; Martin, N.M.; Poirier, L.; Trujillo, A.J.; Reznar, M.M.; Gittelsohn, J. User experience and interface design of an innovative digital application to facilitate group purchasing and delivery of healthy foods between urban retailers and local suppliers in Baltimore City, Maryland. *mHealth* **2024**, *10*, 2. [CrossRef]
15. Maryland Food Bank. Root Causes of Hunger Research: An MFB Strategy Group Research Report. 2024. Available online: https://mdfoodbank.org/wp-content/uploads/2024/02/Maryland-Food-Bank-Root-Causes-of-Hunger-Research-Report.pdf (accessed on 9 July 2024).
16. Misiaszek, C.; Buzogany, S.; Freishtat, H. *Baltimore City's Food Environment Report: 2018 Report*; Johns Hopkins Center for a Livable Future: Baltimore, MD, USA, 2018.
17. Lewis, E.C.; Pei, X.; Stephenson, J.; Poirier, L.; Gittelsohn, J. P22-034-23 Adapting a healthy food access adult consumer impact questionnaire for online use to better reach an under-resourced urban community. *Curr. Dev. Nutr.* **2023**, *7*, 101737. [CrossRef]
18. Gittelsohn, J.; Anderson Steeves, E.; Mui, Y.; Kharmats, A.Y.; Hopkins, L.C.; Dennis, D. B'More healthy communities for kids: Design of a multi-level intervention for obesity prevention for low-income African American children. *BMC Public Health* **2014**, *14*, 942. [CrossRef]
19. Centers for Disease Control and Prevention. Defining Adult Overweight & Obesity. Updated 3 June 2022. Available online: https://www.cdc.gov/obesity/php/about/index.html (accessed on 9 July 2024).
20. Blumberg, S.J.; Bialostosky, K.; Hamilton, W.L.; Briefel, R.R. The effectiveness of a short form of the Household Food Security Scale. *Am. J. Public Health* **1999**, *89*, 1231–1234. [CrossRef] [PubMed] [PubMed Central]
21. Hedrick, V.E.; Savla, J.; Comber, D.L.; Flack, K.D.; Estabrooks, P.A.; Nsiah-Kumi, P.A.; Ortmeier, S.; Davy, B.M. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): Sugar-sweetened beverages and total beverage energy intake. *J. Acad. Nutr. Diet.* **2012**, *112*, 840–849. [CrossRef] [PubMed]
22. Fausnacht, A.G.; Myers, E.A.; Hess, E.L.; Davy, B.M.; Hedrick, V.E. Update of the BEVQ-15, a beverage intake questionnaire for habitual beverage intake for adults: Determining comparative validity and reproducibility. *J. Hum. Nutr. Diet.* **2020**, *33*, 729–737. [CrossRef] [PubMed]
23. Block, G.; Sternfeld, B.; Block, C.H.; Block, T.J.; Norris, J.; Hopkins, D.; Quesenberry, C.P.; Husson, G.; Clancy, H.A. Development of Alive! (A Lifestyle Intervention Via Email), and its effect on health-related quality of life, presenteeism, and other behavioral outcomes: Randomized controlled trial. *J. Med. Internet Res.* **2008**, *10*, e43. [CrossRef]

24. Lalonde, I.; Graham, M.; Slovinec-D'Angelo, M.; Beaton, L.; Brown, J.; Block, T. Validation of the block fat/sugar/fruit/vegetable screener in a cardiac rehabilitation setting. *J. Cardiopulm. Rehabil. Prev.* **2008**, *28*, 340. [CrossRef]
25. Griffin, M.; Martino, R.J.; LoSchiavo, C.; Comer-Carruthers, C.; Krause, K.D.; Stults, C.B.; Halkitis, P.N. Ensuring survey research data integrity in the era of internet bots. *Qual. Quant.* **2022**, *56*, 2841–2852. [CrossRef]
26. Creswell, J.W.; Plano Clark, V.L.; Gutmann, M.L.; Hanson, W.E. Advances in mixed methods research designs. In *Handbook of Mixed Methods in Social and Behavioral Research*; Tashakkori, A., Teddlie, C., Eds.; SAGE: Thousand Oaks, CA, USA, 2003; pp. 209–240.
27. Morse, J.M. Qualitative research: Fact or fantasy? In *Critical Issues in Qualitative Research Methods*; Morse, J.M., Ed.; SAGE: Thousand Oaks, CA, USA, 1994; pp. 1–7.
28. Castro, F.G.; Kellison, J.G.; Boyd, S.J.; Kopak, A. A Methodology for conducting integrative mixed methods research and data analyses. *J. Mix. Methods Res.* **2010**, *4*, 342–360. [CrossRef] [PubMed]
29. Microsoft Corporation. Microsoft Excel for Mac (Version 16.81). 2024. Available online: https://office.microsoft.com/excel (accessed on 9 July 2024).
30. StataCorp. *Stata Statistical Software: Release 18*; StataCorp LLC: College Station, TX, USA, 2023.
31. ATLAS.ti. Scientific Software Development GmbH. ATLAS.ti Web (Version 24) [Qualitative Data Analysis Software]. 2024. Available online: https://atlasti.com (accessed on 9 July 2024).
32. Charmaz, K. Coding in Grounded Theory Practice. In *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*, 1st ed.; Brindle, P., Bryant, A., Clarke, A., Olesen, V., Eds.; SAGE: Thousand Oaks, CA, USA, 2006; pp. 42–71.
33. U.S. Census Bureau. *Estimate of Median Household Income for Baltimore City, MD [MHIMD24510A052NCEN]*; FRED, Federal Reserve Bank of St. Louis: St. Louis, MO, USA, 2023. Available online: https://fred.stlouisfed.org/series/MHIMD24510A052NCEN (accessed on 7 February 2024).
34. USDA Dietary Guidelines for Americans. Available online: https://www.dietaryguidelines.gov/sites/default/files/2019-05/Using%20Food%20Guide.pdf (accessed on 9 July 2024).
35. Harvard Health Publishing, Harvard Medical School. Should I Be Eating More Fiber? 2019. Available online: https://www.health.harvard.edu/blog/should-i-be-eating-more-fiber-2019022115927 (accessed on 9 July 2024).
36. Martínez Steele, E.; Baraldi, L.G.; da Costa Louzada, M.L.; Moubarac, J.-C.; Mozaffarian, D.; Monteiro, C.A. Ultra-processed foods and added sugars in the US diet: Evidence from a nationally representative cross-sectional study. *BMJ Open* **2016**, *6*, e009892. [CrossRef] [PubMed]
37. Wainer, A.; Zabel, J. Homeownership and wealth accumulation for low-income households. *J. Hous. Econ.* **2020**, *47*, 101624. [CrossRef]
38. Pollack, C.E.; Chideya, S.; Cubbin, C.; Williams, B.; Dekker, M.; Braveman, P. Should health studies measure wealth? A systematic review. *Am. J. Prev. Med.* **2007**, *33*, 250–264. [CrossRef] [PubMed]
39. Braveman, P.; Acker, J.; Arkin, E.; Proctor, D. *Wealth Matters for Health Equity*; Robert Wood Johnson Foundation: Princeton, NJ, USA, 2018.
40. Bottino, C.J.; Fleegler, E.W.; Cox, J.E.; Rhodes, E.T. The relationship between housing instability and poor diet quality among urban families. *Acad. Pediatr.* **2019**, *19*, 891–898. [CrossRef] [PubMed]
41. Bruce, M.A.P.; Thorpe, R.J.J.; Beech, B.M.D.; Towns, T.; Odoms-Young, A. Sex, race, food security, and sugar consumption change efficacy among low-income parents in an urban primary care setting. *Fam. Community Health* **2018**, *41* (Suppl. 2), S25–S32. [CrossRef] [PubMed]
42. Fernández, C.R.; Chen, L.; Cheng, E.R.; Charles, N.; Meyer, D.; Monk, C.; Baidal, J.W. Food insecurity and sugar-sweetened beverage consumption among WIC-enrolled families in the first 1000 days. *J. Nutr. Educ. Behav.* **2020**, *52*, 796–800. [CrossRef] [PubMed]
43. Mei, J.; Fulay, A.P.; Wolfson, J.A.; Leung, C.W. Food insecurity and dietary intake among college students with unlimited meal plans at a large, midwestern university. *J. Acad. Nutr. Diet.* **2021**, *121*, 2267–2274. [CrossRef] [PubMed]
44. Moran, A.J.; Subramanian, S.V.; Rimm, E.B.; Bleich, S.N. Characteristics associated with household purchases of sugar-sweetened beverages in US restaurants. *Obesity* **2019**, *27*, 339–348. [CrossRef]
45. Anderson, C.E.; Au, L.E.; Yepez, C.E.; Ritchie, L.D.; Tsai, M.M.; Whaley, S.E. Increased WIC cash value benefit is associated with greater amount and diversity of redeemed fruits and vegetables among participating households. *Curr. Dev. Nutr.* **2023**, *7*, 101986. [CrossRef]
46. Carlson, S.; Neuberger, Z. *WIC Works: Addressing the Nutrition and Health Needs of Low-Income Families for More Than Four Decades*; Center on Budget and Policy Priorities: Washington, DC, USA, 2021. Available online: https://www.cbpp.org/sites/default/files/atoms/files/5-4-15fa.pdf (accessed on 9 July 2024).
47. USDA. National and State Level Estimates of WIC Eligibility and Program Reach in 2021. Updated 22 February 2024. Available online: https://www.fns.usda.gov/research/wic/eligibility-and-program-reach-estimates-2021 (accessed on 9 July 2024).
48. USDA. National and State Level Estimates of WIC Eligibility and Program Reach in 2020. Updated 3 November 2023. Available online: https://www.fns.usda.gov/research/wic/eligibility-and-program-reach-estimates-2020 (accessed on 9 July 2024).

49. Olfert, M.D.; Barr, M.L.; Charlier, C.M.; Famodu, O.A.; Zhou, W.; Mathews, A.E.; Byrd-Bredbenner, C.; Colby, S.E. Self-reported vs. measured height, weight, and BMI in young adults. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2216. [CrossRef] [PubMed]
50. Zhu, S.; Mitsinikos, C.; Poirier, L.; Igusa, T.; Gittelsohn, J. Development of a system dynamics model to guide retail food store policies in Baltimore City. *Nutrients* **2021**, *13*, 3055. [CrossRef] [PubMed]

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Exploring the Impact of Sociodemographic Characteristics and Health Literacy on Adherence to Dietary Recommendations and Food Literacy

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Abstract: This study investigates food literacy-related abilities and adherence to dietary recommendations in relation to sociodemographic characteristics and health-related features (health literacy, self-rated health and morbidity) in the North-Western region of Romania. This is a secondary analysis of cross-sectional data collected in 2019 from a representative and randomised sample of 1572 individuals. A questionnaire was employed to record participants' sociodemographic characteristics, food-related and health-related features. Most participants were non-adherent to dietary recommendations for fruit and vegetables (83.5%), fish and seafood (61.3%), and water intake (67.9%). However, most participants reported an adequate ability to understand the connection between nutrition and health (89.1%), to distinguish between healthy and less healthy options (84.4%), and to acquire nutrition information (75.6%). Non-adherence to dietary recommendations and low food literacy abilities were more prevalent in disadvantaged groups (older age, rural settings, retirement or social welfare, low educational attainment, formerly married). Health literacy was negatively associated with not adhering to dietary recommendations and poor self-rated food literacy abilities. The study suggests that low socioeconomic status negatively impacts food literacy and adherence to dietary recommendations among Romanian adults. Identifying target populations to improve food-related abilities and health literacy can aid public health services in improving health outcomes.

Keywords: health literacy; dietary recommendations; dietary intake; food literacy; self-rated health; adherence; Romania; representative sample; cross-sectional study

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1. Introduction

The relationship between nutrition and disease is well-researched. Evidence is available to help develop solutions to prevent nutrition-related diseases and implement large-scale options, especially in key populations [1–3]. Health literacy (HL) is a mediator of health outcomes, necessary for understanding and using common health information. Deficiencies in health education are associated with low access to preventive care services, difficulties with self-management of chronic diseases, and inadequate health status of populations [4]. Increasing scientific evidence demonstrates that those with low health literacy suffer from chronic non-communicable diseases in a higher proportion and show adverse health outcomes [5,6]. Since nutrition is a major fundamental factor in developing and treating type 2 diabetes mellitus, high blood pressure, hyperlipidemia, and obesity, reduced food literacy (FL) can be particularly alarming. Improved HL and FL have been shown to result in diets that are both healthier and of higher quality [7,8]. Similarly, diets of higher quality have been linked to a lower risk of developing chronic diseases related to diet [9]. Preventing these diseases in any population requires understanding and applying nutritional knowledge, referred to as the nutritional awareness [10].

Although eating habits are multifactorial, FL represents an important determining factor [11,12]. FL, an integral component of health literacy (HL), is a collection of interrelated knowledge, skills, and behaviours critical for a healthy diet. Specifically, FL encompasses the four domains of planning, managing, selecting, preparing, and eating, providing a framework for understanding and influencing dietary behaviours. Existing FL interventions are highly varied in nature, targeting different groups, implementing various strategies, and assessing different FL domains [13]. Given the broad cultural, social, and economic factors that shape food and diet choices, such interventions must be carefully tailored to specific population groups [14,15]. In addition to this demographic diversity, successful interventions must account for the diverse dietary needs across different developmental stages of a person's lifespan [16]. Within this context, FL involves more than just acquiring specific skills. It requires understanding the health-related consequences, such as overweight and obesity, and developing effective learning mechanisms, such as information seeking and professional support. This comprehensive view of FL implies that these factors are not merely part of FL's definition but are influential elements that are both affected by and can influence FL [17]. Although the significance of FL is increasingly recognised, research on FL in Europe, including Romania, is scarce [18]. There is a critical need for evidence-based research providing a comprehensive understanding of FL's domains, determinants, and influential factors. Such research could help develop effective food-related knowledge, behaviours, skills, and systems [17].

Previous research typically focused on the associations between dietary behaviours, HL, FL, and quality of life in populations with certain chronic conditions [19–24]. A systematic review from 2018 evaluated the association between health literacy and adherence to dietary recommendations [25]. It produced mixed results, with only five out of eleven associations between health literacy and eating practices being significant and direct. The authors suggested that research on how health literacy relates to dietary adherence is limited, and further studies on the subject should be conducted. Adhering to dietary guidelines is linked to improved health outcomes. Therefore, people are encouraged to improve their diet by reducing their consumption of certain foods and increasing their consumption of healthy options such as fruits and vegetables [26].

In this regard, little is known about FL and dietary behaviours in Romania. There is a strong need for more accurate data and effective nutrition programs in Romania, a country still facing problems of undernutrition and in which issues associated with food overconsumption and diet-related non-communicable diseases are on the rise [27–29]. Recent statistics indicate that 57,7% of Romanians are overweight or obese [30]. Currently, the major causes of death in Romania are diet-related non-communicable diseases, such as cardiovascular diseases, stroke, cancer, and type 2 diabetes [31].

The purpose of this study is to examine the relationships between sociodemographic characteristics, HL, self-reported health and morbidity, and non-adherence to dietary recommendations and FL concepts (the connection between health and nutrition and nutrition information seeking) of a representative sample from the North-Western region of Romania. The results of this study could support the design of public health services in Romania by targeting specific groups that could benefit from food literacy programs and reaching those with inadequate food literacy-related abilities and dietary intake.

2. Materials and Methods

2.1. Study Design

We performed a secondary analysis on cross-sectional data gathered for the project named "Evaluating and enhancing the population's knowledge in the North-West region of Romania regarding soy product types and the influence of nutrition on health." The data set comprises information from 1715 participants residing in five counties within the North-Western region of Romania. This region covers 2 million individuals and is divided into five counties, which include 35 urban and 340 rural communities. A representative stratified random sample from this region was selected using a systematic random sampling method.

A proportional number of households were systematically randomly selected according to the size of urban and rural areas from the Romanian counties of Bihor, Sălaj, Bistrița-Năsăud, Maramureș, and Cluj. In the five regions, 15 urban and 28 rural communities were selected, then polling sites, and then the starting streets at each polling site. After the initial starting point, every fifth address was selected to which one questionnaire was filled out until the required questionnaires were collected for that starting place. Thus, 1715 households were included in this study between March and November 2019. The survey questions were read by trained field technicians who completed the questionnaire using the Survey Monkey platform on mobile devices, ensuring consistent administration. The eligibility criteria for participants were: 18 years or above, Romanian residency and language, no clear sign of psychological or learning disabilities, and willingness to answer the survey. Additionally, data obtained from 143 participants were excluded from the current analysis due to incomplete responses regarding dietary intake, health literacy, and food literacy domains.

2.2. Questionnaire

The questionnaire is part of a more extensive study that assessed general and sociodemographic characteristics of the sample, questions regarding self-rated health and morbidity, dietary behaviour, health literacy, food literacy concepts, interest in healthy eating, perceptions of being informed regarding health aspects, the use and understanding of nutrition labels, and general notions about sugar and soy consumption. In this cross-sectional study, we utilised questions from previously validated questionnaires in other settings as the basis for our survey instrument. The items selected from previously developed instruments were methodically translated into Romanian and adapted following WHO guidelines, involving steps like translation, expert panel review, back-translation, pre-testing, cognitive debriefing, and final consensus [32]. The current study presents adherence to dietary recommendations and FL concepts in relation to sociodemographic characteristics, health literacy and self-reported health features. The general and sociodemographic questions include gender, residence, age, educational attainment, job status, marital status, and parental status. The questionnaire was pilot tested on a convenience sample of 100 persons for content validity, comprehensiveness, and reliability before data collection started.

2.3. Measures

2.3.1. Adherence to Dietary Recommendations

Participants reported their food consumption behaviour using a food frequency questionnaire comprising 18 variables that measured their consumption of starchy products, fruits, nuts and seeds, vegetables, milk and dairy products, meat, fish and seafood, eggs, oil and fats, and water. The initial question, "How often do you eat the following foods?", queried participants about the frequency of their regular consumption of each food group in the last month individually (7-point scale: "more than six times a day", "2–5 times a day", "once a day", "3–5 times a week", "1–2 times per week", "2–3 times a month", and "never/less than once a month"). The instrument was based on pre-existing validated food frequency questionnaires adapted and translated for the study [33,34]. During the administration of the food frequency questionnaires, the field technicians presented examples of portion sizes for each food group. These portion sizes were based on the Food-Based Dietary Guidelines reported by the Romanian Nutrition Society [35]. The technicians provided visual references to assist participants in accurately estimating their food portion sizes for each specific food group. In the pilot phase of the study, the internal consistency of the questionnaire, as assessed by Cronbach's alpha, was found to be high ($\alpha = 0.917$), indicating strong reliability of the instrument for our sample. For our analysis, we used the National Food-Based Dietary Guidelines [35] to compute the variables of adherence to fruit and vegetables, fish and seafood, and water recommendations. For the number of fruit and vegetable servings a day, the recommended cut-off was more than five times a day. The

fish and seafood intake had a cut-off of more than 1–2 times per week, and the cut-off for water intake was more than six glasses per day.

2.3.2. Food Literacy Concepts

The basis for our survey instrument was the Short Food Literacy Questionnaire (SFLQ) for adults, a validated questionnaire for measuring food literacy in an adult population developed by Krause et al. [36]. We adapted and translated three questions from the SFLQ that were most relevant to the aim of the study, namely: (1) "When I have questions on healthy nutrition, I know where I can find information on this issue"; (2) "How easy is it for you to evaluate the longer-term impact of your dietary habits on your health?"; (3) "How easy is it for you to evaluate if a specific food is relevant for a healthy diet?". The first question measures the ability to acquire information about food, food preparation, and the influence of nutrition on health (functional food literacy). The last two questions evaluate critical food literacy domains: (2) the ability to understand the connection between nutrition and health, (3) to assess whether a food contributes to healthy nutrition and to distinguish between healthy and less healthy options, (4) to determine if a food contributes to healthy nutrition. The responses were measured on a Likert scale from 1 ("very difficult") to 4 ("very easy"). For our analysis, the questions were dichotomised into "difficult" (scored 1) and "easy" (scored 0). During the pilot study phase, the three items were administered, demonstrating satisfactory internal consistency as evidenced by a Cronbach's alpha of 0.769.

2.3.3. Health Literacy

Health literacy was assessed using the Romanian version of the European Health Literacy Survey Questionnaire, a short version with 16 items (HLS-EU-Q16). A separate article was previously published containing the results on the validation of the HLS-EU-Q16 questionnaire and exploring HL predictors in this sample from the North-Western region of Romania [37]. The questionnaire demonstrated good internal consistency during pretesting with a Cronbach's alpha of 0.813. In the current data analysis of the HLS-EU-Q16 questionnaire, the total scores obtained were treated as continuous data.

2.3.4. Self-Perceived General Health and Morbidity

Self-perceived general health and morbidity were assessed using translated questions from the European Health Interview Survey [38]: (1) "How is your health in general?", which was rated on a 5-point Likert scale from 1 = very good to 5 = very bad, and (2) "Do you have any longstanding illness or health problem? [By longstanding, I mean illnesses or health problems that have lasted, or are expected to last, for six months or more.]" with the following response possibilities "Yes, more than one," "Yes, one longstanding illness," and "No". These were recoded as moderate/good general health (1–3) and poor health (4–5) and, respectively, yes (1–2) and no (3). The two self-reported indicators represent reliable and valid instruments to measure health in general and ill health [39–42].

2.4. Statistical Analysis

All statistical analyses were performed using SPSS Software (version 29; MacOS). Data were reported as frequencies and percentages for categorical variables and as means and standard deviations for continuous variables. Univariate and multivariate logistic regression models were conducted to evaluate the relationship between dependent variables, including sociodemographic characteristics (gender, residence, age, educational attainment, job status, marital status, and parental status), self-reported health features (self-perceived general health and morbidity), and health literacy, and the independent variables, namely non-adherence to dietary recommendations and low self-rated food literacy abilities. A Pearson correlation analysis was conducted to examine the relationships between non-adherence to dietary recommendations, low self-rated food literacy domains, health literacy, and self-reported health and morbidity. The statistical significance threshold chosen was $p < 0.05$.

3. Results

3.1. Participant Profile

Out of 1715 participants who responded to the survey (response rate equal to 72.63%), 1572 participants were included in the current statistical analysis. We excluded respondents who did not answer questions regarding health literacy, food literacy, and items regarding food intake. The sociodemographic features of the participants are presented in Table 1. Most of the sample were females (62.0%), and most lived in rural areas (53.0%). The average age was 52.94 years (DS = 16.83). Regarding educational attainment, respondents' most common form of education was high school (44.5%), followed by university studies (21.0%). A small percentage of the sample (0.5%) had no formal education. Most of the sample was economically inactive, with 55.2% of participants identifying as students, on pension/social welfare, or homemakers. Most participants included in the study were married (68.6%) and reported having children (81.2%).

Table 1. Sample description (*n* = 1572).

Variables		*n*	%
Gender	Female	974	62.0
	Male	598	38.0
Age (years)	18–29	169	10.8
	30–39	199	12.7
	40–49	271	17.2
	50–59	307	19.5
	60–69	356	22.6
	70 years and older	270	17.2
Residence	Urban	736	46.8
	Rural	833	53.0
	Missing	3	0.2
Educational attainment	Without formal education	8	0.5
	Elementary school	70	4.5
	Middle school	257	16.3
	High school/Professional school	699	44.5
	Post-secondary school	155	9.9
	University	330	21.0
	Missing/Not wanting to respond	53	3.4
Job status	Worker	699	44.5
	Job-seeking unemployed	46	2.9
	Pension or on social welfare	675	42.9
	Student	61	3.9
	Homemaker	87	5.5
	Missing/Not wanting to respond	4	0.3
Parental status	Parent	1276	81.2
	Non-parent	296	18.8
Marital status	Currently married	1079	68.6
	Never married	203	12.9
	Widowed	226	14.4
	Separated or divorced	45	2.9
	Cohabiting	15	1.0
	Missing/Not wanting to respond	4	0.3

The levels of health literacy in the sample tested are considered unsatisfactory, with 42.9% of the participants having sufficient HL levels and only 16.3% having excellent health literacy levels. In our sample, most participants reported having moderate to good health (85.3%), with a smaller group reporting poor health (14.7%). Regarding

longstanding illnesses, a slight majority of participants (53.3%) indicated they did not have any. In contrast, nearly half of the participants (46.7%) reported having at least one longstanding illness.

3.2. Factors Associated with Non-Adherence to Dietary Recommendations

Table 2 shows factors associated with non-adherence to dietary guidelines for daily fruit and vegetable consumption, weekly fish and seafood consumption, and daily water consumption. The overall percentage of participants not adhering to more than five portions of fruit and vegetables per day was 83.5%. The level of non-adherence to the recommended amount of fruit and vegetables was significantly lower for participants unemployed and looking for a job (OR = 0.40, 95% CI: 0.20–0.80), those retired or on social welfare (OR = 0.53, 95% CI: 0.40–0.72), elderly (OR = 0.98, 95% CI: 0.98–0.99), and who self-reported living with at least one chronic condition (OR = 0.69, 95% CI: 0.53–0.91). The dietary recommendation for weekly fish and seafood consumption was not followed by 61.3% of the sample. There was a significant difference between non-adherence to the weekly recommended amount of fish and seafood intake and gender, residence, educational attainment, marital status, job status, and health literacy. Fish and seafood consumption was lower among rural residents (OR = 1.49, 95% CI: 1.22–1.83), individuals who did not complete secondary education (OR = 2.07, 95% CI: 1.58–2.70), who were formerly married (OR = 1.50, 95% CI: 1.14–1.96), who have retired or receive social welfare (OR = 1.34, 95% CI: 1.08–1.66), and students (OR = 2.13, 95% CI: 1.18–3.85). Non-adherence to fish and seafood dietary recommendations was negatively associated with a higher health literacy score (OR = 0.98, 95% CI: 0.96–0.99) and being male (OR = 0.75, 95% CI: 0.61–0.93). In the case of water consumption, 67.9% of the sample reported inadequate intake. There was a significant negative association between inadequate intake and the health literacy score (OR = 0.98, 95% CI: 0.96–0.99) and a positive association with older age (OR = 1.00, 95% CI: 1.00–1.01), low educational attainment (OR = 1.32, 95% CI: 1.01–1.72), and poor self-rated health (OR = 1.75, 95% CI: 1.26–2.43).

In the multivariable model of factors influencing dietary habits, specific variables were found to significantly affect the consumption of fruits and vegetables, fish and seafood, and water intake.

Employment status emerged as a key factor for those consuming fewer than 5 portions of fruit and vegetables per day. Those unemployed and searching for work were 61.8% less likely (aOR: 0.38, 95% CI: 0.18–0.78) to meet this consumption level compared to employed individuals. Similarly, retirees or those on social welfare were 52.4% less likely (aOR: 0.476, 95% CI: 0.30–0.74) to consume the recommended portions of fruits and vegetables.

In terms of fish and seafood consumption, place of residence and education level significantly influenced the likelihood of eating less than one portion per week. Residents of rural areas were 1.47 times more likely (aOR: 1.47, 95% CI: 1.18–1.82) to fall below this consumption level compared to their urban counterparts. Individuals who had not completed secondary education were 62% more likely (aOR: 1.62, 95% CI: 1.19–2.19) to consume less fish and seafood.

For those consuming less than 1.5 litres of water daily, self-reported health status and the presence of longstanding illness were critical. Individuals with poor health were 81.3% more likely (aOR: 1.81, 95% CI: 1.26–2.59) to consume less water. Conversely, those with at least one longstanding illness were 28.2% less likely (aOR: 0.71, 95% CI: 0.55–0.92) to fall short of this water consumption level.

Other factors such as gender, marital status, parental status, age, and health literacy did not exhibit significant associations in these multivariate models. While potentially impactful, they did not meet the statistical significance threshold in this analysis.

Table 2. Factors associated with non-adherence to dietary recommendations.

Variables		Fruit & Vegetables <5 Portions/Day		Fish & Seafood <1 Portion/Week		Water <1.5 Litters/Day	
		n **(%)**	**OR (95% CI)**	***n*** **(%)**	**OR (95% CI)**	***n*** **(%)**	**OR (95% CI)**
Gender	Female	804 (82.5)	Ref.	621 (63.8)	Ref.	662 (68.0)	Ref.
	Male	508 (84.9)	1.19 (0.90–1.57)	342 (57.2)	**0.75 (0.61–0.93)** **	406 (67.9)	0.99 (0.80, 1.24)
Residence	Urban	626 (85.1)	Ref.	413 (56.1)	Ref.	509 (69.2)	Ref.
	Rural	684 (82.1)	1.24 (0.94, 1.62)	547 (65.7)	**1.49 (1.22, 1.83)** ***	557 (66.9)	0.90 (0.72, 1.11)
Educational attainment	Finished high school	996 (84.1)	Ref.	677 (57.2)	Ref.	781 (66.0)	Ref.
	Not finished high school	269 (80.3)	1.30 (0.95, 1.77)	246 (73.4)	**2.07 (1.58, 2.70)** ***	241 (71.9)	**1.32 (1.01, 1.72)** *
Marital status	Married/Cohabiting	917 (83.8)	Ref.	643 (58.8)	Ref.	738 (67.5)	Ref.
	Never married	147 (85.0)	1.09 (0.69, 1.70)	112 (64.7)	1.28 (0.92, 1.79)	117 (67.6)	1.00 (0.71, 1.42)
	Formerly married	248 (81.3)	0.84 (0.60, 1.16)	208 (68.2)	**1.50 (1.14, 1.96)** ***	213 (69.8)	1.11 (0.84, 1.47)
Parental status	Non-parent	252 (83.1)	Ref.	185 (62.5)	Ref.	196 (66.2)	Ref.
	Parent	1060 (85.1)	0.85 (0.60, 1.21)	778 (61.0)	1.06 (0.82, 1.38)	872 (68.3)	0.90 (0.69, 1.18)
Labour Market status	Worker	612 (87.6)	Ref.	397 (56.8)	Ref.	461 (66.0)	Ref.
	Job-seeking unemployed	34 (73.9)	**0.40 (0.20, 0.80)** **	30 (65.2)	1.42 (0.76, 2.66)	35 (76.1)	1.64 (0.82, 3.29)
	Retired/Social welfare	534 (79.1)	**0.53 (0.40, 0.72)** ***	431 (63.9)	**1.34 (1.08, 1.66)** **	475 (70.4)	1.22 (0.97, 1.53)
	Student	56 (91.8)	1.59 (0.62, 4.08)	45 (73.8)	**2.13 (1.18, 3.85)** *	43 (70.5)	1.23 (0.69, 2.18)
	Homemaker	74 (85.1)	0.80 (0.43, 1.52)	57 (65.5)	1.44 (0.90, 2.30)	50 (57.5)	0.69 (0.44, 1.09)
Age	Years (continuous)	−3.25 (−1.02, −5.49)	**0.98 (0.98, 0.99)** **	0.69 (−1.01, 2.40)	1.00 (0.99, 1.00)	1.96 (0.18, 3.75)	**1.00 (1.00, 1.01)** *
Health Literacy	Score (continuous)	−0.14 (−0.73, 1.01)	0.99 (0.97–1.01)	−0.72 (−1.38, −0.05)	**0.98 (0.96, 0.99)** *	−0.80 (−1.49, −0.10)	**0.98 (0.96, 0.99)** *
Self-rated health	Moderate/Good	1125 (83.9)	Ref.	812 (60.6)	Ref.	889 (66.3)	Ref.
	Poor	187 (81.0)	0.81 (0.57–1.16)	151 (65.4)	1.23 (0.91–1.64)	179 (77.5)	**1.75 (1.26, 2.43)** ***
Longstanding illnesses	No	716 (85.7)	Ref.	514 (61.6)	Ref.	570 (68.3)	Ref.
	Yes	591 (80.7)	**0.69 (0.53–0.91)** **	447 (61.1)	1.02 (0.83–1.25)	493 (67.3)	0.95 (0.77, 1.18)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Bold font denotes statistical significance. Statistical test: univariate logistic regression. Abbreviations: CI = confidence interval; OR = odds ratio. For continuous variables, values are presented as mean difference (MD) with a 95% confidence interval (95% CI) instead of *n* (%).

3.3. Factors Associated with Poor Food Literacy-Related Abilities

The results of the evaluated food literacy concepts are more encouraging, with most participants reporting an adequate ability to understand the connection between nutrition and health (89.1%), to distinguish between healthy and less healthy options (84.4%), and to acquire information about nutrition (75.6%). Table 3 summarises the results concerning sociodemographic and health-related factors associated with food literacy.

An inadequate understanding of the connection between nutrition and health was positively associated with individuals living in a rural setting (OR = 1.60, 95% CI: 1.13–2.26) who had not finished secondary education (OR = 2.64, 95% CI: 1.85–3.75), with those formerly married compared to those currently married (OR = 1.68, 95% CI: 1.15–2.44), having children (OR = 1.86, 95% CI: 1.12–3.10), with those retired or on social welfare compared to employed (OR = 1.59, 95% CI:1.11–2.27), with older age (OR = 1.02, 95% CI: 1.01–1.03) and with poor self-rated health (OR = 1.59, 95% CI: 1.05–2.41). A higher health literacy score was negatively associated with a low understanding of the connection

between nutrition and health (OR = 0.84, 95% CI: 0.82–0.87), as well as with those who never married compared to coupled individuals (OR = 0.46, 95% CI: 0.22–0.98).

Table 3. Factors associated with low self-rated abilities regarding food literacy concepts.

Variables		Low Understanding of the Connection between Nutrition & Health		Low Ability to Distinguish between Healthy & Less Healthy Options		Low Ability to Acquire Information about Nutrition	
		n (%)	OR (95% CI)	*n* (%)	OR (95% CI)	*n* (%)	OR (95% CI)
Gender	Female	86 (8.9)	Ref.	118 (12.2)	Ref.	225 (23.1)	Ref.
	Male	69 (11.6)	1.35 (0.96, 1.89)	117 (19.6)	**1.76 (1.33, 2.32)** ***	144 (24.2)	1.05 (0.83, 1.34)
Residence	Urban	56 (7.6)	Ref.	123 (16.8)	Ref.	150 (20.4)	Ref.
	Rural	97 (11.7)	**1.60 (1.13, 2.26)** **	110 (13.2)	0.75 (0.57, 1.00)	217 (26.1)	**1.37 (1.08, 1.74)** **
Educational attainment	Finished high school	91 (7.7)	Ref.	166 (14.1)	Ref.	221 (18.7)	Ref.
	Incomplete high school	60 (18.1)	**2.64 (1.85, 3.75)** ***	58 (17.4)	1.28 (0.92, 1.78)	128 (38.2)	**2.68 (2.06, 3.49)** ***
Marital status	Married/Cohabiting	102 (9.4)	Ref.	159 (14.6)	Ref.	232 (21.3)	Ref.
	Never married	8 (4.6)	**0.46 (0.22, 0.98)** *	25 (14.5)	0.98 (0.62, 1.56)	24 (13.9)	**0.59 (0.37–0.84)** *
	Formerly married	45 (14.8)	**1.68 (1.15, 2.44)** **	51 (16.7)	1.17 (0.83, 1.65)	113 (37.0)	**2.17 (1.65–2.86)** ***
Parental status	Non-parent	18 (6.1)	Ref.	35 (11.8)	Ref.	52 (17.6)	Ref.
	Parent	137 (10.8)	**1.86 (1.12, 3.10)** *	200 (15.7)	1.39 (0.94, 2.04)	317 (24.9)	**1.55 (1.12, 2.15)** **
Labor Market status	Worker	56 (8.0)	Ref.	95 (13.6)	Ref.	118 (17.0)	Ref.
	Job-seeking unemployed	7 (15.2)	2.05 (0.87, 4.78)	8 (17.4)	1.33 (0.60, 2.94)	10 (21.7)	1.36 (0.65, 2.81)
	Retired/social welfare	82 (12.2)	**1.59 (1.11, 2.27)** *	116 (17.2)	1.32 (0.98, 1.77)	214 (31.7)	**2.27 (1.76, 2.93)** ***
	Student	1 (1.6)	0.19 (0.02, 1.40)	7 (11.5)	0.82 (0.36, 1.85)	5 (8.2)	0.43 (0.17, 1.11)
	Homemaker	8 (9.2)	1.15 (0.53, 2.51)	9 (10.3)	0.73 (0.35, 1.50)	22 (25.3)	1.65 (0.98, 2.79)
Age	Years (continuous)	6.09 (3.31, 8.87)	**1.02 (1.01, 1.03)** ***	2.45 (0.12, 4.79)	**1.00 (1.00, 1.01)** *	8.11 (6.19, 10.04)	**1.03 (1.02, 1.03)** ***
Health Literacy	Score (continuous)	−6.48 (−7.52, −5.44)	**0.84 (0.82, 0.87)** ***	−4.52 (−5.41, −3.64)	**0.89 (0.87, 0.91)** ***	−5.74 (−6.45, −5.02)	**0.85 (0.83, 0.87)** ***
Self-rated health	Moderate/Good	123 (9.2)	Ref.	186 (13.9)	Ref.	270 (20.2)	Ref.
	Poor	32 (13.9)	**1.59 (1.05, 2.41)** *	49 (21.3)	**1.67 (1.18, 2.38)** **	99 (42.9)	**2.96 (2.21, 3.97)** ***
Longstanding illnesses	No	75 (9.0)	Ref.	116 (13.9)	Ref.	160 (19.2)	Ref.
	Yes	80 (11.0)	0.79 (0.57, 1.11)	119 (16.3)	0.83 (0.62, 1.09)	209 (28.7)	**1.69 (1.34, 2.14)** **

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Bold font denotes statistical significance. Statistical test: univariate logistic regression. Abbreviations: CI = confidence interval; OR = odds ratio. For continuous variables, values are presented as mean difference (MD) with a 95% confidence interval (95% CI) instead of *n* (%).

A low ability to distinguish between healthy and less healthy options was more frequent in men (OR = 1.76, 95% CI: 1.33–2.32), elderly (OR = 1.00, 95% CI: 1.00–1.01) and those with poor-self rated health (OR = 1.67, 95% CI: 1.18–2.38). High health literacy (OR = 0.89, 95% CI: 0.87–0.91) reported a negative association with a low ability to distinguish between healthy and less healthy options.

A low ability to acquire nutrition information was significantly more frequent in those of older age (OR = 1.03, 95% CI: 1.02–1.03), rural residence (OR = 1.37, 95% CI: 1.08–1.74), who had not finished high school (OR = 2.68, 95% CI:2.06–3.49), were formerly married (OR = 2.17, 95% CI: 1.65–2.86), have children (OR = 1.55, 95% CI: 1.12–2.15), and those who are retired or on social welfare compared to employed (OR= 2.27, 95% CI: 1.76–2.93). In terms of self-reported health features, living with at least one longstanding illness

(OR = 1.69, 95% CI: 1.34–2.14) and poor self-rated health (OR = 2.96, 95% CI: 2.21–3.97) were positively associated with a low ability to acquire nutrition information. Individuals with high health literacy (OR = 0.85, 95% CI: 0.83–0.87) and those who never married (OR = 0.59, 95% CI: 0.37–0.94) were more likely to self-report that they know where to obtain information on healthy nutrition.

In the multivariate model for assessing factors associated with a low understanding of nutrition and health, a low ability to distinguish between healthy and less healthy options, and a low ability to acquire information about nutrition, several significant variables were identified across the three dependent variables.

Health literacy was the most prevalent, affecting all three dependent variables. Each unit increase in the scale significantly reduced the odds of low understanding of nutrition and health by 15% (aOR: 0.85, 95% CI: 0.82–0.88), low ability to distinguish between healthy and less healthy options by 11% (aOR: 0.89, 95% CI: 0.87–0.91), and low ability to acquire information about nutrition by 13% (aOR: 0.87, 95% CI: 0.84–0.89).

Being female was significantly associated with being 1.75 times more likely to have a low ability to distinguish between healthy and less healthy options (aOR: 1.75, 95% CI: 1.27–2.40). Residence in a rural area was associated with a 38% lower likelihood of having a low ability to distinguish between healthy and less healthy options (aOR: 0.62, 95% CI: 0.45–0.85).

The parental status also significantly affected the ability to distinguish between healthy and less healthy options, with parents being two times more likely to report a low ability (aOR: 1.94, 95% CI: 1.08–3.48).

Being separated, divorced, or widowed significantly increased the likelihood of having a low ability to acquire information about nutrition by 59% (aOR: 1.59, 95% CI: 1.12–2.26). Having poor health status was associated with an 82% higher likelihood of having a low ability to acquire nutrition information (aOR: 1.82, 95% CI: 1.26–2.62). Finally, each additional year of age increased the likelihood of having a low ability to acquire nutrition information by 1.5% (aOR: 1.015, 95% CI: 1.00–1.03).

The following variables did not show a statistically significant association with any of the three dependent variables: education level, employment status, and the existence of a medical condition.

3.4. The Association between Non-Adherence to Dietary Recommendations, Self-Reported Health Features, Health Literacy, and Food Literacy Concepts

A Pearson correlation examined the relationship between non-adherence to dietary recommendations, healthy literacy, self-reported health and morbidity, and low self-rating of food literacy abilities (Table 4). The relationship between low self-rating of abilities regarding food literacy was statistically significant, positive, and weak in strength between all domains, except for the ability to acquire nutrition information and distinguish healthy and less healthy options, which was moderate in power. Non-adherence to the dietary guidelines regarding the intake of fish and seafood products was positively associated with a low ability to acquire nutrition information. Inadequate hydration behaviour was positively associated with low trust in nutritional information from media, non-adherence to fruit and vegetable recommendations, as well as with fish and seafood intake recommendations. Poor self-rated health showed a significant positive correlation with low self-rating of three of the abilities regarding food literacy (except for trust in nutritional information from media) and low water intake. Living with a longstanding illness showed a significant positive correlation with poor self-rated health and a low ability to acquire information about nutrition, while a negative correlation with a low intake of fruit and vegetables. The relationship between health literacy and the other variables was statistically significant and negative, except for fruit and vegetable intake. The relationships of health literacy ranged from weak to moderate in strength for all the variables examined.

Table 4. Relationship between non-adherence to dietary recommendations, health-related aspects, and food literacy concepts.

Variables	*n* (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Low understanding of the connection between nutrition and health	155 (9.9)	1							
(2) Low ability to distinguish between healthy and less healthy options	235 (14.9)	**−0.257** **	1						
(3) Low ability to acquire information about nutrition	369 (23.5)	**0.199** **	**0.312** **	1					
(4) Intake of fruit and vegetables < 5 portions/day	1312 (83.5)	0.010	0.005	0.021	1				
(5) Intake of fish and seafood products < 1 portion/week	963 (61.3)	0.031	0.008	**0.093** **	0.008	1			
(6) Intake of water < 1.5 litters/day	1068 (67.9)	0.008	0.044	0.043	**0.109** **	**0.089** **	1		
(7) Health literacy score	49.68 (6.58)	**−0.271** **	**−0.234** **	**−0.361** **	−0.007	**0.053** *	**−0.067** *	1	
(8) Poor self-rated health	231 (14.7)	**0.056** *	**0.073** **	**0.189** **	−0.028	0.035	**0.085** **	**−0.174** **	1
(9) Living with a longstanding illness	732 (46.6)	0.034	0.033	**0.112** **	**−0.067** **	−0.005	−0.010	**−0.141** **	**0.345** **

* Correlation is significant at the 0.01 level (2-tailed), ** Correlation is significant at the 0.001 level (2-tailed). Bold font denotes statistical significance. Statistical test: Pearson correlation. For the health literacy score, values are presented as mean (M) with standard deviation (SD) instead of *n* (%).

4. Discussion

This study contributes to the existing knowledge by providing a comprehensive analysis of the relationship between food literacy, adherence to dietary recommendations, sociodemographic characteristics, and health-related features among adults in the North-Western region of Romania. The representative sample in our study is predominantly consistent with the data reported by the National Institute of Statistics in 2019, with the proportion of individuals living in urban (46.8%) and rural (53.0%) areas in our sample closely resembling that of the North-Western population in 2019 (52.41% urban and 47.59% rural). Similarly, when considering the economically active population in our sample (47.4%), the percentage is near the rate recorded for Romania in 2019 (47.6%). The economically inactive population in our sample (52.3%), with 42.9% being pensioners or social welfare recipients, aligns with the national statistics for the economically inactive population aged 15 and over (50.78%) and the average number of pensioners in 2019 (35.63%) [43].

Regarding dietary intake, the European Health Interview Survey findings showed that only 2% of the Romanian population eats at least five portions of fruit and vegetables daily [44,45]. This differs from the findings presented here, where the overall percentage of Romanian participants adhering to more than five portions of fruit and vegetables per day was 16.5%. In this study, we found that older individuals, those who are retired, receiving social welfare, or unemployed were less likely to deviate from the recommended fruit and vegetable dietary guidelines. This study brings new insights to the understanding of

fruit and vegetable consumption patterns among different sociodemographic groups in Romania. Our research shows that older individuals, those retired or on social welfare, and the unemployed were less likely to deviate from the recommended fruit and vegetable dietary guidelines. Interestingly, our findings contradict the notion of a clear socioeconomic and educational gradient in fruit and vegetable consumption often reported in the literature, which found lower consumption rates among the low-income-education groups compared to the high-income-education groups [46–49]. Contrary to several previous studies [49,50], we found no gender difference in fruit and vegetable intake in the Romanian sample. The discrepancy between these findings may be attributed to a variety of factors not fully explored in our study, such as cultural traditions, dietary habits, or the relative affordability and accessibility of fresh produce in Romania compared to other regions. This suggests that gender-related dietary habits may vary widely by geographical and cultural context, reinforcing the importance of local data in public health research and planning. This is a tendency in the north and west regions and has a reverse tendency in the south and east regions of Europe [51]. The current results seem consistent with other research, which found that in areas where the availability and affordability of fruits and vegetables are higher, lower socioeconomic categories tend to consume more fruits and vegetables than individuals with a higher socio-economical rank [51,52]. Roos et al. suggest that individuals from lower socioeconomic classes from the south and east European regions may have increased accessibility to more affordable vegetables and fruits and are more likely to grow or procure vegetables from non-commercial channels [51].

Another important finding was that 38.7% of the sample reported fish and seafood intake at least once per week. These results support previously published studies, which showed that between 39–41% of Romanians consume fish and seafood at least once per week [53]. Fish and seafood consumption was lower among men, those from rural settings, those who did not complete secondary education, were formerly married, retired, or on social welfare, and students. This is in accordance with previously published data, where higher socioeconomic status (e.g., higher income, higher educational attainment) is associated with higher fish consumption frequency [54,55]. This finding is consistent with previously reported data on fish and seafood consumption, which shows that women, compared to men, have a higher intake of fish [54,56–58]. Regarding water intake, only 32.1% of the sample consumed at least six glasses of water per day. Older individuals reported inadequate fluid intake more frequently. No previous data regarding water intake was recorded in Romania, although data is available for other European countries [59–61]. Earlier studies with data from European countries have demonstrated that the percentage of individuals with a markedly low fluid intake (<1500 mL) was found to be between 24–42% for women based on different age groups and between 33–43% for men, respectively [59]. The current findings align with previous research in demonstrating the interconnectedness of water intake with age, health literacy, educational attainment, and self-rated health. Our finding of a negative association between inadequate water intake and high health literacy scores is supported by previous studies [62,63], highlighting the critical role of health literacy in hydration, particularly among older adults. The positive association we found between inadequate water intake and older age aligns with previous work [64–66], which emphasises the decrease in water consumption and thirst sensation with advancing age.

Our results also suggest the influence of education level on water intake, reinforcing the idea that socioeconomic factors, including education, play a significant role in healthful behaviours, such as adequate hydration [65,67,68]. Finally, the positive association we found between inadequate water intake and poor self-rated health is supported by the literature [64,69], which suggests that low water consumption might coexist with other unhealthy behaviours and attitudes and is associated with poorer self-rated health status. Overall, the current study contributes to a growing body of evidence suggesting the need for a comprehensive approach to promoting adequate water intake, considering a variety of factors such as age, health literacy, education level, and self-rated health.

Existing knowledge about food literacy abilities and what influences them needs to be improved. This often leads to assumptions being made about the most suitable groups for targeted health programs [70]. This study sheds new light on these issues, offering a unique view into distinct food literacy abilities, dietary habits, and participants' demographic profiles that would benefit from a food and health literacy program in Romania. The findings on measuring health literacy in Romania indicated that gender and education demonstrated a positive association with health literacy, while age and self-reported health showed a negative association with health literacy [37]. Even though government programs often focus on the needs of low-income and disadvantaged populations [71,72], the insights from this study deepen our understanding of food literacy-related aspects, which could benefit a wider range of individuals.

Our study also explored the influence of various sociodemographic factors on food literacy-related abilities. It was noted that men reported a lower capacity to distinguish between healthy and less healthy options. This echoes the recommendation for tailoring food literacy programs to demographic factors such as gender [15]. This is consistent with findings by Lee, who observed that women generally exhibit more positive attitudes toward food and good eating habits, which was attributed to sociocultural factors and their traditionally assigned role in preparing and cooking food [73]. The research conducted by Krause et al. [36] and Sponslee et al. [74] corroborated that females display superior levels of food and health literacy compared to their male counterparts and are more likely to incorporate healthy dietary practices into their daily routines.

Further, we found that individuals from lower socioeconomic backgrounds, such as those without a high school diploma, retired or on social welfare, and formerly married, had a lower ability to understand the connection between nutrition and health and to acquire nutrition information. These findings align with previous research, which indicates that people with lower socioeconomic status have lower food literacy levels [15].

Other researchers employing representative samples from the population underscore that specific demographic groups—such as males, younger adults, and those with limited education—may yield more efficacious outcomes from cooking and food skills-focused programs [75,76]. The current results regarding the fact that older individuals and those that are retired or on social welfare had issues with the ability to understand the connection between nutrition and health, distinguish between healthy and less healthy options, and acquire information about nutrition, may be explained by the national economic and social development context, in which the growing number of retired individuals exceeded the number of employees in the economy. The current social system for older people needs to provide a decent household income. Older persons from Romania are the social category subjected to the highest injustices in the market economy [77,78].

Our findings are in line with a study which investigated nutrition information-seeking behaviour in five European countries, and reported notable disparities in seeking nutrition information. It is primarily men, individuals with low levels of education, low income, and poor health among the surveyed populations who profess not to seek nutritional information actively. As such, these population groups should be prioritised for targeted nutrition information education [79]. A recent study further analysed the segmentation of consumers based on nutrition information-seeking behaviour, and, in the study, a category of consumers termed 'uninterested consumers' was characterised by a low level of food literacy, a tendency to prioritise cost over nutrition, and a marked difficulty in engagement. Predominantly older males with the least education and food literacy among the groups studied made up this category. These individuals tended to value the affordability of food more than its nutritional content, resulting in a lower frequency of consumption of healthful foods. The findings highlight the ineffectiveness of merely providing information to this group, emphasising the necessity for a more nuanced approach [80]. When examining the eating habits of Romanian, a previous study found that they tend to adopt unhealthy eating habits, consuming foods high in saturated fats, sugar, and additives [29]. These habits reflect the influence of highly industrialized societies and the prevalence of unbalanced

food products. However, there is a positive trend emerging among Romanian consumers towards healthier and more sustainable food options, characterised by a preference for foods with a low degree of processing. Our study contributes by adding context to the need for tailored food literacy programs and targeted nutrition information education for specific population groups.

Individuals with poor self-rated health and inadequate health literacy reported low food literacy levels, reaffirming that insufficient health literacy can be a barrier to understanding nutrition and healthy food practices [17,81]. Living with a longstanding illness was positively correlated with poor self-rated health and a low ability to acquire nutritional information in our sample. This aligns with previous research that suggests healthy individuals tend to have higher health and food literacy levels than individuals with chronic diseases. This underlines the importance of health and food literacy in disease self-management and indicates a potential area of intervention for improving health outcomes [79].

This study was a comprehensive cross-sectional study with large sample size. However, due to this design, the findings should be interpreted cautiously regarding temporality or causation. The sample was randomly selected, so it is representative of the North-Western region of Romania. However, not all participants approached desired to be part of the study, which might represent self-selection bias, even with the control measures in place such as randomised polling sites, streets and using a specific data collection pace. It is possible that individuals who did not complete the evaluation were from culturally and linguistically diverse groups who were possibly the least health and nutrition literate in a Romanian context.

The overrepresentation of women in the study sample, potentially due to the timing of data collection during working hours, may have introduced some bias. Despite this, our sample is not drastically misaligned with the general population of the North Western region of Romania, where women made up 51.70% in 2019, according to the National Institute of Statistics [43]. Nonetheless, the potential overrepresentation of women might slightly skew the reflection of the targeted population in this study. While the data collection period (March to November 2019) was designed to minimise the impact of potential seasonal variation in diet, we acknowledge that the possibility of seasonal effects on dietary habits cannot be completely excluded. In addition, this study examined multiple factors affecting healthy nutrition behaviours, attitudes, and knowledge. Considering that the data was self-reported and obtained using subjective questionnaires, it may be subject to a social desirability bias. It might reflect self-confidence rather than actual abilities and knowledge. The findings about adherence to dietary guidelines and food literacy-related skills were only partially comprehensive due to constraints such as the extensive length of the questionnaire, cognitive load, and reading level considerations, which could potentially burden respondents. The questions that were incorporated were deemed significant for this population based on a review of the limited existing literature on the subject and the consensus of the research team. Therefore, future studies are suggested to obtain more information, including the exploration of more food literacy domains and determinants that still need to be tested (e.g., disease and anthropometric data).

Within the field of public health nutrition in Romania, this study contributes to the limited body of research in the field and highlights a deeper understanding of the importance of improving healthy eating behaviours and abilities in disadvantaged Romanians. These results are important to governmental authorities leading public health and health professional organisations for the development of effective nutrition programs and strategies for addressing specific needs. Public health nutrition campaigns and educational programs may aim to improve consumers' abilities regarding healthy eating to positively influence their health literacy and knowledge, adherence to dietary recommendations, and general health. The success of different approaches and tools that may be used to educate consumers about the consequences of their dietary choices for their health depends on the consumers' interests in healthy eating and favourable attitudes towards these concepts.

Educating consumers about the consequences of their dietary choices for their health may raise awareness and interest in health and improve the subjective significance of this issue when making food choices.

5. Conclusions

The present research aimed to examine adherence to dietary recommendations, food literacy-related abilities, and their determinants in a representative sample from a region in Romania. These aspects need to be adequately investigated in Romania and Eastern Europe. The results indicate an independent association with health literacy, self-rated health, dietary behaviour, and food literacy. Socioeconomic inequalities (lower education attainment, individuals living in rural areas, older age categories, and job status) play a significant role in dietary behaviours and food literacy. Recognising and addressing problems of low food literacy abilities and non-adherence to dietary recommendations in participants could facilitate the reduction of possible long-term negative health outcomes.

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Informed Consent Statement: The participants were informed on how their data will be processed prior to completing the survey and provided their written consent.

Data Availability Statement: The data that support the findings of this study are available from Babeș-Bolyai University. Data are available from the authors with the permission of Babeș-Bolyai University.

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References

1. Popkin, B.M. Global nutrition dynamics: The world is shifting rapidly toward a diet linked with noncommunicable diseases. *Am. J. Clin. Nutr.* **2006**, *84*, 289–298. [CrossRef] [PubMed]
2. World Health Organization. *Global Nutrition Policy Review 2016–2017: Country Progress in Creating Enabling Policy Environments for Promoting Healthy Diets and Nutrition*; World Health Organization: Geneva, Switzerland, 2018; p. 156.
3. World Health Organization Regional Office for Europe. *Better Food and Nutrition in Europe: A Progress Report Monitoring Policy Implementation in the WHO European Region*; World Health Organization Regional Office for Europe: Copenhagen, Denmark, 2018.
4. Gibbs, H.D.; Ellerbeck, E.F.; Gajewski, B.; Zhang, C.; Sullivan, D.K. The Nutrition Literacy Assessment Instrument is a Valid and Reliable Measure of Nutrition Literacy in Adults with Chronic Disease. *J. Nutr. Educ. Behav.* **2018**, *50*, 247–257.e241. [CrossRef] [PubMed]

5. Malloy-Weir, L.; Cooper, M. Health literacy, literacy, numeracy and nutrition label understanding and use: A scoping review of the literature. *J. Hum. Nutr. Diet* **2017**, *30*, 309–325. [CrossRef]
6. Rosas, R.; Pimenta, F.; Leal, I.; Schwarzer, R. FOODLIT-PRO: Conceptual and empirical development of the food literacy wheel. *Int. J. Food Sci. Nutr.* **2021**, *72*, 99–111. [CrossRef] [PubMed]
7. Taylor, M.K.; Sullivan, D.K.; Ellerbeck, E.F.; Gajewski, B.J.; Gibbs, H.D. Nutrition literacy predicts adherence to healthy/unhealthy diet patterns in adults with a nutrition-related chronic condition. *Public Health Nutr.* **2019**, *22*, 2157–2169. [CrossRef]
8. Vettori, V.; Lorini, C.; Milani, C.; Bonaccorsi, G. Towards the Implementation of a Conceptual Framework of Food and Nutrition Literacy: Providing Healthy Eating for the Population. *Int. J. Environ. Res. Public Health* **2019**, *16*, 5041. [CrossRef]
9. Reedy, J.; Krebs-Smith, S.M.; Miller, P.E.; Liese, A.D.; Kahle, L.L.; Park, Y.; Subar, A.F. Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. *J. Nutr.* **2014**, *144*, 881–889. [CrossRef]
10. Silk, K.J.; Sherry, J.; Winn, B.; Keesecker, N.; Horodynski, M.A.; Sayir, A. Increasing nutrition literacy: Testing the effectiveness of print, web site, and game modalities. *J. Nutr. Educ. Behav.* **2008**, *40*, 3–10. [CrossRef]
11. Yuen, E.Y.N.; Thomson, M.; Gardiner, H. Measuring Nutrition and Food Literacy in Adults: A Systematic Review and Appraisal of Existing Measurement Tools. *Health Lit. Res. Pract.* **2018**, *2*, e134–e160. [CrossRef]
12. Perez-Cueto, F.J.A. An Umbrella Review of Systematic Reviews on Food Choice and Nutrition Published between 2017 and-2019. *Nutrients* **2019**, *11*, 2398. [CrossRef]
13. Vidgen, H.A.; Gallegos, D. Defining food literacy and its components. *Appetite* **2014**, *76*, 50–59. [CrossRef] [PubMed]
14. Cullen, T.; Hatch, J.; Martin, W.; Higgins, J.W.; Sheppard, R. Food Literacy: Definition and Framework for Action. *Can. J. Diet Pract. Res.* **2015**, *76*, 140–145. [CrossRef] [PubMed]
15. Butcher, L.M.; Platts, J.R.; Le, N.; McIntosh, M.M.; Celenza, C.A.; Foulkes-Taylor, F. Can addressing food literacy across the life cycle improve the health of vulnerable populations? A case study approach. *Health Promot. J. Aust.* **2021**, *32* (Suppl. 1), 5–16. [CrossRef] [PubMed]
16. Begley, A. *Developing Food Literacy through the Health Sector in Food Literacy: Key Concepts for Health and Education*; Vidgen, H., Ed.; Taylor and Francis Ltd.: London, UK, 2016; p. 262.
17. Rosas, R.; Pimenta, F.; Leal, I.; Schwarzer, R. FOODLIT-PRO: Food Literacy Domains, Influential Factors and Determinants—A Qualitative Study. *Nutrients* **2019**, *12*, 88. [CrossRef]
18. Truman, E.; Lane, D.; Elliott, C. Defining food literacy: A scoping review. *Appetite* **2017**, *116*, 365–371. [CrossRef]
19. Aljefree, N.; Ahmed, F. Association between dietary pattern and risk of cardiovascular disease among adults in the Middle East and North Africa region: A systematic review. *Food Nutr. Res.* **2015**, *59*, 27486. [CrossRef]
20. Bonaccio, M.; Di Castelnuovo, A.; Bonanni, A.; Costanzo, S.; De Lucia, F.; Pounis, G.; Zito, F.; Donati, M.B.; de Gaetano, G.; Iacoviello, L.; et al. Adherence to a Mediterranean diet is associated with a better health-related quality of life: A possible role of high dietary antioxidant content. *BMJ Open* **2013**, *3*, e003003. [CrossRef]
21. El Ansari, W.; Suominen, S.; Berg-Beckhoff, G. Is Healthier Nutrition Behaviour Associated with Better Self-Reported Health and Less Health Complaints? Evidence from Turku, Finland. *Nutrients* **2015**, *7*, 8478–8490. [CrossRef]
22. Govindaraju, T.; Sahle, B.W.; McCaffrey, T.A.; McNeil, J.J.; Owen, A.J. Dietary Patterns and Quality of Life in Older Adults: A Systematic Review. *Nutrients* **2018**, *10*, 971. [CrossRef]
23. Burger, J.P.W.; de Brouwer, B.; IntHout, J.; Wahab, P.J.; Tummers, M.; Drenth, J.P.H. Systematic review with meta-analysis: Dietary adherence influences normalization of health-related quality of life in coeliac disease. *Clin. Nutr.* **2017**, *36*, 399–406. [CrossRef]
24. Kim, S.; Love, F.; Quistberg, D.A.; Shea, J.A. Association of health literacy with self-management behavior in patients with diabetes. *Diabetes Care* **2004**, *27*, 2980–2982. [CrossRef] [PubMed]
25. Carrara, A.; Schulz, P.J. The role of health literacy in predicting adherence to nutritional recommendations: A systematic review. *Patient Educ. Couns.* **2018**, *101*, 16–24. [CrossRef] [PubMed]
26. de Abreu, D.; Guessous, I.; Vaucher, J.; Preisig, M.; Waeber, G.; Vollenweider, P.; Marques-Vidal, P. Low compliance with dietary recommendations for food intake among adults. *Clin. Nutr.* **2013**, *32*, 783–788. [CrossRef] [PubMed]
27. Petrovici, D.A.; Ritson, C. Food consumption patterns in Romania. *Br. Food J.* **2000**, *102*, 290–308. [CrossRef]
28. Nastasescu, V.; Mititelu, M.; Stanciu, T.I.; Draganescu, D.; Grigore, N.D.; Udeanu, D.I.; Stanciu, G.; Neacsu, S.M.; Dinu-Pirvu, C.E.; Oprea, E.; et al. Food Habits and Lifestyle of Romanians in the Context of the COVID-19 Pandemic. *Nutrients* **2022**, *14*, 504. [CrossRef]
29. Voinea, L.; Vrânceanu, D.M.; Filip, A.; Popescu, D.V.; Negrea, T.M.; Dina, R. Research on Food Behavior in Romania from the Perspective of Supporting Healthy Eating Habits. *Sustainability* **2019**, *11*, 5255. [CrossRef]
30. World Health Organization Regional Office for Europe. *WHO European Regional Obesity Report 2022*; World Health Organization Regional Office for Europe: Copenhagen, Denmark, 2022.
31. European Commission Eurostat. Causes of Death Statistics—Statistics Explained. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Causes_of_death_statistics#Main_causes_of_death_by_country_in_2019 (accessed on 15 March 2023).
32. World Health Organization. *WHO Guidelines on Translation and Adaptation of Instruments*; WHO: Geneva, Switzerland, 2018.
33. Bredin, C.; Naimimohasses, S.; Norris, S.; Wright, C.; Hancock, N.; Hart, K.; Moore, J.B. Development and relative validation of a short food frequency questionnaire for assessing dietary intakes of non-alcoholic fatty liver disease patients. *Eur. J. Nutr.* **2020**, *59*, 571–580. [CrossRef]

34. Cleghorn, C.L.; Harrison, R.A.; Ransley, J.K.; Wilkinson, S.; Thomas, J.; Cade, J.E. Can a dietary quality score derived from a short-form FFQ assess dietary quality in UK adult population surveys? *Public Health Nutr.* **2016**, *19*, 2915–2923. [CrossRef]
35. Romanian Nutrition Society. *Ghid Pentru Alimentaţia Sănătoasă*; Performantica: Iași, Romania, 2006.
36. Grea Krause, C.; Beer-Borst, S.; Sommerhalder, K.; Hayoz, S.; Abel, T. A short food literacy questionnaire (SFLQ) for adults: Findings from a Swiss validation study. *Appetite* **2018**, *120*, 275–280. [CrossRef]
37. Coman, M.A.; Forray, A.I.; Van den Broucke, S.; Chereches, R.M. Measuring Health Literacy in Romania: Validation of the HLS-EU-Q16 Survey Questionnaire. *Int. J. Public Health* **2022**, *67*, 1604272. [CrossRef]
38. European Union. *European Health Interview Survey (EHIS Wave 2) Methodological Manual*; Publications Office of the European Union: Luxembourg, 2013.
39. Hintzpeter, B.; Finger, J.D.; Allen, J.; Kuhnert, R.; Seeling, S.; Thelen, J.; Lange, C. European Health Interview Survey (EHIS) 2—Background and study methodology. *J. Health Monit.* **2019**, *4*, 66–79. [CrossRef] [PubMed]
40. Cullati, S.; Bochatay, N.; Rossier, C.; Guessous, I.; Burton-Jeangros, C.; Courvoisier, D.S. Does the single-item self-rated health measure the same thing across different wordings? Construct validity study. *Qual. Life Res.* **2020**, *29*, 2593–2604. [CrossRef] [PubMed]
41. Mutz, J.; Lewis, C.M. Cross-classification between self-rated health and health status: Longitudinal analyses of all-cause mortality and leading causes of death in the UK. *Sci. Rep.* **2022**, *12*, 459. [CrossRef] [PubMed]
42. Van der Heyden, J.; De Bacquer, D.; Tafforeau, J.; Van Herck, K. Reliability and validity of a global question on self-reported chronic morbidity. *J. Public Health* **2014**, *22*, 371–380. [CrossRef]
43. The National Institute of Statistics—Romania. Social Statistics—TEMPO-Online. Available online: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table (accessed on 16 April 2023).
44. European Commission Eurostat. How Much Fruit and Vegetables Do You Eat Daily?—Products Eurostat News. Available online: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220104-1 (accessed on 16 April 2023).
45. European Commission Eurostat. Statistics. Available online: https://ec.europa.eu/eurostat/databrowser/view/hlth_ehis_fv3b/default/table?lang=en (accessed on 16 April 2023).
46. Stea, T.H.; Nordheim, O.; Bere, E.; Stornes, P.; Eikemo, T.A. Fruit and vegetable consumption in Europe according to gender, educational attainment and regional affiliation-A cross-sectional study in 21 European countries. *PLoS ONE* **2020**, *15*, e0232521. [CrossRef]
47. Azzolina, D.; Vedovelli, L.; Gallipoli, S.; French, M.; Ghidina, M.; Lamprecht, M.; Tsiountsioura, M.; Lorenzoni, G.; Gregori, D. Nutrients and Caloric Intake Associated with Fruits, Vegetables, and Legumes in the Elderly European Population. *Nutrients* **2020**, *12*, 2746. [CrossRef]
48. Azagba, S.; Sharaf, M.F. Disparities in the frequency of fruit and vegetable consumption by socio-demographic and lifestyle characteristics in Canada. *Nutr. J.* **2011**, *10*, 118. [CrossRef]
49. Irala-Estevez, J.D.; Groth, M.; Johansson, L.; Oltersdorf, U.; Prattala, R.; Martinez-Gonzalez, M.A. A systematic review of socio-economic differences in food habits in Europe: Consumption of fruit and vegetables. *Eur. J. Clin. Nutr.* **2000**, *54*, 706–714. [CrossRef]
50. Hoy, M.K.; Goldman, J.D.; Moshfegh, A.J. Differences in fruit and vegetable intake of U.S. adults by sociodemographic characteristics evaluated by two methods. *J. Food Compos. Anal.* **2017**, *64*, 97–103. [CrossRef]
51. Roos, G.; Johansson, L.; Kasmel, A.; Klumbiene, J.; Prattala, R. Disparities in vegetable and fruit consumption: European cases from the north to the south. *Public Health Nutr.* **2001**, *4*, 35–43. [CrossRef]
52. Prattala, R.; Hakala, S.; Roskam, A.J.; Roos, E.; Helmert, U.; Klumbiene, J.; Van Oyen, H.; Regidor, E.; Kunst, A.E. Association between educational level and vegetable use in nine European countries. *Public Health Nutr.* **2009**, *12*, 2174–2182. [CrossRef]
53. European Commission, Directorate-General for Maritime Affairs and Fisheries. *The EU Consumer Habits—Annex 1: Mapping and Analysis of Existing Studies on Consumer Habits*; European Union: Brussels, Belgium, 2016.
54. Pieniak, Z.; Verbeke, W.; Scholderer, J.; Brunsø, K.; Olsen, S.O. European consumers' use of and trust in information sources about fish. *Food Qual. Prefer.* **2007**, *18*, 1050–1063. [CrossRef]
55. Samoggia, A.; Castellini, A. Health-Orientation and Socio-Demographic Characteristics as Determinants of Fish Consumption. *J. Int. Food Agribus. Mark.* **2017**, *30*, 211–226. [CrossRef]
56. Verbeke, W.; Vackier, I. Individual determinants of fish consumption: Application of the theory of planned behaviour. *Appetite* **2005**, *44*, 67–82. [CrossRef]
57. Verbeke, W.; Vermeir, I.; Brunsø, K. Consumer evaluation of fish quality as basis for fish market segmentation. *Food Qual. Prefer.* **2007**, *18*, 651–661. [CrossRef]
58. Cardoso, C.; Lourenco, H.; Costa, S.; Goncalves, S.; Nunes, M.L. Survey into the seafood consumption preferences and patterns in the portuguese population. Gender and regional variability. *Appetite* **2013**, *64*, 20–31. [CrossRef]
59. Elmadfa, I.; Meyer, A.L. Patterns of drinking and eating across the European Union: Implications for hydration status. *Nutr. Rev.* **2015**, *73* (Suppl. 2), 141–147. [CrossRef]
60. European Commission. Intake of Drinking Water and Total Non-Alcoholic Beverage Intake | Knowledge for Policy. Available online: https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/defining-water-overview-4_en (accessed on 16 April 2023).

61. Malisova, O.; Athanasatou, A.; Pepa, A.; Husemann, M.; Domnik, K.; Braun, H.; Mora-Rodriguez, R.; Ortega, J.F.; Fernandez-Elias, V.E.; Kapsokefalou, M. Water Intake and Hydration Indices in Healthy European Adults: The European Hydration Research Study (EHRS). *Nutrients* **2016**, *8*, 204. [CrossRef] [PubMed]
62. Picetti, D.; Foster, S.; Pangle, A.K.; Schrader, A.; George, M.; Wei, J.Y.; Azhar, G. Hydration health literacy in the elderly. *Nutr. Healthy Aging* **2017**, *4*, 227–237. [CrossRef] [PubMed]
63. Saboga-Nunes, L.; Medeiros, M.; Bittlingmayer, U. Health literacy impact on nutrition status and water intake in children. *Eur. J. Public Health* **2020**, *30*, ckaa165.1244. [CrossRef]
64. Goodman, A.B.; Blanck, H.M.; Sherry, B.; Park, S.; Nebeling, L.; Yaroch, A.L. Behaviors and attitudes associated with low drinking water intake among US adults, Food Attitudes and Behaviors Survey, 2007. *Prev. Chronic Dis.* **2013**, *10*, 120248. [CrossRef] [PubMed]
65. Gazan, R.; Sondey, J.; Maillot, M.; Guelinckx, I.; Lluch, A. Drinking Water Intake Is Associated with Higher Diet Quality among French Adults. *Nutrients* **2016**, *8*, 689. [CrossRef] [PubMed]
66. Kim, J.; Yang, Y.J. Plain water intake of Korean adults according to life style, anthropometric and dietary characteristic: The Korea National Health and Nutrition Examination Surveys 2008–2010. *Nutr. Res. Pract.* **2014**, *8*, 580–588. [CrossRef]
67. Mellett, A.; Leddy, S.; Mullee, A. The barriers and facilitators contributing to water intake in adults. *Proc. Nutr. Soc.* **2022**, *81*, E102. [CrossRef]
68. Yang, M.; Chun, O.K. Consumptions of plain water, moisture in foods and beverages, and total water in relation to dietary micronutrient intakes and serum nutrient profiles among US adults. *Public Health Nutr.* **2015**, *18*, 1180–1186. [CrossRef]
69. Chang, L.-L.; Lin, Y.-C.; Lo, T.C.; Chen, M.-C.; Kuo, H.-W. Understanding the Lifestyle Correlates with Chronic Constipation and Self-Rated Health. *Food Nutr. Sci.* **2015**, *06*, 391–398. [CrossRef]
70. Begley, A.; Butcher, L.M.; Bobongie, V.; Dhaliwal, S.S. Identifying Participants Who Would Benefit the Most from an Adult Food-literacy Program. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1272. [CrossRef]
71. Pettigrew, S.; Biagioni, N.; Moore, S.; Pratt, I.S. Whetting disadvantaged adults' appetite for nutrition education. *Public Health Nutr.* **2017**, *20*, 2629–2635. [CrossRef]
72. Stormacq, C.; Wosinski, J.; Boillat, E.; Van den Broucke, S. Effects of health literacy interventions on health-related outcomes in socioeconomically disadvantaged adults living in the community: A systematic review. *JBI Evid. Synth.* **2020**, *18*, 1389–1469. [CrossRef]
73. Lee, Y.; Kim, T.; Jung, H. The Relationships between Food Literacy, Health Promotion Literacy and Healthy Eating Habits among Young Adults in South Korea. *Foods* **2022**, *11*, 2467. [CrossRef]
74. Sponselee, H.C.S.; Kroeze, W.; Poelman, M.P.; Renders, C.M.; Ball, K.; Steenhuis, I.H.M. Food and health promotion literacy among employees with a low and medium level of education in the Netherlands. *BMC Public Health* **2021**, *21*, 1273. [CrossRef] [PubMed]
75. McGowan, L.; Pot, G.K.; Stephen, A.M.; Lavelle, F.; Spence, M.; Raats, M.; Hollywood, L.; McDowell, D.; McCloat, A.; Mooney, E.; et al. The influence of socio-demographic, psychological and knowledge-related variables alongside perceived cooking and food skills abilities in the prediction of diet quality in adults: A nationally representative cross-sectional study. *Int. J. Behav. Nutr. Phys. Act.* **2016**, *13*, 111. [CrossRef] [PubMed]
76. Murakami, K.; Shinozaki, N.; Livingstone, M.B.E.; Yuan, X.; Tajima, R.; Matsumoto, M.; Masayasu, S.; Sasaki, S. Associations of food choice values and food literacy with overall diet quality: A nationwide cross-sectional study in Japanese adults. *Br. J. Nutr.* **2023**, 1–11. [CrossRef] [PubMed]
77. Precupetu, I.; Aartsen, M.; Vasile, M. Social Exclusion and Mental Wellbeing in Older Romanians. *Soc. Incl.* **2019**, *7*, 4–16. [CrossRef]
78. Pleșa, R. Aspects Related To The Socio-Economic Situation Of The Retired Persons In Romania. *Ann. Univ. Petroşani Econ.* **2010**, *10*, 257–266.
79. Niedzwiedzka, B.; Mazzocchi, M.; Aschemann-Witzel, J.; Gennaro, L.; Verbeke, W.; Traill, W.B. Determinants of information behaviour and information literacy related to healthy eating among Internet users in five European countries. *Inf. Res. Int. Electron. J.* **2014**, *19*, 15.
80. Wang, Y.; Wang, J.; Shen, Q. A Consumer Segmentation Study of Nutrition Information Seeking and Its Relation to Food Consumption in Beijing, China. *Foods* **2022**, *11*, 453. [CrossRef]
81. Rosas, R.; Pimenta, F.; Leal, I.; Schwarzer, R. FOODLIT-tool: Development and validation of the adaptable food literacy tool towards global sustainability within food systems. *Appetite* **2022**, *168*, 105658. [CrossRef] [PubMed]

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Socio-Demographic Factors Associated with Rural Residents' Dietary Diversity and Dietary Pattern: A Cross-Sectional Study in Pingnan, China

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Abstract: There is limited evidence regarding the factors correlated with dietary diversity (DD) and dietary pattern (DP) in rural residents of China. This study aims to identify the DD and DP of rural residents and their association with socio-demographic factors. A cross-sectional survey was conducted in Pingnan, China. The Food Frequency Questionnaire (FFQ) was applied to evaluate dietary intake. Latent class analysis (LCA) was used to identify patterns of six food varieties, including vegetables–fruits, red meat, aquatic products, eggs, milk, and beans–nuts. Generalized linear models and multiple logistic regression models were used to determine factors associated with the DD and DP. Three DPs were detected by LCA, namely "healthy" DP (47.94%), "traditional" DP (33.94%), and "meat/animal protein" DP (18.11%). Females exhibited lower DD ($\beta = -0.23$, $p = 0.003$) and were more likely to adhere to "traditional" DP (OR = 1.46, $p = 0.039$) and "meat/animal protein" DP (OR = 2.02, $p < 0.001$). Higher educational levels and annual household income (AHI) were positively associated with higher DD ($p < 0.05$) and less likely to have "traditional" DP and "meat/animal protein" DP ($p < 0.05$). Non-obese people exhibited higher DD ($\beta = 0.15$, $p = 0.020$) and were less likely to have "meat/animal protein" DP (OR = 0.59, $p = 0.001$). Our study reveals that females, those with lower educational levels and AHI, and obese people are more likely to have a lower DD and are more likely to adhere to "traditional" DP and "meat/animal protein" DP. The local, regional, and even national performance of specific diet-related health promotion measures and interventions must target these vulnerable populations to improve a healthier DD and DP.

Keywords: dietary diversity; dietary pattern; socio-demographic factors; rural residents

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1. Introduction

Dietary intake is well known as a significant determinant of health [1], and improving dietary patterns are likely to improve population morbidity and mortality [2]. According to previous work, dietary intake is a complicated behavior that cannot be reduced to consuming a single type of food [3]. Indeed, the types of food and their interactions hinder the investigation of the links between specific foods and diseases [4]. For this reason, the study needs to shift to dietary diversity (DD) and dietary pattern (DP) analysis to measure the multidimensional features of food intake. DD is known as the number of different food varieties consumed over a given reference period [5], and has been recommended as an indicator for evaluating the composition of the diet [6]. High DD scores have been strongly associated with better physical performance, lower mortality, and higher quality of life [7,8]. National and international dietary standards have largely acknowledged the

importance and value of DD [9]. Similarly, DPs reflect the interrelations among the different food varieties and provide a more accurate depiction of dietary behavior [4]. It fosters further research regarding single foods and nutritional guidelines due to providing the context for identifying specific food groups that are either protective or harmful [10]. A systematic review has shown that following healthier dietary patterns (DPs), such as the Mediterranean DP, can reduce the risk of mortality and non-fatal myocardial infarction in people [11]. However, socio-demographic factors have been shown to significantly influence food choices [12,13]. Therefore, it is crucial to identify determinants of DD and DP in the population and to explore whether they contribute to previously described socio-demographic differences in disease prevalence.

Several factors associated with DD and DP have been previously reported [14–16]. Previous studies have found significant associations between sex and DD or DP. Specifically, males are usually related to an unhealthy pattern, while overweight or obese females are more likely to experience food cravings and consume more foods [14,17]. Moreover, older adults typically make positive decisions concerning their nutrition and health and tend toward a healthier diet than younger people [18,19]. Additionally, socioeconomic factors such as education level, financial situation, and knowledge of a healthy diet also significantly influence DD and DP, mainly due to the lower intake of proteins, fruits, and vegetables [16,17,20]. Healthy foods, including protein-rich foods, are more expensive than foods high in saturated fat or carbohydrates [21]. From a public health perspective, understanding the related factors of high (low) DD and the (un) healthier DP for different groups of individuals will allow for improved diet policy and aid in health resource allocation [4]. Although relevant research is already assessing risk factors for DD and DP, some of these studies have been confined to susceptible groups for more specificity. Primarily, it is vital to acknowledge that mainland China has a large number of farmers, and rural areas are the most vulnerable areas and require special attention [22]. However, there is limited evidence regarding the factors correlated with DD and DP in rural residents.

With the rapid economic and social development, Chinese rural residents have changed the single-food diet in the past and are constantly moving towards a healthy diet. Nevertheless, a small number of foods consumed and an unreasonable single-food DP remain a big concern in many rural areas, particularly in underdeveloped areas [23]. Pingnan is an impoverished county in Fujian Province's inland and mountainous regions. The seventh national census, completed in 2021, recorded a number of 139,815 inhabitants living in Pingnan [24]. According to the Statistical Bulletin on National Economic and Social Development of Pingnan in 2022, the annual disposable income per capita was CNY 26,416 (equivalent to USD 3720 using an exchange rate of USD to CNY 1 to 7.10) [25]. Under the background of comprehensively promoting rural revitalization to achieve more effective and comprehensive health poverty alleviation strategies, the Adult Chronic Disease and Nutrition Surveillance were conducted in Pingnan by the Provincial Center for Disease Control and Prevention (CDC). Using data from this surveillance, this study aims to discover the DD and DP with the socio-demographic correlates for rural residents. The study's findings may provide the necessary scientific basis for the local and regional relevant government departments to develop or adjust more effective measures and strategies, as well as good health diet programs, to improve DD and DP in rural residents by targeting specific populations.

2. Materials and Methods

2.1. Study Design and Samples

The cross-sectional data were derived from the Adult Chronic Disease and Nutrition Surveillance in Pingnan, China, between June and August 2022. The questionnaire used in the survey was based on previous Nutrition and Health Surveys conducted in China, which can increase the reliability of the data. Detailed information about this survey was given in a report from China CDC [26]. This survey adopted a conversational design and a multistage systematic clustered random sampling design to select subjects with a good representative

sample. In the first stage, the number of inhabitants in different towns/villages were thoroughly investigated before sampling. According to the latest Pingnan census data, Pingnan is divided into 11 towns/villages. One of the towns was divided into six sampling units due to the large population to match with other towns/villages. A total of 16 towns/villages were included in the first-stage sampling, and the population distribution of each sampling unit was relatively balanced. The Probability Proportionate to Size (PPS) [26,27] sampling was adopted to select six towns/villages from 16 towns/villages. Then, three villages were randomly selected from each selected township by PPS, and a total of 18 villages were finally selected. If the population was too small, two or more villages situated next to each other were merged into one sampling unit. Next, each selected village was divided into several groups of villagers/residents according to the scale of about 60 households. Two groups of villagers/residents were randomly selected from each village by PPS, and a total of 36 groups of villagers/residents were used for this study. In the last stage, one target respondent aged 18 and over was sampled from 50 households per resident group using the Kish selection table method. There are ten households reserved for replacement. Overall, 1800 participants were included in the survey.

Inclusion criteria: participants who: (1) were aged 18 and over; (2) were residents or lived locally for over six months; (3) were conscious, without psychiatric problems/disorders; (4) were informed of the purpose of the study and willing to cooperate; (5) were able to complete the survey. The exclusion criteria were those unable to complete the questionnaire due to critical diseases or poor compliance and non-cooperation.

2.2. Data Collection

In our study, well-trained investigators fluent in the local dialect conducted face-to-face interviews using a standardized paper questionnaire to collect information on demographic characteristics and dietary intake. The demographic information includes gender, age, marital status, educational level, annual household income (AHI), smoking, drinking, waist circumference, hypertension, and diabetes. Age was further divided into three groups: 18–44 (younger people), 45–59 (middle-aged people), and over 60 (older adults). Marital status was grouped into married (married/cohabitating) and others (unmarried/widowed/divorced/separated). Educational level was classified into five groups: below primary school, primary school, junior high school, senior high school, and junior college or above. AHI was categorized into four groups: <12,000 yuan, $\geq$12,000 yuan and <19,999 yuan, $\geq$20,000 yuan and <59,999 yuan, and $\geq$60,000 yuan. Smoking was classified as current and non-current smoking (including never smoked and already quit smoke). Drinking was categorized as drinking (including drinking within 30 days and before 30 days) and non-drinking. Obesity assessed by abdominal obesity was defined as yes if a waist circumference of $\geq$90 cm for men and $\geq$85 cm for women in physical examination. Hypertension was defined as yes if answered as diagnosed with high blood pressure by a doctor in township health centers or community service centers, or medical institutions above the level. Diabetes was defined as yes if answered as diagnosed with diabetes by a doctor in township health centers or community service centers, or medical institutions above the level.

A variety of dietary intake in the past 12 months was surveyed by uniformly trained investigators using the Food Frequency Questionnaire (FFQ) to evaluate the dietary structure. FFQ are available in previous Adult Chronic Disease and Nutrition Surveillance Surveys with good reliability and validity [26,28]. Our study selected six food varieties: vegetables–fruits, red meat, aquatic products, eggs, milk, and beans–nuts. There are options for intake, yes or no, to ask about food frequency. The choice for yes was four optional responses "daily", "weekly", "monthly", and "yearly." Vegetables–fruits were defined as sufficient if answered daily/weekly and were coded as 1. If they responded to others, they were coded as 0. Red meat was defined as sufficient if answered daily and was coded as 1. If they responded to others, there were coded as 0. Aquatic products, eggs, milk, and beans–nuts were defined as sufficient if answered daily/weekly and were coded as 1. If

they responded to others, they were coded as 0. Finally, six food varieties were formed. DD was calculated by adding together these six food varieties. The DD ranged from zero (none of the six selected food varieties occurred) to six (all six selected food varieties occurred). A higher DD means more diversity and a wider variety of food intake.

2.3. Statistical Analysis

Data analysis consisted of four steps. Firstly, a descriptive analysis of the demographic characteristics, six selected food varieties, and DD was conducted with frequencies and proportions. Secondly, a Latent Class Analysis (LCA) was used in six food varieties to identify the DP of rural residents in Pingnan. Three DPs were identified. A high score indicates a high probability of sufficient food variety intake. Thirdly, the Chi-square test was performed to compare the demographic characteristics across the DD and DPs. Afterwards, generalized linear models were used to assess factors associated with the DD, and the coefficient (β) with associated 95% confidence interval (CI) and *p*-values were presented in the model. Finally, multiple logistic regression analysis was used to identify the influencing factors of different DPs, and odds ratios (ORs) as well as 95% confidence intervals (CIs) and *p*-values were calculated. The database was established and double-entered independently through Epidata 3.1 and analyzed in the Statistical Package for the Social Sciences (SPSS) version 25.0 (SPSS Inc., Chicago, IL, USA) and Mplus version 8.3, with a significance level of 0.05.

LCA is a methodological approach that explains population heterogeneity in the data by identifying underlying subgroups of individuals, thus allowing the examination of different DPs while dealing with the diverse nature of the population [29]. For the model evaluation, five model fit indexes were adopted: the Akaike Information Criterion (AIC) [30], the Bayesian Information Criterion (BIC) [31], the sample size adjusted Bayesian Information Criterion (ssaBIC) [32], Lo-Mendell-Rubin (LMR), Bootstrapped Likelihood Ratio Test (BLRT), and Entropy (higher value is preferred) [33]. For AIC, BIC, and ssaBIC, the lowest absolute values suggest an excellent model class [34]. With LMR and BLRT, a significant *p*-value indicates that the model is superior to the model with one less class [29]. Nonetheless, the final choice was based on the investigator's assessment of interpretable results [35]. This study chose the 3-class because of the lower AIC, BIC, and ssaBIC, higher entropy, and LMR-LRT and BLRT < 0.001.

3. Results

3.1. General Demographic Characteristics of the Study Participants

The general demographic characteristics of the study participants are shown in Table 1. A total of 1800 rural residents were included in the study, among whom 888 were males (49.33%), and 912 were females (50.67%). Participants were divided into age groups, 18–44 years, 45–59 years, and 60 years or older, accounting for 18.61%, 41.44%, and 39.95% of the total sample, respectively. Most respondents were married (86.44%) with a primary school education or lower (59.05%). Participants' AHI ranged from 20,000 to 59,999 yuan (43.61%) and 60,000 yuan or more (23.83%), accounting for most of the sample. Moreover, 29.06% of respondents reported smoking, 27.50% said drinking, 27.61% had obesity, 33.89% had hypertension, and 17.28% had diabetes.

Table 1. Demographic information for survey participants (n = 1800).

Variable		Participants	Constitutional Ratio (%)
Gender	Male	888	49.33
	Female	912	50.67

Table 1. *Cont.*

Variable		Participants	Constitutional Ratio (%)
Age (years)	18–44	335	18.61
	45–59	746	41.44
	≥60	719	39.95
Marital status	Married	1556	86.44
	Others	244	13.56
Educational level	Below primary school	534	29.66
	Primary school	529	29.39
	Junior high school	380	21.11
	Senior high school	194	10.78
	Junior college or above	163	9.06
AHI (CNY)	<12,000	234	13.00
	12,000–19,999	352	19.56
	20,000–59,999	785	43.61
	≥60,000	429	23.83
Smoking	Yes	523	29.06
	No	1277	70.94
Drinking	Yes	495	27.50
	No	1305	72.50
Obesity	Yes	497	27.61
	No	1303	72.39
Hypertension	Yes	610	33.89
	No	1190	66.11
Diabetes	Yes	311	17.28
	No	1489	82.72

Abbreviation: AHI = annual household income; CNY = China Yuan.

3.2. The Six Food Varieties and Dietary Diversity

Figure 1 shows the characteristics of percentages for food varieties. Of the six food varieties, participants who intake sufficient eggs, vegetables–fruits, aquatic products, and red meat presented high rates, with 90.83%, 79.72%, 73.33%, and 59.89%, respectively. In contrast, those who intake sufficient milk and beans–nuts presented low percentages, with 47.94% and 40.72%. Figure 2 illustrates the constitution ratio of the DD. Among those respondents, 18,55% had two or lower food varieties, 18.89% had three food varieties, 23.00% were four food varieties, 23.61% were five food varieties, and 16.16% reported six food varieties.

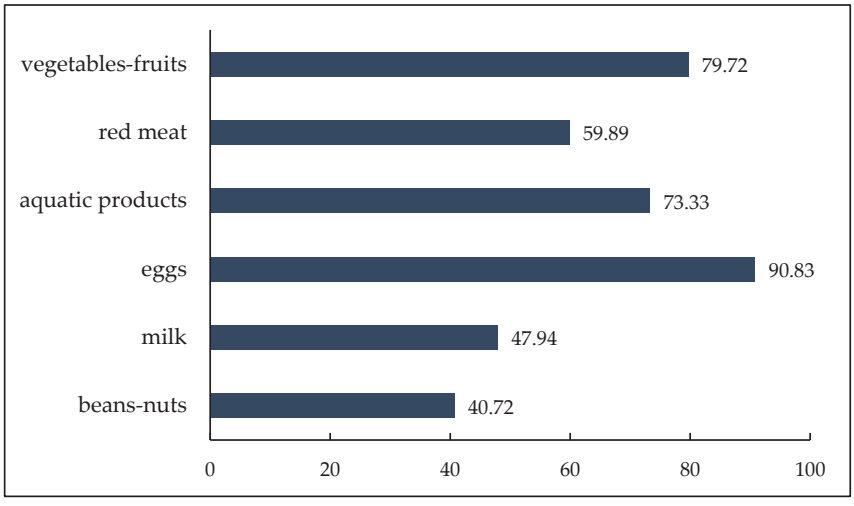

Figure 1. The percentage of six food varieties (%).

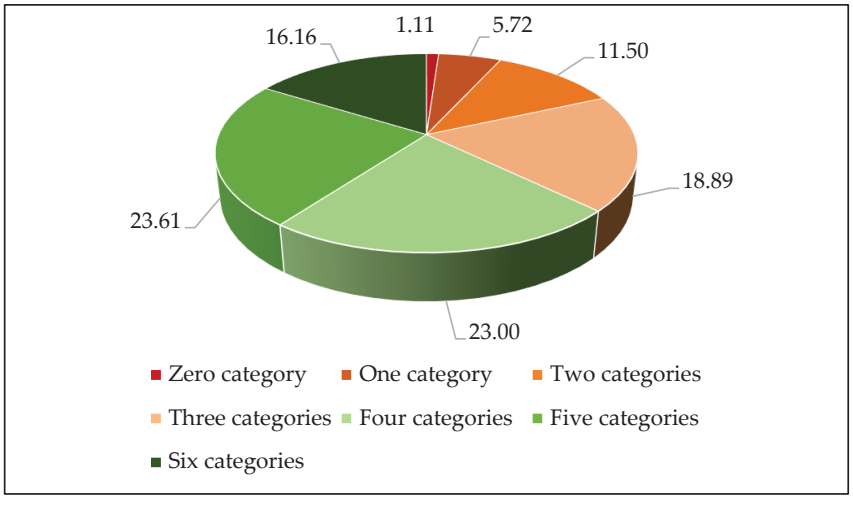

Figure 2. The constitution ratio for the dietary diversity (%). Note: Percentages may not add up to 100% due to rounding.

3.3. Latent Class Analysis of Dietary Patterns

Latent class models with 1–5 classes were estimated, as Table 2 showed. The 3-class solution was selected as the final model for this study because of the lower AIC, BIC, and ssaBIC, higher entropy, and LMR-LRT and BLRT < 0.001 (AIC: 11,462.201; BIC: 11,572.112; ssaBIC: 11,508.573, and entropy: 0.656). Finally, three DPs were detected. Figure 3 presents the estimated class-specific response probabilities, which show the three DPs among the 3-class solution, and the constitution ratio of each DP is illustrated in Figure 4. DP 1 was characterized by individuals with the highest probability of consuming the most food variety, including 47.94% of the samples. Compared to the other DPs, DP 1 can be characterized as a "healthy" DP. DP 2 accounted for one-third of the sample (33.94%). It included those with high probabilities for intake of vegetables–fruits, animal foods such as red meat, aquatic products, and eggs, low possibilities for sufficient milk, and beans–nuts.

DP 2 can be described as showing a "traditional" DP. DP 3 was characterized by individuals with a high probability of consuming animal foods such as red meat, aquatic products, and eggs, with low possibilities for sufficient vegetables–fruits, milk, and beans–nuts, including 18.11% of the samples. DP 3 can be labelled as the "meat/animal protein" DP compared to the other DPs.

Table 2. Latent class analysis model fit statistics.

Model	AIC	BIC	ssaBIC	LRT *p*-Value	BLRT *p*-Value	Entropy
1-class	12,367.612	12,400.585	12,381.524	-	-	-
2-class	11,525.404	11,596.846	11,555.546	<0.001	<0.001	0.633
3-class	11,462.201	11,572.112	11,508.573	<0.001	<0.001	0.656
4-class	11,438.537	11,586.916	11,501.139	0.004	<0.001	0.586
5-class	11,440.136	11,626.984	11,518.968	0.182	1.000	0.622

Abbreviation: AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, ssaBIC = sample size adjusted Bayesian Information Criterion, LRT = Lo–Mendell–Rubin likelihood ratio test, BLRT = Bootstrapped Likelihood Ratio Test.

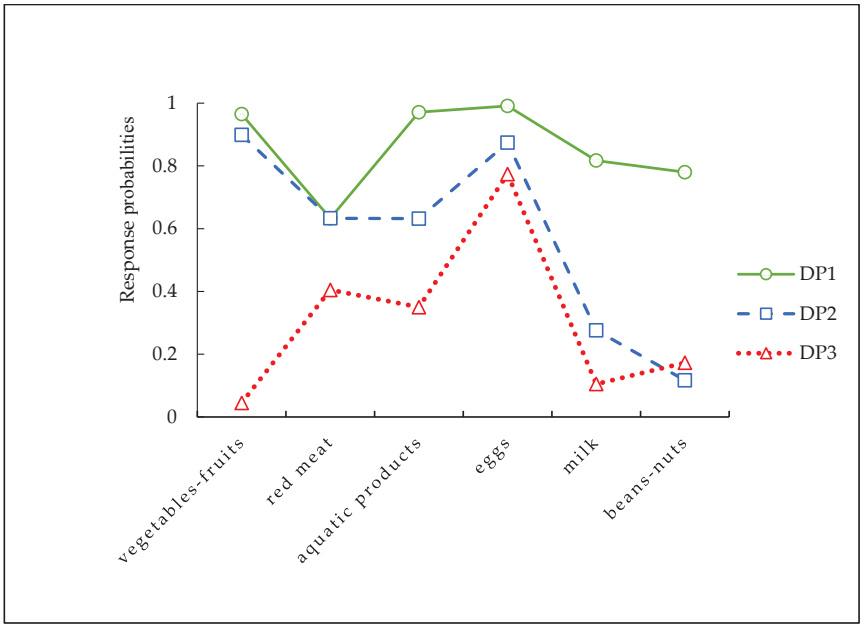

Figure 3. Estimated class-specific response probabilities for six food varieties. Note: A high score indicates a high probability of a sufficient food variety intake. Abbreviation: DP 1 = "healthy" dietary pattern, DP 2 = "traditional" dietary pattern, DP 3 = "meat/animal protein" dietary pattern.

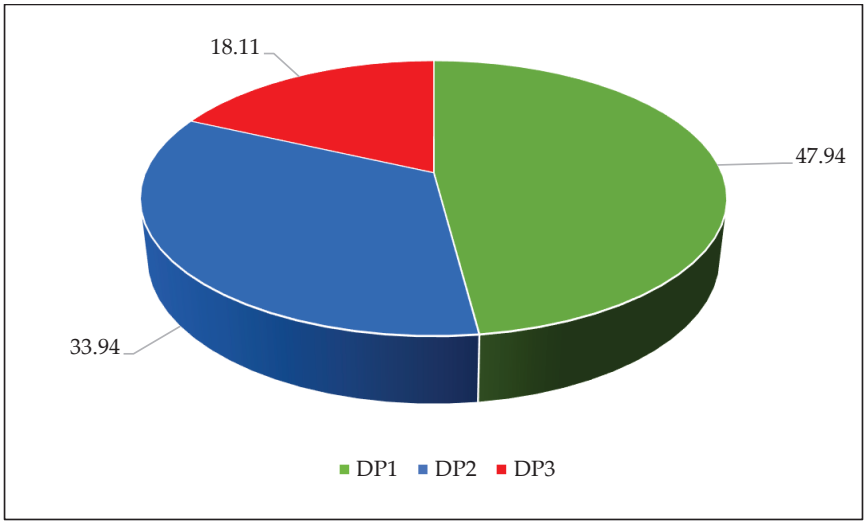

Figure 4. The constitution ratio for each dietary pattern. Abbreviation: DP 1 = "healthy" dietary pattern, DP 2 = "traditional" dietary pattern, DP 3 = "meat/animal protein" dietary pattern (%). Note: Percentages may not add up to 100% due to rounding.

3.4. Distribution of Demographic Information among Participants by the Dietary Diversity and by Dietary Patterns

The distribution of demographic information among participants by the DD is presented in Table 3. Chi-squared tests observed that gender (χ^2 = 16.059, p = 0.003), age (χ^2 = 106.496, $p < 0.001$), educational level (χ^2 = 279.110, $p < 0.001$), AHI (χ^2 = 180.460, $p < 0.001$), smoking status (χ^2 = 13.527, p = 0.009), obesity (χ^2 = 18.797, $p < 0.001$), and hypertension (χ^2 = 33.835, $p < 0.001$) were significantly associated with the DD. The distribution of demographic information among participants by DPs is presented in Table 4. Chi-squared tests illustrated that gender (χ^2 = 25.793, $p < 0.001$), age (χ^2 = 91.568, $p < 0.001$), educational level (χ^2 = 232.449, $p < 0.001$), AHI (χ^2 = 120.361, $p < 0.001$), smoking status (χ^2 = 21.174, $p < 0.001$), drinking status (χ^2 = 7.098, p = 0.029), obesity (χ^2 = 26.836, $p < 0.001$), and hypertension (χ^2 = 36.651, $p < 0.001$) were significantly associated with DPs.

Table 3. Distribution of demographic information among participants by the dietary diversity.

Variable	DD ≤ 2 (n = 330)	DD = 3 (n = 340)	DD = 4 (n = 414)	DD = 5 (n = 425)	DD = 6 (n = 291)
Gender (χ^2 = 16.059, p = 0.003)					
Male	170 (19.14)	175 (19.71)	227 (25.56)	197 (22.18)	119 (13.40)
Female	160 (17.54)	165 (18.09)	187 (20.50)	228 (25.00)	172 (18.86)
Age (years) (χ^2 = 106.496, $p < 0.001$)					
18–44	28 (8.36)	51 (15.22)	75 (22.39)	85 (25.37)	96 (28.66)
45–59	109 (14.61)	148 (19.84)	181 (24.26)	187 (25.07)	121 (16.22)
≥60	193 (26.84)	141 (19.61)	158 (21.97)	153 (21.28)	74 (10.29)
Marital status (χ^2 = 6.135, p = 0.189)					
Married	281 (18.06)	295 (18.96)	346 (22.24)	377 (24.23)	257 (16.52)
Others	49 (20.08)	45 (18.44)	68 (27.87)	48 (19.67)	34 (13.93)

Table 3. *Cont.*

Variable	DD ≤ 2 (n = 330)	DD = 3 (n = 340)	DD = 4 (n = 414)	DD = 5 (n = 425)	DD = 6 (n = 291)
Educational level (χ^2 = 279.110, p < 0.001)					
Below primary school	158 (29.59)	122 (22.85)	131 (24.53)	81 (15.17)	42 (7.87)
Primary school	116 (21.93)	118 (22.31)	127 (24.01)	104 (19.66)	64 (12.10)
Junior high school	43 (11.32)	66 (17.37)	97 (25.53)	109 (28.68)	65 (17.11)
Senior high school	11 (5.67)	26 (13.40)	31 (15.98)	67 (34.54)	59 (30.41)
Junior college or above	2 (1.23)	8 (4.91)	28 (17.18)	64 (39.26)	61 (37.42)
AHI (CNY) (χ^2 = 180.460, p < 0.001)					
<12,000	82 (35.04)	62 (26.50)	44 (18.80)	35 (14.96)	11 (4.70)
12,000–19,999	92 (26.14)	69 (19.60)	94 (26.70)	70 (19.89)	27 (7.67)
20,000–59,999	122 (15.54)	152 (19.36)	183 (23.31)	193 (24.59)	135 (17.20)
≥60,000	34 (7.93)	57 (13.29)	93 (21.68)	127 (29.60)	118 (27.51)
Smoking (χ^2 = 13.527, p = 0.009)					
Yes	105 (20.08)	112 (21.41)	128 (24.47)	116 (22.18)	62 (11.85)
No	225 (17.62)	228 (17.85)	286 (22.40)	309 (24.20)	229 (17.93)
Drinking (χ^2 = 3.392, p = 0.495)					
Yes	90 (18.39)	97 (18.62)	107 (23.52)	110 (24.14)	91 (15.33)
No	240 (18.18)	243 (19.60)	307 (21.62)	315 (22.22)	200 (18.38)
Obesity (χ^2 = 18.797, p < 0.001)					
Yes	119 (23.94)	100 (20.12)	106 (21.33)	108 (21.73)	64 (12.88)
No	211 (16.19)	240 (18.42)	308 (23.64)	317 (24.33)	227 (17.42)
Hypertension (χ^2 = 33.835, p < 0.001)					
Yes	148 (24.26)	119 (19.51)	146 (23.93)	127 (20.82)	70 (11.48)
No	182 (15.29)	221 (18.57)	268 (22.52)	298 (25.04)	221 (18.57)
Diabetes (χ^2 = 4.754, p = 0.314)					
Yes	63 (20.26)	67 (21.54)	66 (21.22)	74 (23.79)	41 (13.18)
No	267 (17.93)	273 (18.33)	348 (23.37)	351 (23.57)	250 (16.79)

Abbreviation: AHI = annual household income; CNY = China Yuan. DD = dietary diversity.

Table 4. Distribution of demographic information among participants by three dietary patterns.

Variable	DP 1 (n = 863)	DP 2 (n = 611)	DP 3 (n = 326)
Gender (χ^2 = 25.793, p < 0.001)			
Male	387 (43.58)	301 (33.90)	200 (22.52)
Female	476 (52.19)	310 (33.99)	126 (13.82)
Age (years) (χ^2 = 91.568, p < 0.001)			
18–44	212 (63.28)	103 (30.75)	20 (5.97)
45–59	371 (49.73)	262 (35.12)	113 (15.15)
≥60	280 (38.94)	246 (34.21)	193 (26.84)
Marital status (χ^2 = 0.851, p = 0.653)			
Married	751 (45.90)	528 (34.02)	277 (20.08)
Others	112 (48.26)	83 (33.93)	49 (17.80)
Educational level (χ^2 = 232.449, p < 0.001)			
Below primary school	161 (30.15)	229 (42.88)	144 (26.97)
Primary school	214 (40.45)	196 (37.05)	119 (22.50)
Junior high school	211 (55.53)	124 (32.63)	45 (11.84)
Senior high school	138 (71.13)	41 (21.13)	15 (7.73)
Junior college or above	139 (85.28)	21 (12.88)	3 (1.84)
AHI (CNY) (χ^2 = 120.361, p < 0.001)			
<12,000	68 (29.06)	93 (39.74)	73 (31.20)
12,000–19,999	126 (35.80)	149 (42.33)	77 (21.88)
20,000–59,999	386 (49.17)	270 (34.40)	129 (16.43)
≥60,000	283 (65.97)	99 (23.08)	47 (10.96)

Table 4. *Cont.*

Variable	DP 1 (n = 863)	DP 2 (n = 611)	DP 3 (n = 326)
Smoking (χ^2 = 21.174, p < 0.001)			
Yes	219 (41.87)	177 (33.84)	127 (24.28)
No	644 (50.43)	434 (33.99)	199 (15.58)
Drinking (χ^2 = 7.098, p = 0.029)			
Yes	234 (47.27)	153 (30.91)	108 (21.82)
No	629 (48.20)	458 (35.10)	218 (16.70)
Obesity (χ^2 = 26.836, p < 0.001)			
Yes	195 (39.24)	181 (36.42)	121 (24.35)
No	668 (51.27)	430 (33.00)	205 (15.73)
Hypertension (χ^2 = 36.651, p < 0.001)			
Yes	247 (40.49)	209 (34.26)	154 (25.25)
No	616 (51.76)	402 (33.78)	172 (14.45)
Diabetes (χ^2 = 1.895, p = 0.388)			
Yes	141 (45.34)	116 (37.30)	66 (21.22)
No	722 (48.49)	495 (33.24)	348 (23.37)

Abbreviation: AHI = annual household income; CNY = China Yuan. DP 1 = "healthy" dietary pattern, DP 2 = "traditional" dietary pattern, DP 3 = "meat/animal protein" dietary pattern.

3.5. Generalized Linear Regression Analysis of Factors Affecting the Dietary Diversity

As demonstrated in Table 5, generalized linear regression analysis was presented to study the factors associated with DD. Overall, the females (β = −0.23, 95% CI = −0.38 to −0.08, p = 0.003) exhibited lower DD compared with the males. According to the educational level group, individuals who had a primary school education (β = 0.23, 95% CI = 0.08 to 0.38, p = 0.003), junior high school education (β = 0.61, 95% CI = 0.43 to 0.78, p < 0.001), senior high school education (β = 0.92, 95% CI = 0.70 to 1.15, p < 0.001), and junior college or above (β = 1.17, 95% CI = 0.93 to 1.41, p < 0.001) exhibited higher DD than those below the primary school. Moreover, compared to participants' AHI of less than 12,000 yuan, those AHI ranging from 20,000 to 59,999 yuan (β = 0.43, 95% CI = 0.24 to 0.62, p < 0.001) and 60,000 yuan or more (β = 0.58, 95% CI = 0.37 to 0.80, p < 0.001) tended to have higher DD. Additionally, non-obese populations (β = 0.15, 95% CI = 0.02 to 0.29, p = 0.020) tended to have higher DD than obese populations.

Table 5. Generalized linear regression analysis of factors associated with the dietary diversity.

Variable	β (95%CI)	*p*
Gender (reference = Male)	-	-
Female	−0.23 (−0.38, −0.08)	0.003
Age (years) (reference = ≥60)	-	-
18–44	0.08 (−0.11, 0.26)	0.423
45–59	0.04 (−0.10, 0.17)	0.612
Marital status (reference = Married)	-	-
Others	0.04 (−0.13, 0.21)	0.641
Educational level (reference = Below primary school)	-	-
Primary school	0.23 (0.08, 0.38)	0.003
Junior high school	0.61 (0.43, 0.78)	<0.001
Senior high school	0.92 (0.70, 1.15)	<0.001
Junior college or above	1.17 (0.93, 1.41)	<0.001
AHI (CNY) (reference = <12,000)	-	-
12,000–19,999	0.15 (−0.05, 0.36)	0.149
20,000–59,999	0.43 (0.24, 0.62)	<0.001
≥60,000	0.58 (0.37, 0.80)	<0.001
Smoking (reference = Yes)	-	-
No	0.09 (−0.07, 0.25)	0.274
Drinking (reference = Yes)	-	-
No	0.04 (−0.11, 0.18)	0.608

Table 5. *Cont.*

Variable	β (95%CI)	*p*
Obesity (reference = Yes)	-	-
No	0.15 (0.02, 0.29)	0.020
Hypertension (reference = Yes)	-	-
No	0.12 (−0.01, 0.25)	0.073
Diabetes (reference = Yes)	-	-
No	−0.08 (−0.23, 0.08)	0.317

Abbreviation: AHI = annual household income; CNY = China Yuan.

3.6. Multiple Logistic Regression Analysis of Factors Affecting Dietary Patterns

Multiple logistic regression was used to explore the relationship between the demographic factors and three DPs (Table 6). Three DPs were used as dependent variables, and the DP 1 group was used as the reference group. Those factors were used as an independent variable to be added in the multiple logistic regression analysis. The results showed that females (DP 2: OR = 1.45, 95% CI = 1.08 to 1.94, $p = 0.014$, and DP 3: OR = 2.02, 95% CI = 1.39 to 2.94, $p < 0.001$) were more likely to develop DP 2 and DP 3 than males. Participants aged 18–44 years (DP 2: OR = 1.46, 95% CI = 1.02 to 2.10, $p = 0.039$, and DP 3: OR = 0.49, 95% CI = 0.28 to 0.86, $p = 0.013$) were more likely to have DP 2 and less likely to have DP 3, as compared with those who were 60 years or older. However, in terms of educational level, those with a primary school education (DP 2: OR = 0.63, 95% CI = 0.47 to 0.85, $p = 0.002$, and DP 3: OR = 0.65, 95% CI = 0.47 to 0.92, $p = 0.015$), a junior high school education (DP 2: OR = 0.38, 95% CI = 0.27 to 0.53, $p < 0.001$, and DP 3: OR = 0.28, 95% CI = 0.18 to 0.44, $p < 0.001$), a senior high school education (DP 2: OR = 0.22, 95% CI = 0.14 to 0.35, $p < 0.001$, and DP 3: OR = 0.19, 95% CI = 0.10 to 0.35, $p < 0.001$), and a junior college or above (DP 2: OR = 0.13, 95% CI = 0.07 to 0.22, $p < 0.001$, and DP 3: OR = 0.04, 95% CI = 0.01 to 0.14, $p < 0.001$) were less likely to experience DP 2 and DP 3 compared to those with a lower primary school education. When compared with those whose AHI was less than 12,000 yuan, respondents with an AHI ranged from 20,000 to 59,999 yuan (DP 2: OR = 0.69, 95% CI = 0.47 to 1.00, $p = 0.050$, and DP 3: OR = 0.54, 95% CI = 0.35 to 0.82, $p = 0.005$) and over 60,000 yuan (DP 2: OR = 0.45, 95% CI = 0.29 to 0.69, $p < 0.001$, and DP 3: OR = 0.41, 95% CI = 0.24 to 0.68, $p = 0.001$) were less likely to form DP 2 and DP 3. Compared to those obese populations, non-obese populations (OR = 0.59, 95% CI = 0.44 to 0.80, $p = 0.001$) were less likely to establish DP 3. Further, for those without hypertension diseases (OR = 0.71, 95% CI = 0.52 to 0.96, $p = 0.026$), a lower risk was discovered concerning DP 3. Significantly, as for individuals without diabetes disease (OR = 1.50, 95% CI = 1.03 to 2.19, $p = 0.035$), a higher risk was found concerning DP 3.

Table 6. Multiple logistic regression analysis comparing dietary pattern 2 and 3 to dietary pattern 1.

Variable	DP 2		DP 3	
	OR (95%CI)	*p*	OR (95%CI)	*p*
Gender (reference = Male)	-	-	-	-
Female	1.45 (1.08, 1.94)	0.014	2.02 (1.39, 2.94)	<0.001
Age (years) (reference = ≥60)	-	-	-	-
18–44	1.46 (1.02, 2.10)	0.039	0.49 (0.28, 0.86)	0.013
45–59	1.29 (0.98, 1.68)	0.065	0.77 (0.56, 1.07)	0.119
Marital status (reference = Married)	-	-	-	-
Others	0.91 (0.65, 1.27)	0.572	0.86 (0.57, 1.30)	0.474
Educational level (reference = Below primary school)	-	-	-	-
Primary school	0.63 (0.47, 0.85)	0.002	0.65 (0.47, 0.92)	0.015
Junior high school	0.38 (0.27, 0.53)	<0.001	0.28 (0.18, 0.44)	<0.001
Senior high school	0.22 (0.14, 0.35)	<0.001	0.19 (0.10, 0.35)	<0.001
Junior college or above	0.13 (0.07, 0.22)	<0.001	0.04 (0.01, 0.14)	<0.001

Table 6. *Cont.*

Variable	DP 2		DP 3	
	OR (95%CI)	*p*	OR (95%CI)	*p*
AHI (CNY) (reference = <12,000)	-	-	-	-
12,000–19,999	1.00 (0.67, 1.51)	0.990	0.78 (0.49, 1.25)	0.310
20,000–59,999	0.69 (0.47, 1.00)	0.050	0.54 (0.35, 0.82)	0.005
≥60,000	0.45 (0.29, 0.69)	<0.001	0.41 (0.24, 0.68)	0.001
Smoking (reference = Yes)	-	-	-	-
No	0.99 (0.72, 1.38)	0.976	0.84 (0.57, 1.23)	0.374
Drinking (reference = Yes)	-	-	-	-
No	1.05 (0.79, 1.40)	0.720	0.77 (0.55, 1.08)	0.130
Obesity (reference = Yes)	-	-	-	-
No	0.80 (0.62, 1.04)	0.095	0.59 (0.44, 0.80)	0.001
Hypertension (reference = Yes)	-	-	-	-
No	0.97 (0.75, 1.26)	0.842	0.71 (0.52, 0.96)	0.026
Diabetes (reference = Yes)	-	-	-	-
No	0.97 (0.72, 1.31)	0.861	1.50 (1.03, 2.19)	0.035

Abbreviation: AHI = annual household income; CNY = China Yuan. DP 2 = "traditional" dietary pattern, DP 3 = "meat/animal protein" dietary pattern.

4. Discussion

With significant consequences for public health, diet is a controllable risk factor that should be prioritized [1]. Encouraging a varied diet and a healthy DP could enhance the overall diet since both are equally pivotal links to healthy food and nutrient intake [4,6]. In comparison, rural residents' DD and DP are often underrepresented in food consumption studies. Understanding DD and DP among rural residents and the related factors to drivers of food choice is essential. It can support informing nutritional guidelines specific to rural resident groups and develop tailored interventions to encourage dietary improvement in the long term. Therefore, this study examined several socio-demographic factors concerning DD and DP in adults from Pingnan, China, and contributed significantly to our understanding of the key measures for enhancing rural residents' diets. This study adopted six food groups to calculate the total number of food varieties intake to assess DD. We used the method of LCA to determine the DPs in a representative sample and obtain three DPs: "healthy" DP (which included vegetables–fruit, red meat, aquatic products, egg, milk, beans–nuts), "traditional" DP (which included vegetables–fruit, red meat, aquatic products, egg), and "meat/animal protein" DP (which included red meat, aquatic products, egg). According to the study's findings, gender, educational level, AHI, and obesity were associated with DD; similarly, gender, age, educational level, AHI, obesity, hypertension, and diabetes were the correlated factors for the DPs.

Specifically, females were negatively correlated with the higher DD and more likely to develop the "traditional" DP and "meat/animal protein" DP than males, which is inconsistent with previous studies [18,36]. The survey in Poverty Areas of Northwest China found no significant difference between sex and DD [36]. Additionally, research has shown that females adhere more to healthy DPs than males [17,18]. Although, a study agrees that females in China will learn more dietary knowledge to promote a healthy diet for family members because they are primarily responsible for food preparation [22]. However, compared with males, females in rural areas generally tend to have subordinate status in the household and less access to primarily high-quality food [37]. In addition, no significant relationship between age and DD was found in our analysis, which was not congruent with a former study that showed that the younger aged group had lower DD than the older ones [38]. Interestingly, younger participants in our samples were more likely to have "traditional" DP than older adults, but "meat/animal protein" DP showed the reverse result. This finding is inconsistent with the previous studies showing the same point of view that older adults usually make positive decisions concerning their nutrition and follow healthier DP [19,38]. A possible reason is that, on the one hand, younger people skipped

meals more frequently, especially breakfast and night eating, and had fewer servings of dairy products, thus leading to worse DP throughout the day [18]. On the other hand, some older adults living in rural areas limited by the low economic conditions or living alone might spend less money on expensive food like fruits, dairy products, and nuts or purchase less food [16]. Therefore, public health nutrition interventions aiming to enhance dietary knowledge and improve diets should target the group of females, younger people, and older adults.

The findings of this study support a large body of research indicating higher socioeconomic status, including a high level of education and more AHI, substantially correlated with higher DD and healthier DP [9,16,17,20]. Regarding AHI factors, income reflects purchasing power and indicates a person's financial resources [9]. The determinants of food variety choices are complex, and the price is one of many factors guiding these choices, and a low income can restrain people from spending more money on more food choices [39]. Another often-cited reason for poor DD and DP among low-income individuals is the cost of healthy food [20]. Financially constrained people may consume lower-quality diets, such as fewer fruits and vegetables or more high energy-dense foods, than more affluent populations [20,40]. In terms of educational level, education allows people to obtain information about nutritional knowledge and healthy DP, which ultimately leads to higher DD and better DP. Furthermore, people with a higher educational level tend to have higher incomes and better purchasing power than those with a lower academic level. Therefore, dietary knowledge must be enhanced to improve the poor DD and DP among rural residents with low-education and less-income groups. Meanwhile, the government should step up extensive health education efforts to promote diet-related health education that facilitates the change from unhealthy to healthy eating behaviors in rural areas.

In fact, owing to the complexity of foods and the potential associations between dietary components, the relationship between diet and obesity is intricate [41]. Previous studies have shown a positive association between a higher risk of obesity and DP with increased consumption of red meat abundant in saturated fat and cholesterol [42–44]. In the present study, the non-obese population was inversely associated with "meat/animal protein" DP, indicating that rural residents with obesity who consume more meat or animal food deserve further attention. Nevertheless, we found a positive relationship between the non-obese population and higher DD, which was inconsistent with prior finds in the literature [45,46]. A study in a less developed region suggested that obesity was associated with higher DD among adults in southwest China [45]. One explanation may be that rural residents in the non-obese population tend to increase their intake of healthy foods, such as fruit and vegetables, rather than meat, though, it has been regarded that higher DD is associated with higher consumption of total energy and is linked to obesity [46], whereas a systematic review showed that the relationship between adiposity and DD depends on the healthy degree of eatables and variety of all kinds of food, and a healthy diet implies a reduction in metabolic-related risks [47]. For example, a lower risk of obesity was associated with a low intake of healthy foods (fruits and vegetables) that contributes to higher DD [48]. Another explanation for the finding might be that a varied but balanced diet is attributed to providing a rational nutrient supply. The literature suggests that one reason for increasing obesity is the dietary imbalance coming with DD [45]. Briefly, those who have obesity should be advocating eating healthy foods (e.g., fruits and vegetables) and a balanced diet in rural areas.

According to the results of a systematic review and a dose–response meta-analysis between food groups and the risk of hypertension, it is generally accepted that an increased risk of hypertension was associated with red meat and processed meat [49]. Based on the findings of the present study, those participants without hypertension were negatively associated with "meat/animal protein" DP, which underscores a healthy diet is essential for participants with hypertension in rural areas. Interestingly, our study showed that those participants without diabetes were positively associated with "meat/animal protein" DP, which confirms the relationship between diabetes and diet factors. People with diabetes

are likely to follow a healthier diet than those without diabetes possibly because they have learned about nutrition knowledge from physicians and followed a diabetic diet for glycemic control [50]. This suggests that people without diabetes should also be taken into consideration to increase their ability to choose healthier diets in rural areas where nutrition and health knowledge are inadequate. Notably, we did not observe an association between smoking or drinking and DD or DP, which is inconsistent with many previous studies [4,46,51]. A possible reason for this finding is that the behavior factors (e.g., smoking and drinking) might have a smaller impact on the dietary choices of the rural residents than other factors. Previously published studies have demonstrated the clustering of health/risk behaviors [52–54]. Additionally, evidence shows that changes in one risk behavior are related to changes in another behavior [54]. Thus, the association between smoking or drinking and diet in the Pingnan region needs further study.

A strength of our study was that it included a rigorous sampling process and investigation process, which used multistage systematic clustered random sampling, the use of validated tools for assessing diet, and conducted quite strict quality control to obtain high-quality, representative data to increase the validity and generalizability of our findings. Further, this study used the LCA method to identify DPs and provides a new perspective. However, several limitations of this study should be noted. First, the cross-sectional study design allows us to describe associations but it was difficult to determine causality or explore the direction of associations based on the present findings. Second, the estimation of food intake was based on retrospective self-reports from the past 12 months using the FFQ. Although well-trained investigators conducted interviews to help improve accuracy, recall bias may still result in overestimating or underestimating intake. Third, we focused on analyzing socio-demographic factors but lacked other potential variables, as many factors may influence food intake. Thus, more research focusing on rural residents must include additional elements for a comprehensive assessment.

5. Conclusions

In conclusion, the present study identified DD and DP socio-demographic factors in Pingnan, China. Females exhibited lower DD and were more likely to adhere to "traditional" DP and "meat/animal protein" DP. Those with higher educational levels and AHI were positively associated with higher DD, while less likely to have "traditional" DP and "meat/animal protein" DP. Non-obese people exhibited higher DD and were less likely to have "meat/animal protein" DP. Our study suggests that vulnerable populations which tend to have a lower DD and are more likely to adhere to "traditional" DP and "meat/animal protein" DP, which is most evident among those who are female, those with lower educational levels and AHI, and obese people. Our findings highlight that the policymakers must perform specific diet-related health promotion measures and interventions that target these vulnerable populations to improve a healthier DD and DP. For instance, implementing health interventions, public education, and support programs for rural communities, particularly promoting greater diversity and a wider variety of food intake as well as eating healthy foods (such as fruits and vegetables) and balanced diets.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Fujian Medical University (no. 2022B14).

According to the Statistics Law of the People's Republic of China, the Committee of the Pingnan CDC also approved the survey (no. 2022-184).

Informed Consent Statement: Written informed consent has been obtained from all participants in the survey.

Data Availability Statement: The data are not publicly available due to the data containing information that could compromise the participants' privacy.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **2019**, *393*, 1958–1972. [CrossRef] [PubMed]
2. Martinez-Gonzalez, M.A.; Zazpe, I.; Razquin, C.; Sanchez-Tainta, A.; Corella, D.; Salas-Salvado, J.; Toledo, E.; Ros, E.; Munoz, M.A.; Recondo, J.; et al. Empirically-derived food patterns and the risk of total mortality and cardiovascular events in the PREDIMED study. *Clin. Nutr.* **2015**, *34*, 859–867. [CrossRef] [PubMed]
3. Mozaffarian, D.; Rosenberg, I.; Uauy, R. History of modern nutrition science—Implications for current research, dietary guidelines, and food policy. *BMJ* **2018**, *361*, k2392. [CrossRef] [PubMed]
4. Marques-Vidal, P.; Waeber, G.; Vollenweider, P.; Guessous, I. Socio-demographic and lifestyle determinants of dietary patterns in French-speaking Switzerland, 2009–2012. *BMC Public Health* **2018**, *18*, 131. [CrossRef]
5. Ruel, M.T. Operationalizing dietary diversity: A review of measurement issues and research priorities. *J. Nutr.* **2003**, *133*, 3911S–3926S. [CrossRef]
6. Tavakoli, S.; Dorosty-Motlagh, A.R.; Hoshiar-Rad, A.; Eshraghian, M.R.; Sotoudeh, G.; Azadbakht, L.; Karimi, M.; Jalali-Farahani, S. Is dietary diversity a proxy measurement of nutrient adequacy in Iranian elderly women? *Appetite* **2016**, *105*, 468–476. [CrossRef]
7. Otsuka, R.; Tange, C.; Nishita, Y.; Kato, Y.; Tomida, M.; Imai, T.; Ando, F.; Shimokata, H. Dietary Diversity and All-Cause and Cause-Specific Mortality in Japanese Community-Dwelling Older Adults. *Nutrients* **2020**, *12*, 1052. [CrossRef]
8. Schwingshackl, L.; Bogensberger, B.; Hoffmann, G. Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: An Updated Systematic Review and Meta-Analysis of Cohort Studies. *J. Acad. Nutr. Diet.* **2018**, *118*, 74–100.e111. [CrossRef]
9. Zhang, C.; Zhang, J.; Xiao, S.; Shi, L.; Xue, Y.; Zheng, X.; Benli, X.; Chen, Y.; Li, X.; Kai, Y.; et al. Health-related quality of life and its association with socioeconomic status and diet diversity in Chinese older adults. *Front. Public. Health* **2022**, *10*, 999178. [CrossRef]
10. Tapsell, L.C.; Neale, E.P.; Satija, A.; Hu, F.B. Foods, Nutrients, and Dietary Patterns: Interconnections and Implications for Dietary Guidelines. *Adv. Nutr.* **2016**, *7*, 445–454. [CrossRef]
11. Karam, G.; Agarwal, A.; Sadeghirad, B.; Jalink, M.; Hitchcock, C.L.; Ge, L.; Kiflen, R.; Ahmed, W.; Zea, A.M.; Milenkovic, J.; et al. Comparison of seven popular structured dietary programmes and risk of mortality and major cardiovascular events in patients at increased cardiovascular risk: Systematic review and network meta-analysis. *BMJ* **2023**, *380*, e072003. [CrossRef]
12. Gazan, R.; Bechaux, C.; Crepet, A.; Sirot, V.; Drouillet-Pinard, P.; Dubuisson, C.; Havard, S. Dietary patterns in the French adult population: A study from the second French national cross-sectional dietary survey (INCA2) (2006–2007). *Br. J. Nutr.* **2016**, *116*, 300–315. [CrossRef]
13. Naska, A.; Fouskakis, D.; Oikonomou, E.; Almeida, M.D.; Berg, M.A.; Gedrich, K.; Moreiras, O.; Nelson, M.; Trygg, K.; Turrini, A.; et al. Dietary patterns and their socio-demographic determinants in 10 European countries: Data from the DAFNE databank. *Eur. J. Clin. Nutr.* **2006**, *60*, 181–190. [CrossRef]
14. Imperatori, C.; Innamorati, M.; Tamburello, S.; Continisio, M.; Contardi, A.; Tamburello, A.; Fabbricatore, M. Gender differences in food craving among overweight and obese patients attending low energy diet therapy: A matched case-control study. *Eat. Weight Disord.* **2013**, *18*, 297–303. [CrossRef]
15. Chalermsri, C.; Herzig van Wees, S.; Ziaei, S.; Ekstrom, E.C.; Muangpaisan, W.; Rahman, S.M. Exploring the Experience and Determinants of the Food Choices and Eating Practices of Elderly Thai People: A Qualitative Study. *Nutrients* **2020**, *12*, 3497. [CrossRef] [PubMed]
16. Chalermsri, C.; Rahman, S.M.; Ekstrom, E.C.; Muangpaisan, W.; Aekplakorn, W.; Satheannopakao, W.; Ziaei, S. Socio-demographic characteristics associated with the dietary diversity of Thai community-dwelling older people: Results from the national health examination survey. *BMC Public Health* **2022**, *22*, 377. [CrossRef] [PubMed]
17. Arruda, S.P.; da Silva, A.A.; Kac, G.; Goldani, M.Z.; Bettiol, H.; Barbieri, M.A. Socioeconomic and demographic factors are associated with dietary patterns in a cohort of young Brazilian adults. *BMC Public Health* **2014**, *14*, 654. [CrossRef]
18. Mendez, I.; Fasano, M.V.; Guajardo, V.; Zonis, L.; Kovalskys, I. Dietary Patterns in the Argentinian Population and Their Association with Sociodemographic Characteristics: Results from the ELANS Study (2014–2015). *Front. Nutr.* **2022**, *9*, 778390. [CrossRef]

19. de Juras, A.R.; Hsu, W.C.; Hu, S.C. Dietary Patterns and Their Association with Sociodemographic and Lifestyle Factors in Filipino Adults. *Nutrients* **2022**, *14*, 886. [CrossRef] [PubMed]
20. Alkerwi, A.; Vernier, C.; Sauvageot, N.; Crichton, G.E.; Elias, M.F. Demographic and socioeconomic disparity in nutrition: Application of a novel Correlated Component Regression approach. *BMJ Open* **2015**, *5*, e006814. [CrossRef]
21. Rao, M.; Afshin, A.; Singh, G.; Mozaffarian, D. Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open* **2013**, *3*, e004277. [CrossRef]
22. Jiang, K.; Wen, Y.; Li, S.; Wang, T.; Li, Z.; Sharma, M.; Shi, Z.; Zhao, Y. Differences in Awareness of Chinese Dietary Guidelines Among Urban and Rural Residents: A Cross-Sectional Survey in Southwest China. *Int. J. Public. Health* **2023**, *68*, 1605344. [CrossRef] [PubMed]
23. Jin, T.; Li, L. Does Smartphone Use Improve the Dietary Diversity of Rural Residents? Evidence from Household Survey Data from 5 Provinces. *Int. J. Environ. Res. Public. Health* **2022**, *19*, 11129. [CrossRef] [PubMed]
24. Seventh National Census Bulletin of Ningde. Available online: http://www.ningde.gov.cn/zwgk/tjxx/tjgb/202106/t20210615_1486325.htm (accessed on 15 June 2021).
25. Statistical Bulletin on National Economic and Social Development of Pingnan in 2022. Available online: http://www.pingnan.gov.cn/zwgk/sjfb/tjgb/202304/t20230407_1748915.htm (accessed on 7 April 2023).
26. Yu, D.; Zhao, L.; Zhang, J.; Yang, Z.; Yang, L.; Huang, J.; Fang, H.; Guo, Q.; Xu, X.; Ju, L.; et al. China Nutrition and Health Surveys (1982–2017). *China CDC Wkly.* **2021**, *3*, 193–195. [CrossRef] [PubMed]
27. Chen, W.; Ren, H.; Wang, N.; Xiong, Y.; Xu, F. The relationship between socioeconomic position and health literacy among urban and rural adults in regional China. *BMC Public Health* **2021**, *21*, 527. [CrossRef]
28. Guo, Q.; Fang, H.; Zhao, L.; Ju, L.; Xu, X.; Yu, D. Level of Fruit and Vegetable Intake and Its Relationship with Risk for Malnutrition in China's Adult Labor Force: China Nutrition and Health Surveillance, 2015–2017. *Nutrients* **2023**, *15*, 1431. [CrossRef]
29. Hu, J.; Yang, R.; Li, D.; Zhao, S.; Wan, Y.; Tao, F.; Fang, J.; Zhang, S. A latent class analysis of psychological symptoms and health risk behaviors among Chinese adolescents. *Asian J. Psychiatry* **2021**, *55*, 102518. [CrossRef] [PubMed]
30. Akaike, H. Factor analysis and AIC. *Psychometrika* **1987**, *52*, 317–332. [CrossRef]
31. Gideon, S. Estimating the Dimension of a Model. *Ann. Stat.* **1978**, *6*, 461–464. [CrossRef]
32. Sclove, S.L. Application of model-selection criteria to some problems in multivariate analysis. *Psychometrika* **1987**, *52*, 333–343. [CrossRef]
33. Kim, S.Y. Determining the Number of Latent Classes in Single- and Multi-Phase Growth Mixture Models. *Struct. Equ. Modeling* **2014**, *21*, 263–279. [CrossRef]
34. Choi, E.H.; Kang, M.J.; Lee, H.J.; Yun, M.S. A Latent Class Analysis of Health-Related Quality of Life in Korean Older Adults. *Int. J. Environ. Res. Public. Health* **2021**, *18*, 7874. [CrossRef] [PubMed]
35. Atzendorf, J.; Apfelbacher, C.; Gomes de Matos, E.; Kraus, L.; Piontek, D. Patterns of multiple lifestyle risk factors and their link to mental health in the German adult population: A cross-sectional study. *BMJ Open* **2018**, *8*, e022184. [CrossRef] [PubMed]
36. Wang, Z.; Chen, Y.; Tang, S.; Chen, S.; Gong, S.; Jiang, X.; Wang, L.; Zhang, Y. Dietary Diversity and Nutrient Intake of Han and Dongxiang Smallholder Farmers in Poverty Areas of Northwest China. *Nutrients* **2021**, *13*, 3908. [CrossRef] [PubMed]
37. Gokhale, D.; Rao, S. Socio-economic and socio-demographic determinants of diet diversity among rural pregnant women from Pune, India. *BMC Nutr.* **2022**, *8*, 54. [CrossRef]
38. Ahn, Y.; Lee, Y.; Park, H.; Song, K. Gender and age group differences in nutrition intake and dietary quality of Korean adults eating alone: Based on Korean National Health and Nutrition Examination Survey Data, 2013–2016. *Nutr. Res. Pract.* **2021**, *15*, 66–79. [CrossRef]
39. Darmon, N.; Drewnowski, A. Does social class predict diet quality? *Am. J. Clin. Nutr.* **2008**, *87*, 1107–1117. [CrossRef]
40. Drewnowski, A.; Darmon, N. Food choices and diet costs: An economic analysis. *J. Nutr.* **2005**, *135*, 900–904. [CrossRef]
41. Zhen, S.; Ma, Y.; Zhao, Z.; Yang, X.; Wen, D. Dietary pattern is associated with obesity in Chinese children and adolescents: Data from China Health and Nutrition Survey (CHNS). *Nutr. J.* **2018**, *17*, 68. [CrossRef]
42. Shu, L.; Shen, X.M.; Li, C.; Zhang, X.Y.; Zheng, P.F. Dietary patterns are associated with type 2 diabetes mellitus among middle-aged adults in Zhejiang Province, China. *Nutr. J.* **2017**, *16*, 81. [CrossRef]
43. Cocate, P.G.; Natali, A.J.; de Oliveira, A.; Alfenas Rde, C.; Peluzio Mdo, C.; Longo, G.Z.; dos Santos, E.C.; Buthers, J.M.; de Oliveira, L.L.; Hermsdorff, H.H. Red but not white meat consumption is associated with metabolic syndrome, insulin resistance and lipid peroxidation in Brazilian middle-aged men. *Eur. J. Prev. Cardiol.* **2015**, *22*, 223–230. [CrossRef] [PubMed]
44. Rouhani, M.H.; Salehi-Abargouei, A.; Surkan, P.J.; Azadbakht, L. Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. *Obes. Rev.* **2014**, *15*, 740–748. [CrossRef]
45. Zhang, Q.; Chen, X.; Liu, Z.; Varma, D.S.; Wan, R.; Zhao, S. Diet diversity and nutritional status among adults in southwest China. *PLoS ONE* **2017**, *12*, e0172406. [CrossRef] [PubMed]
46. Zhou, Y.; Wang, J.; Duan, Y.; Luo, X.; Wan, Z.; Luo, Y.; Li, Y.; Wang, Y.; Xie, J. Dietary diversity and determinants of young adults in central China: A cross-sectional study from 2015 to 2020. *Front. Nutr.* **2022**, *9*, 931107. [CrossRef]
47. Mozaffari, H.; Hosseini, Z.; Lafrenière, J.; Conklin, A.I. The role of dietary diversity in preventing metabolic-related outcomes: Findings from a systematic review. *Obes. Rev.* **2021**, *22*, e13174. [CrossRef] [PubMed]
48. Azadbakht, L.; Esmaillzadeh, A. Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Public. Health Nutr.* **2011**, *14*, 62–69. [CrossRef] [PubMed]

49. Schwingshackl, L.; Schwedhelm, C.; Hoffmann, G.; Knüppel, S.; Iqbal, K.; Andriolo, V.; Bechthold, A.; Schlesinger, S.; Boeing, H. Food Groups and Risk of Hypertension: A Systematic Review and Dose-Response Meta-Analysis of Prospective Studies. *Adv. Nutr.* **2017**, *8*, 793–803. [CrossRef]
50. Li, Y.; Yu, L.; Liu, Z.; Jia, S.; Man, Q.; Zhu, Q.; Li, C.; Yang, Y.; Liu, B.; Zhang, J. Dietary Pattern Associated with the Risk of Poor Glycemic Control in Chinese Diabetic Adults: Results from the China Nutrition and Health Surveillance 2015–2017 Survey. *Nutrients* **2022**, *15*, 56. [CrossRef]
51. Andreeva, V.A.; Allès, B.; Feron, G.; Gonzalez, R.; Sulmont-Rossé, C.; Galan, P.; Hercberg, S.; Méjean, C. Sex-Specific Sociodemographic Correlates of Dietary Patterns in a Large Sample of French Elderly Individuals. *Nutrients* **2016**, *8*, 484. [CrossRef]
52. Liu, M.; Zhang, C.; Cai, H.; Liu, F.; Liu, Y.; Li, J.; Pan, Y.; Guo, C.; He, Z.; Ke, Y. The Willingness to Change Risky Health Behaviors among Chinese Rural Residents: What We Learned from a Population-Based Esophageal Cancer Cohort Study. *PLoS ONE* **2016**, *11*, e0161999. [CrossRef]
53. Ding, D.; Rogers, K.; van der Ploeg, H.; Stamatakis, E.; Bauman, A.E. Traditional and Emerging Lifestyle Risk Behaviors and All-Cause Mortality in Middle-Aged and Older Adults: Evidence from a Large Population-Based Australian Cohort. *PLoS Med.* **2015**, *12*, e1001917. [CrossRef] [PubMed]
54. Ramo, D.E.; Thrul, J.; Vogel, E.A.; Delucchi, K.; Prochaska, J.J. Multiple Health Risk Behaviors in Young Adult Smokers: Stages of Change and Stability over Time. *Ann. Behav. Med.* **2020**, *54*, 75–86. [CrossRef] [PubMed]

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Article

Plant-Based Dietary Indices in Relation to Nutrient and Food Group Intakes in Preschool-Aged Children

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Abstract: Dietary guidance promotes plant-based foods, yet minimal research has examined intake in children. This study examined plant-based food intake in preschool-aged children using plant-based dietary index (PDI) metrics and related these metrics to nutrient and food group intakes. Dietary data were collected from preschool-aged children (n = 283, 3.45 ± 1.22 years) from the Guelph Family Health Study at baseline using the Automated Self-Administered 24-Hour Dietary Assessment Tool. Food intake servings were assigned to 16 food groups for calculation of overall PDI (oPDI), healthful PDI (hPDI), and less healthful (lhPDI) scores and summarized into tertiles for energy-adjusted comparisons. For oPDI, participants in the highest vs. lowest tertile had higher intakes of nutrients and food groups to encourage (e.g., dietary fiber, fruits) as well as lower intakes of nutrients to encourage (e.g., calcium, vitamin D). For hPDI, participants in the highest vs. lowest tertile had higher intakes of nutrients and food groups to encourage and lower intakes of those to limit (e.g., saturated fat, sweets and desserts). For lhPDI, participants in the highest vs. lowest tertile had higher intakes of nutrients and food groups to limit and lower intakes of those to encourage. These results can inform dietetic practice for dietary guidance that promotes plant-based foods in children.

Keywords: dietary guidance; dietary assessment; plant-based dietary index; nutrient intakes; food group intakes; preschool-aged children

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1. Introduction

Dietary guidelines from numerous countries have shifted towards the promotion of sustainable dietary patterns that include higher intakes of plant-based foods [1–5]. Higher intakes of plant-based foods, including nuts, seeds, and legumes, fruits, vegetables, and whole grains, have been related to improved nutrient intake, including higher dietary fiber, micronutrients, and unsaturated fat [6], as well as improved diet quality [7]. Higher intakes of plant-based foods have also been related to improved health outcomes, including lower risk of cardiovascular disease [8–11], type 2 diabetes [12,13], breast cancer [14–16], and all-cause mortality [17–20]. These improvements support the dietary guidance and rationalize the measurement of plant-based food intake in various population segments.

Plant-based food intake can be measured using the plant-based dietary index (PDI), as first described by Satija et al. [12]. The PDI is designed to examine the dietary intake distribution of plant- and animal-based foods using a system that assigns positive or reverse scores to plant foods and reverse scores to animal foods [12]. The metrics include an overall PDI as well as a healthful PDI and an unhealthful PDI that reflect intake of plant-based foods that are healthy (e.g., fruits, whole grains) or less healthy (e.g., sweets and desserts, sugar sweetened beverages (SSBs)) [12]. The PDI metrics have been examined in relation to chronic disease risk in adults in various locations including North America [8,12,21,22],

Europe [23,24], and Korea [10,18,25]. There is rationale to also examine PDI metrics in children, particularly since dietary habits established in young childhood can be associated with health outcomes [26] and persist into adulthood [27]. Therefore, the purpose of the current study was to examine intake of plant-based foods using the PDI metrics and relate them to nutrient and food group intakes in preschool-aged children participating in the Guelph Family Health Study (GFHS).

2. Materials and Methods

2.1. Study Design and Participant Screening

The current study used baseline dietary assessment data from the GFHS, an ongoing cohort study examining the effects of home-based lifestyle interventions on obesity prevention in families with young children. The study was approved by the University of Guelph Research Ethics Board (REB#17-07-003) and registered on ClinicalTrials.gov (NCT02939261). All parents provided written consent and, when possible, children provided verbal assent.

Participants included children between 1.5 and 5 years who were in GFHS families. Families were eligible if they resided in Guelph, Ontario, or surrounding areas, had a parent who could respond to questionnaires in English, and did not have a participating child(ren) with a severe health condition.

Of the 293 children who met the inclusionary criteria, 10 were excluded due to a missing dietary assessment (n = 1) or errors in their dietary assessment entries (n = 6), including an implausible energy intake (<500 kcal/day) (n = 3).

2.2. Anthropometric Measurements

Height was measured using a stadiometer (ShorrBoard, Weight and Measure, LLC., Olney, MD, USA). Body weight was measured using an electronic scale (BOD POD™, COSMED, Concord, CA, USA). Body mass index (BMI) z-scores were calculated using World Health Organization Anthro software (version 3.2.2, Geneva, Switzerland, 2011).

2.3. Dietary Assessment

Dietary assessment was completed by the participant's parent for a 24 h period using the National Cancer Institute's web-based Automated Self-Administered 24 h (ASA24) Dietary Assessment Tool, version ASA24-Canada-2016, adapted to reflect the Canadian food supply, portion sizes, and nutrient composition. ASA24 includes multiple prompts for participants to facilitate accurate data entry and has been validated for use in children [28]. ASA24-Canada analyzes the dietary data using the Canadian Nutrient File and a Health Canada recipe database along with the United States Food and Nutrient Database for Dietary Studies (FNDDS) and the Food Patterns Equivalents Database (FPED). These databases enable ASA24-Canada to output a summary of the food descriptions, energy and nutrient intakes, and United States Department of Agriculture (USDA) Food Pattern components.

2.4. Plant-Based Dietary Index (PDI) Scoring

PDI scores were computed for overall PDI (oPDI), healthful PDI (hPDI), and less healthful PDI (lhPDI), adapted from Satija et al., 2016 [12]. Food intakes from the ASA24 results output were converted from grams to servings using Health Canada's Table of Reference Amounts for Food [29]. Food descriptions reported as mixed dishes were disaggregated and quantified using information from the detailed ASA24 responses and the ASA24 food group variables, followed by conversion to grams using data from the FPED. Food servings were then assigned to 1 of 16 food groups categorized as healthy plant foods (whole grains; fruits; vegetables; nuts, seeds, and legumes; tea and coffee; plant oils and spreads), less healthy plant foods (refined grains; snack chips and French fries; SSB; sweets and desserts; condiments), or animal foods (dairy; eggs; fish; meat; animal-based spreads) (Figure 1). Servings in each food group were totalled for each participant and summarized into food group serving intake quintiles (Q) across all participants. PDI

scores were then computed for each participant by relating their total intake of food group servings to the food group serving intake Qs. For oPDI, scores of 1 were assigned to all plant food group serving intakes that were in Q1 and scores of 5 were assigned to all plant food group serving intakes that were in Q5 (positive scoring such that Q1 = 1, Q2 = 2, Q3 = 3, Q4 = 4, Q5 = 5), and the opposite approach was completed for animal food group serving intakes (reverse scoring such that Q1 = 5, Q2 = 4, Q3 = 3, Q4 = 2, Q5 = 1) (Figure 1). For hPDI, positive scoring was completed for healthy plant food group serving intakes and reverse scoring was completed for less healthy plant food and animal food group serving intakes (Figure 1). For lhPDI, positive scoring was completed for less healthy plant food group serving intakes and reverse scoring was completed for healthy plant food and animal food group serving intakes (Figure 1). Scores were summed within a participant for oPDI, hPDI, and lhPDI with theoretical ranges of 16 to 80.

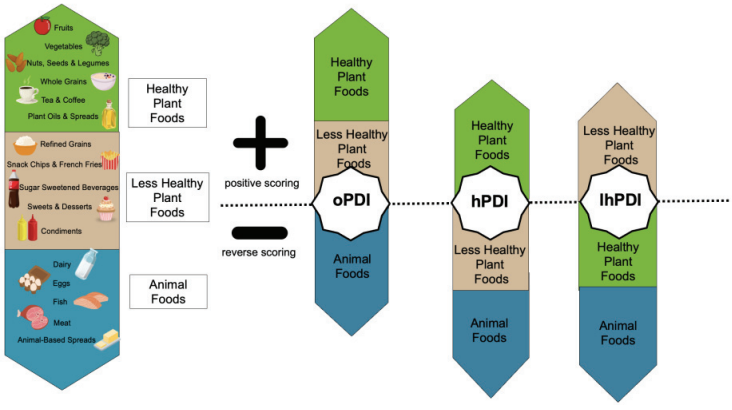


Figure 1. Summary of the PDI metrics scoring process. Abbreviations used: oPDI, overall plant-based dietary index; hPDI, healthful plant-based dietary index; lhPDI, less healthful plant-based dietary index. Created with Canva, adapted with permission from Sarah E. Jarvis.

2.5. Data and Statistical Analysis

All data were analyzed using the Statistical Analysis System (SAS Institute Inc., Version 9.4, Cary, NC, USA) with $p < 0.05$ considered significant. All dietary data were examined for normality using box plots and stem-leaf diagrams and log-transformed where appropriate. Summary statistics were generated for sex, BMI z-score, and PDI scores, and tertiles were computed for PDI scores. Nutrient and food group intakes were compared among oPDI, hPDI, and lhPDI tertiles using the GENMOD procedure (to implement the generalized estimating equation approach to control for correlated outcomes among siblings), adjusted for energy intake, and followed by a Tukey's test for multiple comparisons.

3. Results

3.1. Participant Characteristics

Participants included 148 girls and 135 boys who had a mean ± SD age of 3.45 ± 1.22 years and BMI z-score of 0.58 ± 0.98.

3.2. oPDI Scores in Relation to Nutrient and Food Group Intakes

The median oPDI score was 42 with a range of 26–63 (Figure 2). Tertiles for oPDI were 26–41 (n = 105) for tertile 1, 42–47 (n = 87) for tertile 2, and 48–63 (n = 91) for tertile 3.

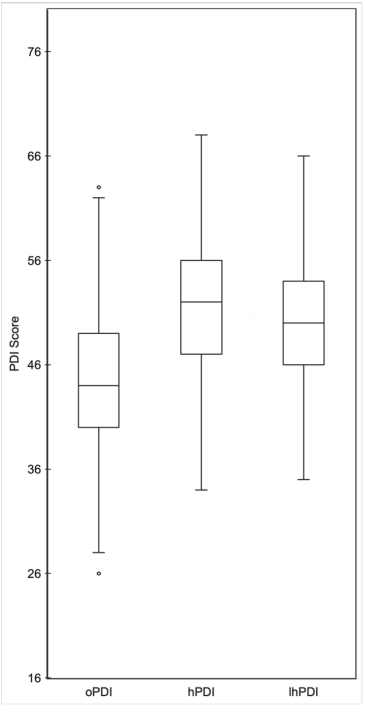
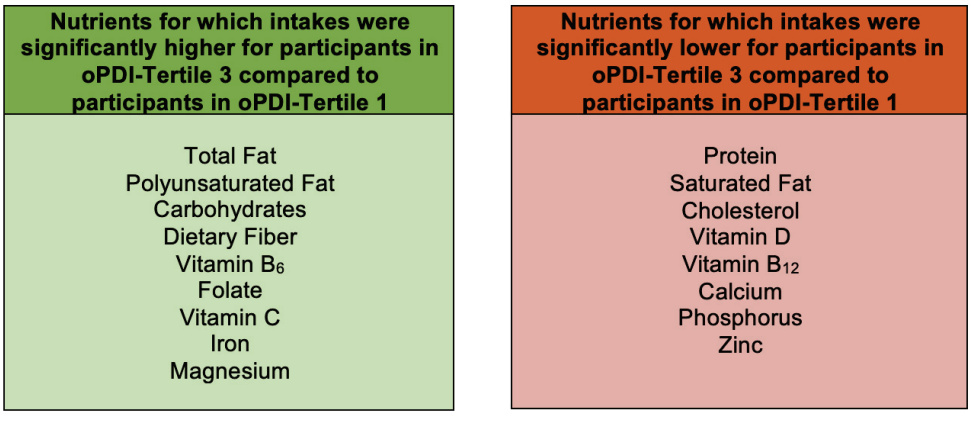


Figure 2. PDI metric box plots. Distribution of PDI scores of children for oPDI, hPDI, and lhPDI. Abbreviations: PDI, plant-based dietary index; oPDI, overall plant-based dietary index; hPDI, healthful plant-based dietary index; lhPDI, less healthful plant-based dietary index.

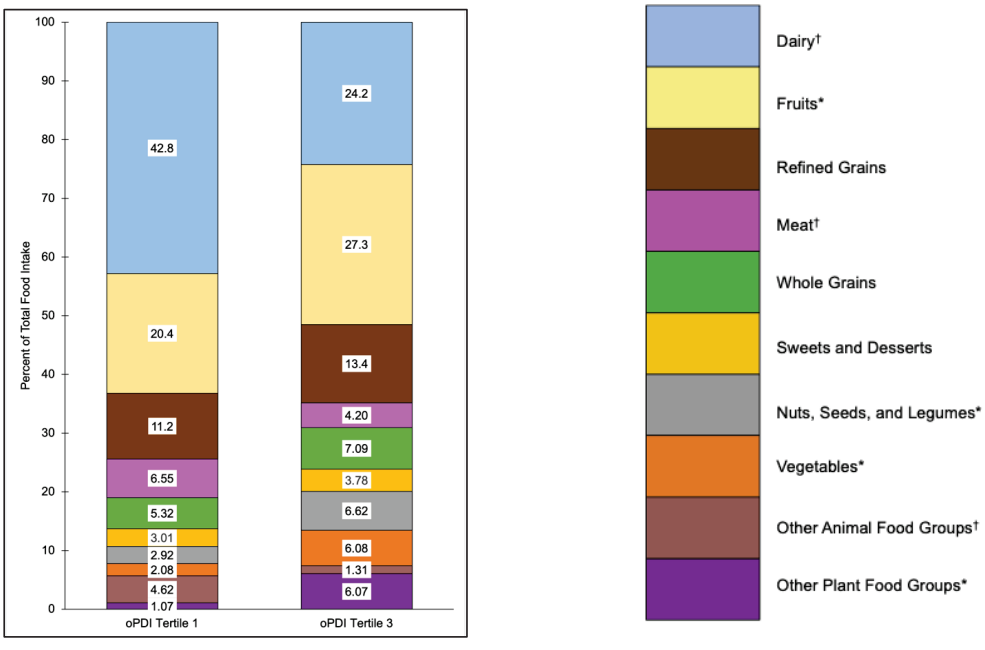
Nutrient intakes that were significantly higher for participants in oPDI tertile 3 compared to tertile 1 included total fat ($p = 0.0004$), polyunsaturated fat ($p = 0.03$), carbohydrates ($p < 0.0001$), dietary fiber ($p < 0.0001$), vitamin B_6 ($p = 0.03$), folate ($p = 0.005$), vitamin C ($p = 0.0002$), iron ($p < 0.0001$), and magnesium ($p < 0.0001$) (Figure 3a and Table S1, Supplementary Data). Nutrient intakes that were significantly lower for participants in oPDI tertile 3 compared to tertile 1 included protein ($p < 0.0001$), saturated fat ($p < 0.0001$), cholesterol ($p < 0.0001$), vitamin D ($p < 0.0001$), vitamin B_{12} ($p < 0.0001$), calcium ($p < 0.0001$), phosphorus ($p < 0.0001$), and zinc ($p = 0.005$) (Figure 3a and Table S1, Supplementary Data).

Food groups that contributed the highest proportions of food intake for oPDI tertiles 1 and 3 included dairy (42.8% and 24.2%, respectively), fruits (20.4% and 27.3%, respectively), and refined grains (11.2% and 13.4%, respectively) (Figure 3b). Food groups that contributed the lowest proportions of food intake accounted for $\leq$3% of total food intake for oPDI tertiles 1 and 3 and included SSB (0% and 2.42%, respectively), snack chips and French fries (0.34% and 1.30%, respectively), condiments (0.30% and 1.49%, respectively), plant oils and spreads (0.22% and 0.43%, respectively), tea and coffee (0.21% and 0.43%, respectively), eggs (2.97% and 0.92%, respectively), animal-based spreads (0.91% and 0.28%, respectively), and fish (0.74% and 0.11%, respectively) (Figure 3b).

Food group proportional intakes that were significantly higher for participants in oPDI tertile 3 compared to tertile 1 included fruits ($p = 0.003$); nuts, seeds, and legumes ($p = 0.01$); vegetables ($p = 0.002$); snack chips and French fries ($p = 0.02$), SSB ($p = 0.03$); and condiments ($p < 0.0001$) (Figure 3b). Food group proportional intakes that were significantly lower for participants in oPDI tertile 3 compared to tertile 1 included dairy ($p < 0.0001$), meat ($p = 0.02$), eggs ($p = 0.0002$), and animal-based spreads ($p < 0.0001$) (Figure 3b).



(**a**)



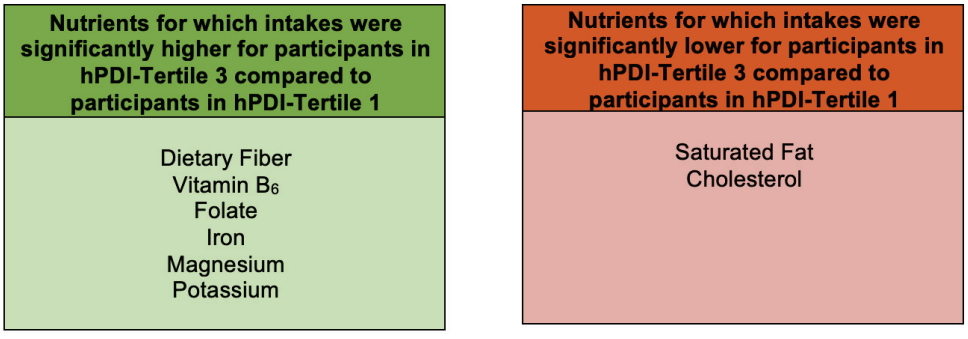
(**b**)

Figure 3. Nutrient intakes (**a**) and food group proportional intakes (**b**) of participants in oPDI tertile 3 compared to oPDI tertile 1. Values within each food group bar segment are percent of total food intake. Other animal food groups and other plant food groups are combinations of food groups with intakes ≤3% of total food intake for both tertiles 1 and 3. Intakes for food groups in the legend with * were significantly higher for oPDI tertile 3 compared to oPDI tertile 1 (within the other plant food groups, this refers to snack chips and French fries, sugar-sweetened beverages, and condiments). Intakes for food groups in the legend with † were significantly lower for oPDI tertile 3 compared to oPDI tertile 1 (within the other animal food groups, this refers to eggs and animal-based spreads). Abbreviations: oPDI, overall plant-based dietary index.

3.3. hPDI Scores in Relation to Nutrient and Food Group Intakes

The median hPDI score was 52 with a range of 34–68 (Figure 2). Tertiles for hPDI were 34–49 (n = 98) for tertile 1, 50–55 (n = 97) for tertile 2 and 56–68 (n = 88) for tertile 3.

Nutrient intakes that were significantly higher for participants in hPDI tertile 3 compared to tertile 1 included dietary fiber ($p < 0.0001$), vitamin B_6 ($p = 0.009$), folate ($p = 0.004$), iron ($p = 0.004$), magnesium ($p < 0.0001$), and potassium ($p < 0.0001$) (Figure 4a and Table S2, Supplementary Data). Nutrient intakes that were significantly lower for participants in hPDI tertile 3 compared to tertile 1 included saturated fat ($p = 0.003$) and cholesterol ($p = 0.0002$) (Figure 4a and Table S2, Supplementary Data).



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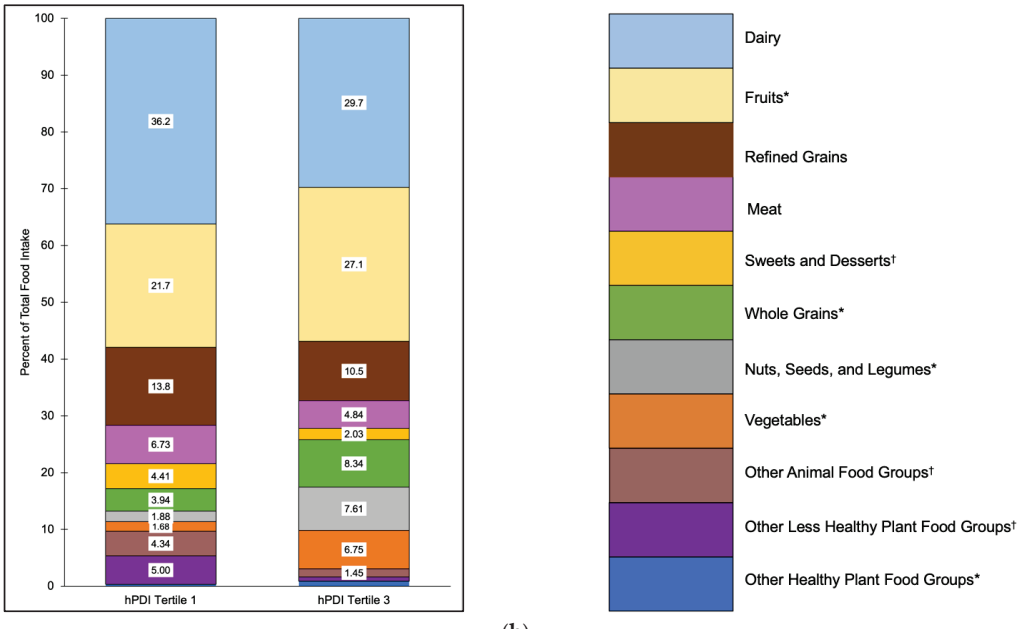


(**b**)

Figure 4. Nutrient intakes (**a**) and food group proportional intakes (**b**) of participants in hPDI tertile 3 compared to hPDI tertile 1. Values within each food group bar segment are percent of total food intake. Other animal food groups, other less healthy plant food groups, and other healthy plant food groups are combinations of food groups with intakes ≤3% of total food intake for both tertiles 1 and 3. Intakes for food groups in the legend with * were significantly higher for hPDI tertile 3 compared to tertile 1 (within the other healthy plant food groups, this refers to plant oils and spreads). Intakes for food groups in the legend with † were significantly lower for hPDI tertile 3 compared to hPDI tertile 1 (within the other animal food groups, this refers to eggs and animal-based spreads, and within the other less healthy plant food groups, this refers to snack chips and French fries, sugar-sweetened beverages, and condiments). Abbreviations: hPDI, healthful plant-based dietary index.

Food groups that contributed the highest proportions of food intake for hPDI tertiles 1 and 3 included dairy (36.2% and 29.7%, respectively), fruits (21.7% and 27.1%, respectively), and refined grains (13.8% and 10.5%, respectively) (Figure 4b). Food groups that contributed the lowest proportions of food intake accounted for ≤3% of total food intake for hPDI tertiles 1 and 3 and included SSB (2.05% and 0.16%, respectively), snack chips and French fries (1.70% and 0.12%, respectively), condiments (1.25% and 0.49%, respectively), tea and coffee (0.26% and 0.48%, respectively), plant oils and spreads (0.08% and 0.39%, respectively), eggs (2.47% and 0.94%, respectively), animal-based spreads (0.96% and 0.29%, respectively), and fish (0.91% and 0.22%, respectively) (Figure 4b).

Food group proportional intakes that were significantly higher for participants in hPDI tertile 3 compared to tertile 1 included fruits ($p = 0.03$), whole grains ($p = 0.0004$), nuts, seeds, and legumes ($p < 0.0001$), vegetables ($p = 0.0005$), and plant oils and spreads ($p < 0.0001$) (Figure 4b). Food group proportional intakes that were significantly lower for participants in hPDI tertile 3 compared to tertile 1 included sweets and desserts ($p = 0.002$), eggs ($p = 0.008$), animal-based spreads ($p < 0.0001$), snack chips and French fries ($p < 0.0001$), SSB ($p = 0.03$), and condiments ($p = 0.02$) (Figure 4b).

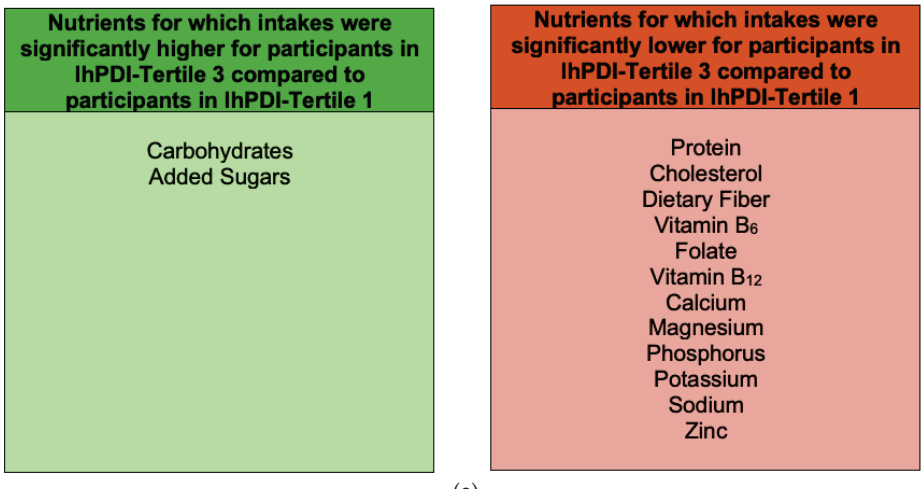
3.4. lhPDI Scores in Relation to Nutrient and Food Group Intakes

The median lhPDI score was 50 with a range of 35–66 (Figure 2). Tertiles for oPDI were 35–47 ($n = 101$) for tertile 1, 48–52 ($n = 86$) for tertile 2, and 53–66 ($n = 96$) for tertile 3.

Nutrient intakes that were significantly higher for participants in lhPDI tertile 3 compared to tertile 1 included carbohydrates ($p = 0.001$) and added sugars ($p < 0.0001$) (Figure 5a and Table S2, Supplementary Data). Nutrient intakes that were significantly lower for participants in lhPDI tertile 3 compared to tertile 1 included protein ($p < 0.0001$), cholesterol ($p < 0.0001$), dietary fiber ($p < 0.0001$), vitamin B_6 ($p = 0.002$), folate ($p = 0.01$), vitamin B_{12} ($p = 0.003$), calcium ($p = 0.0005$), magnesium ($p < 0.0001$), phosphorus ($p < 0.0001$), potassium ($p < 0.0001$), sodium ($p = 0.04$), and zinc ($p < 0.0001$) (Figure 5a and Table S2, Supplementary Data).

Food groups that contributed the highest proportions of food intake for lhPDI tertiles 1 and 3 included dairy (37.0% and 33.2%, respectively), fruits (24.3% and 22.4%, respectively), and refined grains (9.55% and 14.6%, respectively) (Figure 5b). Food groups that contributed the lowest proportions of food intake accounted for ≤3% of total food intake for lhPDI tertiles 1 and 3 and included SSB (0.69% and 3.02%, respectively), snack chips and French fries (0.13% and 2.17%, respectively), condiments (0.34% and 1.41%, respectively), tea and coffee (0.59% and 0.25%, respectively), plant oils and spreads (0.34% and 0.27%, respectively), eggs (2.32% and 1.23%, respectively), animal-based spreads (0.63% and 0.49%, respectively), and fish (0.69% and 0.06%, respectively) (Figure 5b).

Food group proportional intakes that were significantly higher for participants in lhPDI tertile 3 compared to tertile 1 included refined grains ($p = 0.0009$), sweets and desserts ($p < 0.0001$), snack chips and French fries ($p < 0.0001$), and condiments ($p = 0.0003$) (Figure 5b). Food group proportional intakes that were significantly lower for participants in lhPDI tertile 3 compared to tertile 1 included whole grains ($p = 0.02$), vegetables ($p = 0.03$), and fish ($p = 0.008$) (Figure 5b).



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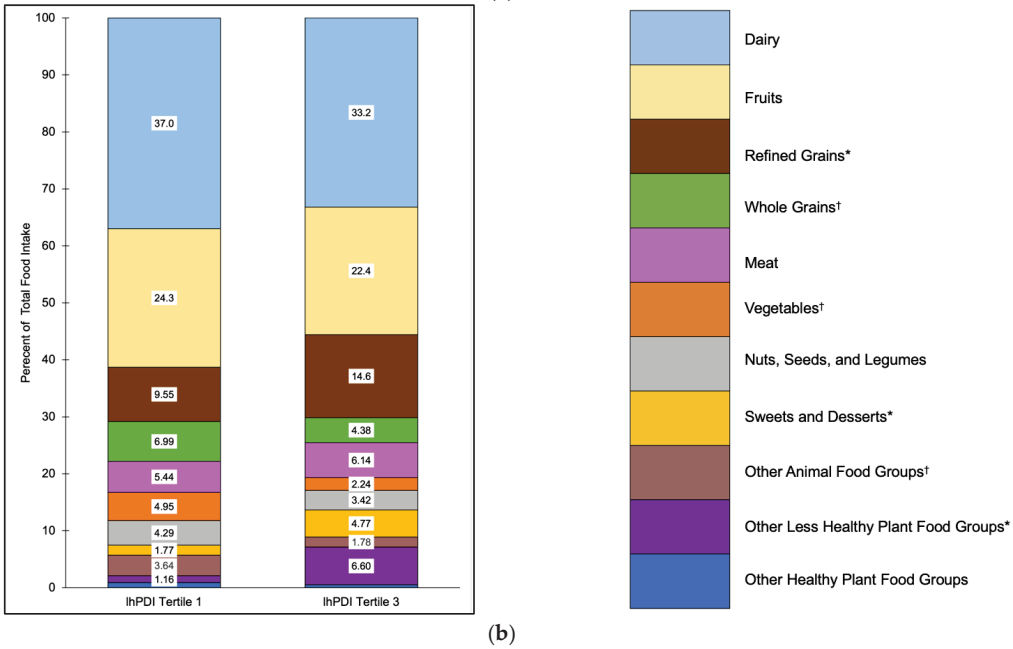

(**b**)

Figure 5. Nutrient intakes (**a**) and food group proportional intakes (**b**) of participants in lhPDI tertile 3 compared to lhPDI tertile 1. Values within each food group bar segment are percents of total food intake. Other animal food groups, other less healthy plant food groups, and other healthy plant food groups are combinations of food groups with intakes ≤3% for both tertiles 1 and 3. Intakes for food groups in the legend with * were significantly higher for lhPDI tertile 3 compared to lhPDI tertile 1 (within the other less healthy plant food groups, this refers to snack chips and French fries, and condiments). Intakes for food groups in the legend with † were significantly lower for lhPDI tertile 3 compared to lhPDI tertile 1 (within the other animal food groups, this refers to fish). Abbreviations: lhPDI, less healthful plant-based dietary index.

4. Discussion

The current study examined plant-based food intake in a sample of 283 preschool-aged children who were participating in the GFHS. Dietary assessment was completed for a 24 h period by each child's parent using the online-based ASA24. The itemized food intakes were converted to servings and categorized into 11 plant food groups or 5 animal food groups for calculation of oPDI scores. Plant food groups were further categorized into healthy or less healthy plant food groups for calculation of hPDI and lhPDI scores. The focus on dietary distribution of plant-based food intakes in young children is relevant as it is a critical stage for growth and development, with unique nutritional requirements [30]. Gaining insights into the nutritional implications of plant-based foods in children's diets is pertinent as evidence demonstrates that childhood dietary habits can persist into adulthood [27]. As such, the current study examined the PDI metric scores and related them to nutrient and food group intakes in a sample of preschool-aged children.

The current study's focus on young children in its examination of plant-based food intake adds diversity to the participants that have been studied in this literature. Adults have been the focus of most of the previous studies of plant-based food intake, which have related PDI metrics to various health conditions [12,14,19,25]. The need for research conducting thorough examinations of plant-based food intake in children is important since childhood dietary habits can continue through into adulthood [27] and relate to health outcomes [26]. Overall, since dietary guidance includes children, the current study's participant sample adds necessary diversity to the plant-based food intake literature.

The range of oPDI scores in the current study is 26–63 out of a theoretical range of 16–80. When oPDI scores are summarized into tertiles, the results show that participants who have higher overall plant intake (oPDI-tertile 3) have higher intakes of nutrients to encourage (polyunsaturated fat, dietary fiber, vitamin B_6, folate, vitamin C, iron, magnesium), and, except for saturated fat and cholesterol, also have lower intakes of nutrients to encourage (protein, vitamin D, vitamin B_{12}, calcium, phosphorus, zinc). The food group intakes accounted for in these nutrient intakes show that participants who have higher oPDI have higher intakes of fruits, vegetables, nuts, seeds, and legumes, and lower intakes of dairy and meat. The majority of PDI studies have been conducted in adults and focus on health outcomes; however, Chen et al. studied children aged 6–9 years living in China [31]. Their food group results show that participants with higher overall plant intake have higher intakes of healthy plant foods and also some less healthy plant foods, although statistical comparisons are not completed and nutrient intakes are not reported [31]. Other PDI studies that have examined nutrient intakes report higher PDI scores in relation to higher intakes of carbohydrates [32,33], polyunsaturated fat [33], dietary fiber and vitamin B_6 [32,33], folate [32], vitamin C [33,34], and magnesium [32,33], and lower intakes of protein [15,21,33,34], total fat [15,33,34], saturated fat [15,33,34], cholesterol, vitamin B_6, vitamin B_{12}, calcium, and magnesium [15,33], although all of these studies were conducted in Iranian adults, except for one that was in South Korean adults [21]. Collectively, these studies support a role for plant foods in promoting the intake of nutrients beneficial for health, but also demonstrate that other nutrients beneficial for health can be lower with varying intakes of certain plant foods. These results argue for a comprehensive dietary approach that includes a diversity of plant foods to support optimal nutrient intake.

The hPDI metric further examines plant food intake by considering the intake of plant foods that are considered healthy. The range of hPDI scores in the current study is 34–68 out of a theoretical range of 16–80. Participants who have higher intakes of healthy plant foods (hPDI-tertile 3) have higher intakes of nutrients to encourage (dietary fiber, vitamin B_6, folate, iron, magnesium, potassium) and lower intakes of a nutrient to limit (saturated fat). These results correspond with higher food group intakes, including higher intakes of healthy plant foods (fruits, whole grains, nuts, seeds, and legumes, vegetables, and plant oils and spreads). Previous PDI studies also report higher hPDI scores in relation to higher intakes of dietary fiber [9,15,33,35], vitamin B_6 [15,33], folate [9,15,21], iron [21], and magnesium [9,15,21], and lower intakes of saturated fat [9,15,21,33,35], although all of

these studies were conducted in adults. These results demonstrate that higher hPDI scores reflect a diet high in food groups to encourage and contribute to optimal nutrient intakes by promoting increased intakes of nutrients to encourage and lower intakes of nutrients to limit.

The lhPDI metric also further examines plant food intake by considering the intake of plant foods that are considered less healthy. The range of lhPDI scores is 35–66 out of a theoretical range of 16–80. Participants who have higher intakes of less healthy plant foods (lhPDI-tertile 3) have higher intakes of nutrients and food groups to limit (added sugars, sweets and desserts, and snack chips and French Fries) and lower intakes of nutrients and food groups to encourage (protein, dietary fiber, several micronutrients, whole grains, vegetables, and fish). These results are consistent with previous studies, all conducted in adults, that also report higher lhPDI scores in relation to higher intakes of added sugars [35], and lower intakes of protein [21,33], dietary fiber [15,21,33,35], and micronutrients, including vitamin B_6 [15,33], folate [15,21], calcium, magnesium, and potassium [21,33]. These findings highlight the consideration of nutritional quality when relating plant food intake to nutrient intakes. A higher intake of plant foods may not always be consistent with higher intakes of nutrients and food groups to encourage, which rationalizes the inclusion of the hPDI and lhPDI metrics in the dietary assessment of plant food intake.

In this study sample of preschool-aged children, dairy, fruits, and refined grains were the most frequently consumed food groups, accounting for >60% of total food intake, regardless of PDI metric or tertile. These food group intake results are consistent with previous studies that report children aged 2–6 years in China most frequently consume cereals, dairy, and fruits [36], and children aged 2–3 years in the United States consume milk and fruit at least once daily [37]. Dairy foods are nutrient-dense, providing high-quality protein and many micronutrients, including calcium and vitamin D to support growth and development in children [38]. Fruits also provide multiple micronutrients and can be high in dietary fiber, which can all support health [39]. Refined grains can be a source of multiple shortfall micronutrients, including folic acid and iron, to contribute toward nutrient adequacy [40]. Nonetheless, dietary intake can always be improved with more variety and increased intakes of certain foods such as vegetables, and nuts, seeds, and legumes, which can contribute several nutrients to encourage, including dietary fiber, polyunsaturated fat, monounsaturated fat, and multiple micronutrients [41,42]. These findings demonstrate a need for greater diversity in children's diets to promote nutrient intake adequacy and foster lifelong healthy dietary habits.

The current study is limited in its use of a single, self-reported 24 h dietary recall, which has inherent recall bias and/or measurement error. A strength of this study is its focus on children, who have been less studied, despite evidence that eating habits at a young age can persist into adulthood [27]. Another strength is the rigorous process employed to disaggregate mixed dishes into individual foods, which contributed to an increased accuracy of food group classification and subsequent PDI metric scoring.

5. Conclusions

In conclusion, the current study examined plant food intake in a sample of 283 preschool-aged children using PDI metrics. The results show that participants who have higher intakes of plant foods (oPDI) have higher intakes of nutrients and food groups to encourage (e.g., dietary fiber, fruits) but also lower intakes of nutrients to encourage (e.g., calcium, vitamin D). When plant food intake is further examined according to healthfulness, results predictably show that participants who have higher intakes of healthy plant foods (hPDI) have higher intakes of nutrients and food groups to encourage (e.g., dietary fiber, fruits), while participants who have higher intakes of less healthy plant foods (lhPDI) have higher intakes of nutrients and food groups to limit (e.g., added sugars and snack chips and French fries). These results provide evidence of the types of plant foods that preschool-aged children are consuming, and support directions for dietetic practice. Future research can

include examinations of PDI scores in relation to health outcomes in children and effects of interventions on PDI scores in children. Overall, the results of this study can contribute toward the development of nutritional strategies that facilitate plant food intake in children.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/nu15214617/s1: Table S1: Nutrient intakes by oPDI tertiles in preschool-aged children; Table S2: Nutrient intakes by hPDI and lhPDI tertiles in preschool-aged children.

Author Contributions: A.M.D., P.F.C.A. and O.A.L. conceptualized the study; P.F.C.A., O.A.L., Z.J.R. and A.M.D. completed the data analyses; D.W.L.M. and J.H. are the Co-Directors of the GFHS and conceptualized the GFHS and supervised the GFHS data collection; A.M.D. oversaw all study activities; P.F.C.A., O.A.L. and A.M.D. wrote the manuscript; and all authors reviewed and approved the manuscript. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Research Ethics Board of the University of Guelph (REB#17-07-003).

Informed Consent Statement: All parents provided written consent and, when possible, children provided assent.

Data Availability Statement: Interested researchers can contact GFHS investigators to explore data availability in alignment with the University of Guelph Research Ethics Board.

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Conflicts of Interest: The authors declare no conflict of interest related to this work.

References

1. U.S. Department of Agriculture; U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025; 9th ed.; December 2020. Available online: https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf (accessed on 10 May 2023).
2. National Health and Medical Research Council. *Australian Dietary Guidelines*; National Health and Medical Research Council: Canberra, Australia, 2013.
3. High Council for Public Health, Paris, Île-de-France, France. French Nutrition and Health Programme's Dietary Guidelines for Adults. 2017. Available online: https://www.fao.org/nutrition/education-nutritionnelle/food-dietary-guidelines/regions/france/previous-versions/fr/ (accessed on 14 May 2023).
4. Ministry of Food, Agriculture and Fisheries of Denmark. The Official Dietary Guidelines Good for Health and Climate. Available online: https://foedevarestyrelsen.dk/publikationer/2021/the-official-dietary-guidelines-good-for-health-and-climate-booklet (accessed on 16 May 2023).
5. Health Canada. Canada's Dietary Guidelines For Health Professionals and Policy Makers. 2019. Available online: https://food-guide.canada.ca/sites/default/files/artifact-pdf/CDG-EN-2018.pdf (accessed on 25 May 2023).
6. Neufingerl, N.; Eilander, A. Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review. *Nutrients* **2021**, *14*, 29. [CrossRef] [PubMed]
7. Parker, H.W.; Vadiveloo, M.K. Diet quality of vegetarian diets compared with nonvegetarian diets: A systematic review. *Nutr. Rev.* **2019**, *77*, 144–160. [CrossRef]
8. Satija, A.; Bhupathiraju, S.N.; Spiegelman, D.; Chiuve, S.E.; Manson, J.E.; Willett, W.; Rexrode, K.M.; Rimm, E.B.; Hu, F.B. Healthful and unhealthful plant-based diets and the risk of coronary heart disease in U.S. adults. *J. Am. Coll. Cardiol.* **2017**, *70*, 411–422. [CrossRef] [PubMed]
9. Heianza, Y.; Zhou, T.; Sun, D.; Hu, F.B.; Qi, L. Healthful plant-based dietary patterns, genetic risk of obesity, and cardiovascular risk in the UK biobank study. *Clin. Nutr.* **2021**, *40*, 4694–4701. [CrossRef] [PubMed]
10. Song, S.; Lee, K.; Park, S.; Shin, N.; Kim, H.; Kim, J. Association between Unhealthful Plant-Based Diets and Possible Risk of Dyslipidemia. *Nutrients* **2021**, *13*, 4334. [CrossRef]
11. Kouvari, M.; Tsiampalis, T.; Chrysohoou, C.; Georgousopoulou, E.; Skoumas, J.; Mantzoros, C.S.; Pitsavos, C.S.; Panagiotakos, D.B. Quality of plant-based diets in relation to 10-year cardiovascular disease risk: The ATTICA cohort study. *Eur. J. Nutr.* **2022**, *61*, 2639–2649. [CrossRef]

12. Satija, A.; Bhupathiraju, S.N.; Rimm, E.B.; Spiegelman, D.; Chiuve, S.E.; Borgi, L.; Willett, W.C.; Manson, J.E.; Sun, Q.; Hu, F.B. Plant-based dietary patterns and incidence of type 2 diabetes in US men and women: Results from three prospective cohort studies. *PLoS Med.* **2016**, *13*, e1002039. [CrossRef] [PubMed]
13. Wang, F.; Baden, M.Y.; Guasch-Ferré, M.; Wittenbecher, C.; Li, J.; Li, Y.; Wan, Y.; Bhupathiraju, S.N.; Tobias, D.K.; Clish, C.B.; et al. Plasma metabolite profiles related to plant-based diets and the risk of type 2 diabetes. *Diabetologia* **2022**, *65*, 1119–1132. [CrossRef]
14. Sasanfar, B.; Toorang, F.; Booyani, Z.; Vassalami, F.; Mohebbi, E.; Azadbakht, L.; Zendehdel, K. Adherence to plant-based dietary pattern and risk of breast cancer among Iranian women. *Eur. J. Clin. Nutr.* **2021**, *75*, 1578–1587. [CrossRef] [PubMed]
15. Rigi, S.; Mousavi, S.M.; Benisi-Kohansal, S.; Azadbakht, L.; Esmaillzadeh, A. The association between plant-based dietary patterns and risk of breast cancer: A case-control study. *Sci. Rep.* **2021**, *11*, 3391. [CrossRef]
16. Romanos-Nanclares, A.; Willett, W.C.; Rosner, B.A.; Collins, L.C.; Hu, F.B.; Toledo, E.; Eliassen, A.H. Healthful and unhealthful plant-based diets and risk of breast cancer in U.S. women: Results from the Nurses' Health Studies. *Cancer Epidemiol. Biomark. Prev.* **2021**, *30*, 1921–1931. [CrossRef]
17. Martínez-González, M.A.; Sánchez-Tainta, A.; Corella, D.; Salas-Salvadó, J.; Ros, E.; Arós, F.; Gómez-Gracia, E.; Fiol, M.; Lamuela-Raventós, R.M.; Schröder, H.; et al. A provegetarian food pattern and reduction in total mortality in the Prevención con Dieta Mediterránea (PREDIMED) study. *Am. J. Clin. Nutr.* **2014**, *100*, 320S–3208S. [CrossRef] [PubMed]
18. Kim, J.; Kim, H.; Giovannucci, E.L. Plant-based diet quality and the risk of total and disease-specific mortality: A population-based prospective study. *Clin. Nutr.* **2021**, *40*, 5718–5725. [CrossRef] [PubMed]
19. Weston, L.J.; Kim, H.; Talegawkar, S.A.; Tucker, K.L.; Correa, A.; Rebholz, C.M. Plant-based diets and incident cardiovascular disease and all-cause mortality in African Americans: A cohort study. *PLoS Med.* **2022**, *19*, e1003863. [CrossRef]
20. Heidemann, C.; Schulze, M.B.; Franco, O.H.; van Dam, R.M.; Mantzoros, C.S.; Hu, F.B. Dietary patterns and risk of mortality from cardiovascular disease, cancer, and all causes in a prospective cohort of women. *Circulation* **2008**, *118*, 230–237. [CrossRef]
21. Kim, H.; Rebholz, C.M.; Garcia-Larsen, V.; Steffen, L.M.; Coresh, J.; Caulfield, L.E. Operational differences in plant-based diet indices affect the ability to detect associations with incident hypertension in middle-aged US adults. *J. Nutr.* **2020**, *150*, 842–850. [CrossRef] [PubMed]
22. Chen, Z.; Drouin-Chartier, J.P.; Li, Y.; Baden, M.Y.; Manson, J.E.; Willett, W.C.; Voortman, T.; Hu, F.B.; Bhupathiraju, S.N. Changes in plant-based diet indices and subsequent risk of type 2 diabetes in women and men: Three U.S. prospective cohorts. *Diabetes Care* **2021**, *44*, 663–671. [CrossRef]
23. Laouali, N.; Shah, S.; MacDonald, C.J.; Mahamat-Saleh, Y.; El Fatouhi, D.; Mancini, F.; Fagherazzi, G.; Boutron-Ruault, M.C. BMI in the associations of plant-based diets with type 2 diabetes and hypertension risks in women: The E3N prospective cohort study. *J. Nutr.* **2021**, *151*, 2731–2740. [CrossRef]
24. Thompson, A.S.; Tresserra-Rimbau, A.; Karavasiloglou, N.; Jennings, A.; Cantwell, M.; Hill, C.; Perez-Cornago, A.; Bondonno, N.P.; Murphy, N.; Rohrmann, S.; et al. Association of healthful plant-based diet adherence with risk of mortality and major chronic diseases among adults in the UK. *JAMA Netw. Open* **2023**, *6*, e234714. [CrossRef]
25. Lee, K.; Kim, H.; Rebholz, C.; Kim, J. Association between different types of plant-based diets and risk of dyslipidemia: A prospective cohort study. *Nutrients* **2021**, *13*, 220. [CrossRef]
26. Luque, V.; Closa-Monasterolo, R.; Grote, V.; Ambrosini, G.L.; Zaragoza-Jordana, M.; Ferré, N.; Theurich, M.; Koletzko, B.; Verduci, E.; Gruszfeld, D.; et al. Dietary patterns acquired in early life are associated with cardiometabolic markers at school age. *Clin. Nutr.* **2021**, *40*, 4606–4614. [CrossRef] [PubMed]
27. Mikkilä, V.; Räsänen, L.; Raitakari, O.T.; Pietinen, P.; Viikari, J. Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. *Br. J. Nutr.* **2005**, *93*, 923–931. [CrossRef] [PubMed]
28. Wallace, A.; Kirkpatrick, S.I.; Darlington, G.; Haines, J. Accuracy of parental reporting of preschoolers' dietary intake using an online self-administered 24-h recall. *Nutrients* **2018**, *10*, 987. [CrossRef] [PubMed]
29. Health Canada. Nutrition Labelling: Table of Reference Amounts for Food. 2016. Available online: https://www.canada.ca/content/dam/hc-sc/healthy-canadians/migration/eating-nutrition/label-etiquetage/regulatory-guidance-directives-reglementaires/reference-amounts-food-quantites-reference-aliments/alt/reference-amounts-food-quantites-reference-aliments-eng.pdf (accessed on 14 June 2023).
30. Roberts, M.; Tolar-Peterson, T.; Reynolds, A.; Wall, C.; Reeder, N.; Rico Mendez, G. The effects of nutritional interventions on the cognitive development of preschool-age children: A systematic review. *Nutrients* **2022**, *14*, 532. [CrossRef] [PubMed]
31. Chen, G.; Su, M.; Chu, X.; Wei, Y.; Chen, S.; Zhou, Y.; Liu, Z.; Zhang, Z. Plant-based diets and body composition in Chinese omnivorous children aged 6–9 years old: A cross-sectional study. *Front Nutr.* **2022**, *9*, 918944. [CrossRef]
32. Asoudeh, F.; Mousavi, S.M.; Keshteli, A.H.; Hasani-Ranjbar, S.; Larijani, B.; Esmaillzadeh, A.; Adibi, P. The association of plant-based dietary pattern with general and abdominal obesity: A large cross-sectional study. *J. Diabetes Met. Disord.* **2023**, *22*, 469–477. [CrossRef]
33. Zamani, B.; Daneshzad, E.; Siassi, F.; Guilani, B.; Bellissimo, N.; Azadbakht, L. Association of plant-based dietary patterns with psychological profile and obesity in Iranian women. *Clin Nutr.* **2020**, *39*, 1799–1808. [CrossRef]
34. Shirzadi, Z.; Daneshzad, E.; Dorosty, A.; Surkan, P.J.; Azadbakht, L. Associations of plant-based dietary patterns with cardiovascular risk factors in women. *J. Cardiovasc. Thorac. Res.* **2022**, *14*, 1–10. [CrossRef]

35. Bolori, P.; Setaysh, L.; Rasaei, N.; Jarrahi, F.; Yekaninejad, M.S.; Mirzaei, K. Adherence to a healthy plant diet may reduce inflammatory factors in obese and overweight women—A cross-sectional study. *Diabetes Metab. Syndr.* **2019**, *13*, 2795–2802. [CrossRef]
36. Ma, Y.; Tan, J.; Tan, Z.; Shang, L. Validity and reliability of semiquantitative food frequency questionnaires for assessing nutrient intake among preschool children in northwest China. *J. Healthc. Eng.* **2022**, *2022*, 1677252. [CrossRef]
37. Fox, M.K.; Condon, E.; Briefel, R.R.; Reidy, K.C.; Deming, D.M. Food consumption patterns of young preschoolers: Are they starting off on the right path? *J. Am. Diet. Assoc.* **2010**, *110*, S52–S59. [CrossRef] [PubMed]
38. Dror, D.K.; Allen, L.H. Dairy product intake in children and adolescents in developed countries: Trends, nutritional contribution, and a review of association with health outcomes. *Nutr. Rev.* **2014**, *72*, 68–81. [CrossRef] [PubMed]
39. Liu, R.H. Health-promoting components of fruits and vegetables in the diet. *Adv. Nutr.* **2013**, *4*, 384S–392S. [CrossRef]
40. Papanikolaou, Y.; Slavin, J.L.; Clemens, R.; Brenna, J.T.; Hayes, D.; Gaesser, G.A.; Fulgoni, V.L. III. Do refined grains have a place in a healthy dietary pattern: Perspectives from an expert panel consensus meeting. *Curr. Dev. Nutr.* **2020**, *4*, nzaa125. [CrossRef] [PubMed]
41. Fulton, S.L.; McKinley, M.C.; Young, I.S.; Cardwell, C.R.; Woodside, J.V. The effect of increasing fruit and vegetable consumption on overall diet: A systematic review and meta-analysis. *Crit. Rev. Food Sci. Nutr.* **2016**, *56*, 802–816. [CrossRef] [PubMed]
42. Mead, L.C.; Hill, A.M.; Carter, S.; Coates, A.M. The effect of nut consumption on diet quality, cardiometabolic and gastrointestinal health in children: A systematic review of randomized controlled trials. *Int. J. Environ. Res. Public Health* **2021**, *18*, 454. [CrossRef]

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Impact of Plant Protein Intakes on Nutrient Adequacy in the US

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Abstract: There is an increasing interest in plant-based diets and higher levels of plant proteins due to rising concerns around health and environmental sustainability issues. We determined the effects of increasing quartiles of plant protein in the diet on nutrient adequacy using a large nationally representative observational dataset. Twenty-four-hour dietary-recall data from NHANES 2013–2018 from 19,493 participants aged 9+ years were used to assess nutrient intakes. Nutritional adequacy was assessed by estimating the percentage of the population with intakes below the EAR or above the AI. A quartile trend was assessed using regression and the significance was set at $P_{quartile\ trend} < 0.05$. With increasing quartiles of plant protein, the adequacy decreased for calcium, potassium, and vitamin D and increased for copper and magnesium for adolescents. Among the adults aged 19–50 years, the adequacy decreased for protein, choline, selenium, vitamin B_{12}, and zinc and increased for copper, folate, iron, magnesium, thiamin, and vitamin C with increasing quartiles of plant protein. The adequacy for calcium, vitamin A, and zinc decreased and it increased for copper, folate, magnesium, thiamin, and vitamin C with increasing quartiles of plant protein among adults aged 51+ years. The results indicate that diets of mixed protein sources (from both animals and plants) are the most nutritionally adequate.

Keywords: protein; plant protein; NHANES; National Health and Nutrition Examination Survey; nutrient adequacy

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1. Introduction

Dietary proteins, particularly component amino acids, are essential for physiological functions and play a critical role in human health and longevity. Many protein sources are available for consumption in the human diet. The Dietary Guidelines for Americans, 2020–2025 recommend a variety of protein foods from both animal and plant sources in healthy dietary patterns [1]. Recently, there has been growing interest in plant-based diets and, more specifically, diets that incorporate higher levels of plant proteins due to rising concerns around health and environmental sustainability [2]. Furthermore, vegetarianism is a growing food-consumption trend and eating behavior [3–6]. According to a recent estimate, approximately 4 billion people globally primarily consume a plant-based diet (which totally or mostly excludes foods of animal origin [7]), and about 60% of the dietary proteins come from plant sources [8,9]. In the US, about a one-third of protein comes from plant sources, which are primarily derived from grain foods [10].

In addition to their protein content, protein foods can be rich in other nutrients. Plant protein foods, such as legumes (including soybeans and pulses), nuts, seeds, and cereal grains contribute to dietary fiber, potassium, folate, vitamin E, and magnesium, while animal-based protein sources, such as meat and dairy products, contribute zinc, vitamin B_{12}, vitamin D, calcium, phosphorus, and iron [11–14]. Legumes can also contribute significant non-heme iron to diets [11]. The effect of different dietary patterns on meeting

protein/amino acid needs, given the impact of numerous different food sources of protein on nutrient intake, nutrient adequacy, and diet quality, is an important consideration in dietary planning. A balanced diet consisting of a variety of food groups has been consistently recommended in dietary guidelines from around the world [15,16]. The Dietary Guidelines for Americans, 2020–2025 also recommend a variety of nutrient-dense protein foods from both plant (beans, peas, lentils, and cereal grains) and animal sources (lean meat, poultry, fish, eggs, as well as low-fat dairy products) to ensure adequate nutrient intake [1].

A systematic review of 141 observational and intervention studies comparing nutritional intakes from plant-based diets and meat-based diets found dietary inadequacies across all dietary patterns and concluded that, while the intakes and status of fiber, folate, vitamin C, vitamin E, and magnesium were higher, vitamin B_{12}, vitamin D, iron, zinc, iodine, and calcium intake and status were lower in vegetarians compared to meat eaters [17]. Alles et al. [18] demonstrated that vegetarians also exhibited a lower estimated prevalence of inadequacies for fiber, vitamin C, and vitamin E and a greater prevalence of inadequacy for thiamin, niacin, vitamin B_6, vitamin B_{12}, zinc, and potassium compared to meat-eaters in a prospective observational study of a French cohort. In a dietary-modeling analysis in NHANES 2007–2010, the prevalence of inadequacy for calcium, vitamin A, and vitamin D increased and it decreased for vitamin C, vitamin E, folate, fiber, iron, and magnesium when animal foods were completely replaced by equal amounts of plant-based foods [19].

As authoritative organizations increasingly promote diets that are higher in plant protein foods, there could be nutritional implications that require consideration. In our recent analyses of U. S. and Canadian cross-sectional data, we reported that dietary protein amount and quality decreased with increasing intakes of plant protein among American and Canadian adults [20,21]. Given the different nutrient contents of plant-based and animal-based protein foods, the objective of this study was to determine the effects of increasing plant-based protein foods in the diet on the nutrient adequacy of not only protein/amino acids, but also other nutrients with dietary reference intakes using a large, nationally representative database of American children and adults. Our a priori hypothesis was that increasing plant-based protein would contribute to the adequacy of some nutrients and reduce the adequacy for other nutrients.

2. Materials and Methods

2.1. Database and Subjects

This cross-sectional analysis used food and nutrient data from What We Eat in America (WWEIA), the dietary component of the National Health and Nutrition Examination Survey (NHANES). The NHANES is an ongoing nationally representative survey research program designed to assess the health and nutritional status of the non-institutionalized U.S. civilian resident population. It is currently a continuous survey conducted by the National Center for Health Statistics (NCHS) using complex, multistage, stratified, and probability sampling methods [22]. For the present analysis, we used data from adolescents aged 9–18 years and adults aged 19–50 and 51+ years, excluding pregnant and/or lactating females and those with zero calorie intake, participating in NHANES 2013–2014, NHANES 2015–2016, and NHANES 2017–2018 (3 consecutive NHANES survey cycles). The final analytic sample consisted of 4605 adolescents aged 9–18 years, 7617 adults aged 19–50 years, and 7271 adults aged 51+ years (see Supplementary Table S1 for participant flow chart). A detailed description of the subject recruitment, survey design, and data collection methods is available online [22] and all data obtained for this study are publicly available at http://www.cdc.gov/nchs/nhanes/, (accessed on 15 August 2021). As the present study was a secondary data analysis that lacked personal identifiers, additional approvals by institutional review boards were not necessary.

2.2. Dietary Intake

Dietary intake data were obtained from reliable in-person 24-h dietary-recall interviews (day 1) using USDA's automated multiple-pass method in the Mobile Examination Center and included a description and the amount of the individual foods and beverages consumed during the 24-h period before the interview (midnight to midnight) for each participant. Complete descriptions of the dietary-interview methods for NHANES are provided elsewhere [22]. Energy and nutrient intake were determined using the NHANES-cycle-specific USDA Food & Nutrient Database for Dietary Studies (FNDDS), as reported in the total nutrient intake files available online [23].

2.3. Calculation of Protein from Plant Sources

The determination of protein sources was similar to that published previously [21]. Briefly, food group composition of each food and beverage consumed was determined using the Food Patterns Equivalents Database (FPED) [24] and intake of protein from foods was determined using the NHANES-cycle-specific FNDDS [23]. To estimate the percentage protein from plant foods, the protein for each food code was regressed onto all of the individual FPED components for all food codes. A regression coefficient (beta) for the protein content of each FPED component was obtained for each FPED component. The estimated percentage protein from a food component was then calculated as follows: [(beta × FPED component)/$\sum$(beta × FPED component)] × 100 [21]. The sum of protein from the non-animal FPED components (fruit, vegetables, grains, soybean, nuts and seeds, and beans and peas) provided an estimate of plant protein intake.

2.4. Statistics

Data were analyzed using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA) after adjusting for the complex sample design of NHANES using appropriate survey weights, strata, primary sampling units, and day one dietary-sample weights. The National Cancer Institute (NCI) method was used to determine the individual usual intakes (IUI) of plant protein and NCI macros were used to estimate distribution of usual intake [25]. Intake quartile ranges across the 25th, 50th, and 75th percentiles were established for the primary analysis, with subjects assigned to quartiles based on individual usual intakes (IUI). The percentage of the population below the Estimated Average Requirement (EAR) or above the Adequate Intake (AI) of nutrients was assessed using the cut-point method (except for iron, for which the probability method was used) to estimate nutrient adequacy [26]. Supplemental analyses were undertaken using defined levels (DFL) of plant protein intake: DFL 1: <25% plant protein; DFL 2: 25%–<50% plant protein; DFL 3: 50%–<75% plant protein; and DFL 4: ≥75% plant protein) for further evaluation across higher consumption levels of plant protein. A quartile trend was assessed using regression of quartile or DFL number (1–4) and mean percentage of the population below the EAR or above AI of each quartile or DFL. The regression coefficient from these analyses provides an evaluation of the relationship of progressively higher levels of plant protein intake on meeting nutrient recommendations (e.g., by representing expected change from each progressively higher intake of plant protein), All data were presented as the mean ± SEM.

3. Results

3.1. Demographics

3.1.1. Adolescents Aged 9–18 Years

The demographic characteristics of the study population of adolescents across the quartiles of plant protein intake are summarized in Table 1. Overall, 4605 U. S. adolescents aged 9–18 years were included the analysis, in which 50.6% of the sample were males. With increasing quartiles of plant protein intake, the percentages of non-Hispanic Asians, those with education below high school, moderate physical activity, and lifetime non-smokers increased ($P_{\text{quartile trend}} < 0.05$), whereas the mean age and the percentages of males, non-

Hispanic Blacks, those with high school education, vigorous physical activity, and obesity decreased ($P_{quartile\ trend} < 0.05$).

Table 1. Demographics of adolescents aged 9–18 years for quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<29.2%)	**Quartile 2 (29.2% to <32.6%)**	**Quartile 3 (32.6% to <36.1%)**	**Quartile 4 (≥36.1%)**	**Beta**	***p***
Sample n	1135	1133	1201	1136		
Population N	10,513,029	10,540,175	10,524,187	10,536,384		
Age (mean)	14.2 ± 0.1	13.7 ± 0.1 *	13.2 ± 0.1 *	13.2 ± 0.1 *	−0.36 ± 0.06	<0.0001
Male (%)	65.4 ± 1.9	52.9 ± 2.3 *	45.6 ± 2.4 *	38.3 ± 2.4 *	−8.86 ± 0.96	<0.0001
Ethnicity						
Hispanic (%)	22.3 ± 2.7	24.5 ± 2.8	25.7 ± 2.7	23.5 ± 3.0	0.47 ± 0.78	0.5492
Non-Hispanic White (%)	53.5 ± 3.1	51.2 ± 3.5	50.1 ± 3.3	50.5 ± 3.5	−1.02 ± 0.95	0.2848
Non-Hispanic Black (%)	15.3 ± 1.9	14.4 ± 1.8	13.8 ± 1.6	11.3 ± 1.5 *	−1.23 ± 0.44	0.0081
Non-Hispanic Asian (%)	4.52 ± 0.73	2.96 ± 0.53 *	5.27 ± 1.01	6.47 ± 1.20	0.82 ± 0.36	0.0283
Other (%)	4.37 ± 1.05	6.92 ± 0.96 *	5.01 ± 0.88	8.23 ± 1.66	0.96 ± 0.63	0.1314
Poverty Income Ratio (PIR)						
<1.35 (%)	32.8 ± 2.7	32.2 ± 2.8	33.0 ± 2.4	31.4 ± 2.5	−0.36 ± 1.09	0.7423
1.35 ≤ 1.85 (%)	12.8 ± 1.8	13.1 ± 1.5	13.0 ± 1.3	10.3 ± 1.1	−0.77 ± 0.68	0.2654
>1.85 (%)	54.3 ± 2.9	54.8 ± 3.0	54.1 ± 2.7	58.3 ± 2.6	1.13 ± 1.03	0.2788
Education						
<High School (%)	99.0 ± 0.3	98.4 ± 0.5	99.1 ± 0.3	99.6 ± 0.2	0.23 ± 0.11	0.0469
High School (%)	0.97 ± 0.28	1.58 ± 0.47	0.85 ± 0.32	0.45 ± 0.20	−0.23 ± 0.11	0.0469
>High School (%)	0	0	0	0	0	
Physical Activity						
Sedentary (%)	17.1 ± 1.6	22.0 ± 1.8 *	21.3 ± 1.9	18.0 ± 1.7	0.20 ± 0.78	0.8038
Moderate (%)	24.8 ± 1.7	27.9 ± 1.9	29.7 ± 1.8	36.9 ± 2.2 *	3.81 ± 0.87	0.0001
Vigorous (%)	58.1 ± 2.3	50.1 ± 2.1 *	49.0 ± 2.4 *	45.1 ± 2.2 *	−4.01 ± 0.97	0.0001
Smoking Never (%)	80.9 ± 1.8	89.3 ± 1.6 *	91.6 ± 1.2 *	91.9 ± 1.3 *	3.52 ± 0.56	<0.0001
Smoking Current (%)	3.06 ± 0.76	1.15 ± 0.49 *	1.78 ± 0.58	1.58 ± 0.77	−0.38 ± 0.32	0.2454
Overweight (%)	18.5 ± 1.7	15.3 ± 1.4	16.7 ± 1.5	16.9 ± 1.5	−0.32 ± 0.74	0.6628
Obese (%)	22.9 ± 2.1	25.0 ± 2.2	18.7 ± 1.4	17.9 ± 1.4	−2.12 ± 0.85	0.0166

Data are presented as mean ± SE. * indicates significant difference from quartile 1 at $p < 0.05$.

3.1.2. Adults Aged 19–50 Years

The demographic characteristics of the study population of adults aged 19–50 years across quartiles of plant protein intake are summarized in Table 2. Of the 7617 U. S. adults (19–50 years) included, 51.5% were males. With increasing quartiles of plant protein intake, the mean age and the percentages of Hispanics, non-Hispanic Asians, those with a college degree, and lifetime non-smokers increased ($P_{quartile\ trend} < 0.05$), whereas the percentages of males, non-Hispanic Blacks, those with lower economic status (poverty income ratio (PIR) < 1.35), education below high school and below a college degree, current smokers, and obesity decreased ($P_{quartile\ trend} < 0.05$).

Table 2. Demographics of adults aged 19–50 years for quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<27.7%)	**Quartile 2 (27.7% to <31.4%)**	**Quartile 3 (31.4% to <35.5%)**	**Quartile 4 (≥35.5%)**	**Beta**	***p***
Sample n	1953	1830	1868	1966		
Population N	31,745,397	31,767,866	31,736,234	31,791,659		

Table 2. *Cont.*

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<27.7%)	**Quartile 2 (27.7% to <31.4%)**	**Quartile 3 (31.4% to <35.5%)**	**Quartile 4 (≥35.5%)**	**Beta**	***p***
Age (mean)	33.2 ± 0.3	34.1 ± 0.3	34.6 ± 0.4 *	35.1 ± 0.3 *	0.62 ± 0.13	<0.0001
Male (%)	60.9 ± 1.4	56.1 ± 1.7 *	46.8 ± 1.7 *	42.4 ± 1.4 *	−6.49 ± 0.64	<0.0001
Ethnicity						
Hispanic (%)	15.9 ± 1.5	17.8 ± 1.7	22.1 ± 2.1 *	23.9 ± 2.1 *	2.84 ± 0.47	<0.0001
Non-Hispanic White (%)	56.2 ± 2.7	59.2 ± 2.3	57.8 ± 2.3	53.1 ± 2.6	−1.06 ± 0.83	0.2064
Non-Hispanic Black (%)	20.4 ± 2.0	13.4 ± 1.3 *	9.92 ± 1.13 *	6.41 ± 0.77 *	−4.55 ± 0.50	<0.0001
Non-Hispanic Asian (%)	3.20 ± 0.36	4.11 ± 0.55	6.76 ± 0.94 *	12.3 ± 1.5 *	3.00 ± 0.46	<0.0001
Other (%)	4.32 ± 0.68	5.46 ± 0.74	3.38 ± 0.57	4.28 ± 0.71	−0.22 ± 0.27	0.4122
Poverty Income Ratio (PIR)						
<1.35 (%)	30.1 ± 2.1	26.7 ± 1.5	23.3 ± 1.5 *	25.3 ± 1.6 *	−1.77 ± 0.70	0.0146
1.35 ≤ 1.85 (%)	9.67 ± 1.19	9.80 ± 0.98	12.2 ± 1.1	11.5 ±0.9	0.78 ± 0.46	0.0944
>1.85 (%)	60.3 ± 2.2	63.5 ± 2.0	64.6 ± 1.9 *	63.2 ± 1.7	0.99 ± 0.72	0.1754
Education						
<High School (%)	40.0 ± 1.8	37.9 ± 2.0	36.1 ± 2.0	33.4 ± 2.1 *	−2.16 ± 0.80	0.0094
High School (%)	36.0 ± 1.4	35.8 ± 1.6	32.9 ± 1.5	30.2 ± 1.4 *	−2.05 ± 0.56	0.0007
>High School (%)	24.0 ± 1.8	26.4 ± 2.2	31.0 ± 1.9 *	36.4 ± 2.2 *	4.21 ± 0.55	<0.0001
Physical Activity						
Sedentary (%)	14.8 ± 1.0	16.5 ± 1.3	19.0 ± 1.3 *	13.9 ± 1.2	−0.05 ± 0.50	0.9249
Moderate (%)	27.1 ± 1.6	28.8 ± 1.6	29.8 ± 1.4	29.0 ± 1.6	0.66 ± 0.70	0.3475
Vigorous (%)	58.0 ± 1.8	54.7 ± 1.6	51.2 ± 1.6 *	57.1 ± 1.8	−0.61 ± 0.89	0.4917
Smoking Never (%)	53.9 ± 1.4	56.1 ± 1.6	61.7 ± 2.0 *	64.1 ± 1.7 *	3.60 ± 0.67	<0.0001
Smoking Current (%)	25.0 ± 1.5	23.6 ± 1.6	18.0 ± 1.5 *	14.1 ± 1.2 *	−3.84 ± 0.65	<0.0001
Overweight (%)	29.7 ± 1.5	29.2 ± 1.7	31.4 ± 1.5	30.5 ± 1.5	0.47 ± 0.65	0.4717
Obese (%)	44.1 ± 1.6	41.3 ± 2.3	37.2 ± 1.6 *	32.4 ± 1.7 *	−3.91 ± 0.65	<0.0001

Data are presented as mean ± SE. * indicates significant difference from quartile 1 at $p < 0.05$.

3.1.3. Adults Aged 51+ Years

The demographic characteristics of the study population of adults aged 51+ years across the quartiles of plant protein (n = 7271) intake are summarized in Table 3, where 46.5% of the individuals were males. With increasing quartiles of plant protein intake, the mean age and the percentages of Hispanics, non-Hispanic Asians, those with college degrees, and lifetime non-smokers increased ($P_{\text{quartile trend}} < 0.05$), whereas the percentages of males, non-Hispanic Blacks, those with lower economic status (PIR < 1.35), education below college degree, current smokers, and obesity decreased ($P_{\text{quartile trend}} < 0.05$).

Table 3. Demographics of adults age 51+ years for quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<29.0%)	**Quartile 2 (29.0% to <33.0%)**	**Quartile 3 (33.0% to <37.0%)**	**Quartile 4 (≥37.0%)**	**Beta**	***p***
Sample n	1774	1783	1766	1948		
Population N	26,533,778	26,665,323	26,590,574	26,613,325		
Age (mean)	62.7 ± 0.3	64.1 ± 0.4 *	64.7 ± 0.4 *	65.0 ± 0.4 *	0.77 ± 0.13	<0.0001
Male (%)	50.2 ± 1.7	46.6 ± 1.5	46.8 ±1.5	42.5 ± 1.9 *	−2.30 ± 0.88	0.0124
Ethnicity						
Hispanic (%)	7.82 ± 1.11	9.13 ± 1.21	9.98 ± 1.16 *	12.1 ± 1.3 *	1.35 ± 0.38	0.0009
Non-Hispanic White (%)	72.6 ± 2.2	74.3 ± 2.35	75.1 ± 1.9	69.2 ± 2.3	−0.94 ± 0.74	0.2083
Non-Hispanic Black (%)	15.7 ± 1.6	11.1 ± 1.14 *	7.35 ± 0.94 *	5.30 ± 0.67 *	−3.50 ± 0.43	<0.0001
Non-Hispanic Asian (%)	1.20 ± 0.19	2.84 ± 0.56 *	3.75 ± 0.50 *	10.4 ± 1.5 *	2.85 ± 0.43	<0.0001
Other (%)	2.65 ± 0.57	2.68 ± 0.86	3.80 ± 0.94	3.08 ± 0.63	0.24 ± 0.31	0.4513

Table 3. *Cont.*

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<29.0%)	**Quartile 2 (29.0% to <33.0%)**	**Quartile 3 (33.0% to <37.0%)**	**Quartile 4 (≥37.0%)**	**Beta**	***p***
Poverty Income Ratio (PIR)						
<1.35 (%)	21.3 ± 2.0	19.9 ± 1.4	16.9 ± 1.3 *	18.1 ± 1.7	−1.26 ± 0.62	0.0487
1.35 ≤ 1.85 (%)	8.42 ± 0.87	9.90 ± 0.89	9.17 ± 0.88	11.6 ± 1.5	0.88 ± 0.55	0.1193
>1.85 (%)	70.3 ± 2.5	70.2 ± 1.8	73.9 ± 1.7	70.3 ± 2.4	0.38 ± 0.82	0.6449
Education						
<High School (%)	38.7 ± 2.3	40.2 ± 2.2	38.6 ± 2.2	35.2 ± 1.8	−1.22 ± 0.84	0.1543
High School (%)	33.0 ± 1.8	32.5 ± 1.7	30.8 ± 1.8	27.6 ± 1.9 *	−1.80 ± 0.77	0.0245
>High School (%)	28.3 ± 2.3	27.3 ± 2.1	30.6 ± 2.4	37.2 ± 2.2 *	3.02 ± 0.82	0.0006
Physical Activity						
Sedentary (%)	29.9 ± 1.7	28.4 ± 2.1	26.6 ± 1.5	27.1 ± 1.6	−1.04 ± 0.76	0.1806
Moderate (%)	39.0 ± 2.0	42.8 ± 2.2	42.4 ± 1.8	42.7 ± 1.9	1.06 ± 1.02	0.3076
Vigorous (%)	31.0 ± 1.9	28.8 ± 1.5	31.0 ± 1.9	30.2 ± 2.1	−0.02 ± 0.79	0.9788
Smoking Never (%)	42.9 ± 2.5	51.5 ± 2.0 *	50.0 ± 2.2 *	55.7 ± 1.6 *	3.70 ± 0.72	<0.0001
Smoking Current (%)	21.0 ± 1.9	16.6 ± 1.6	16.3 ± 1.8	11.7 ± 1.2 *	−2.82 ± 0.49	<0.0001
Overweight (%)	33.0 ± 2.1	33.7 ± 1.6	34.8 ± 1.6	34.8 ± 1.8	0.65 ± 0.86	0.4556
Obese (%)	45.3 ± 2.3	45.3 ± 1.9	39.5 ± 1.8 *	36.5 ± 1.7 *	−3.23 ± 0.74	0.0001

Data are presented as mean ± SE. * indicates significant difference from quartile 1 at $p < 0.05$.

3.2. Nutrient Adequacy

3.2.1. Adolescents Aged 9–18 Years

Table 4 shows the data for the percentage of the population below the EAR and above the AI (for fiber, choline, potassium, sodium, and vitamin K only) with increasing quartiles of plant protein intake in gender-combined adolescents aged 9–18 years. The usual protein intake was 71.7 ± 0.9 g/day and 35.5% of this was from plant sources. With increasing quartiles of plant protein intakes, the percentage of the population below the EAR increased significantly ($P_{quartile\ trend} < 0.05$) for calcium (beta = 5.82 ± 1.36% units per quartile) and vitamin D (beta = 4.02 ± 0.65% units per quartile) and decreased ($P_{quartile\ trend} < 0.05$) for copper (beta = −3.24 ± 1.02% units per quartile) and magnesium (beta = −6.08 ± 0.40% units per quartile). With increasing quartiles of plant protein intakes, the percentage of the population above the AI increased significantly ($P_{quartile\ trend} < 0.05$) for sodium (beta = 0.10 ± 0.03% units per quartile) and decreased significantly ($P_{quartile\ trend} < 0.05$) for potassium (beta = −11.1 ± 1.7% units per quartile). The percentages of the population below the EAR were numerically lowest as follows: for niacin, selenium, vitamin B_{12}, vitamin B_6, vitamin D, and zinc at quartile 1 (<29.2% plant protein); for calcium, vitamin A, and vitamin C at quartile 2 (29.2% to <32.6% plant protein); for copper, folate, iron, riboflavin, and thiamin for quartile 3 (32.6% to <36.1% plant protein); and for magnesium and vitamin E at quartile 4 (>36.1%) of plant protein intake. The percentages of the population above the AI were numerically the highest as follows: for choline and potassium at quartile 1 (<29.2% plant protein); for vitamin K at quartile 2 (29.2% to <32.6% plant protein); and for fiber and sodium at quartile 4 (>36.1%) of plant protein intake.

Similar results were obtained when nutrient adequacy was analyzed across the DFL of the plant protein intake (Supplementary Table S2). For most nutrients (except for fiber, magnesium, sodium, vitamin C, and vitamin E) the numerically lowest percentage of the population below the EAR and the highest percentage of the population above the AI were found when the plant protein was below 50% (DFL 1 and DFL 2) and, for magnesium, vitamin C, and vitamin E, at a plant protein DFL between 50% and ≥75% (DFL 3 to DFL 4).

Table 4. Percentages of adolescents aged 9–18 years with nutrient intakes below estimated average requirement (EAR) or above adequate intake (AI) across quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<29.2%)	**Quartile 2 (29.2% to <32.6%)**	**Quartile 3 (32.6% to <36.1%)**	**Quartile 4 (≥36.1%)**	**Beta**	***p***
Nutrients with EAR [1]	% Population with intakes below EAR					
Protein	0.90 ± 0.09	0.28 ± 0.32	0.69 ± 0.59	7.15 ± 2.32 *	2.14 ± 1.04	0.1316
Calcium	58.5 ± 3.0	58.4 ± 2.9	67.0 ± 3.2	75.1 ± 3.5 *	5.82 ± 1.36	0.0236
Copper	15.8 ± 2.3	10.3 ± 2.3	5.76 ± 1.83 *	6.51 ± 1.96 *	−3.24 ± 1.02	0.0496
Folate, DFE	19.2 ± 3.6	7.12 ± 2.27 *	2.25 ± 1.57 *	6.56 ± 2.50 *	−4.30 ± 2.62	0.1998
Iron	7.36 ± 1.49	5.47 ± 1.11	2.56 ± 0.77 *	5.88 ± 1.53	−0.75 ± 0.90	0.4664
Magnesium	67.7 ± 2.5	59.4 ± 2.6 *	55.4 ± 2.5 *	48.7 ± 2.7 *	−6.08 ± 0.40	0.0006
Niacin	0.36 ± 0.34	0.73 ± 0.47	0.41 ± 0.39	4.53 ± 1.79 *	1.21 ± 0.65	0.1583
Riboflavin	2.65 ± 1.04	2.91 ± 0.97	1.15 ± 0.78	8.00 ± 2.11 *	1.41 ± 1.16	0.3113
Selenium	0.04 ± 0.06	0.11 ± 0.14	0.06 ± 0.11	1.74 ± 1.01	0.50 ± 0.27	0.1603
Thiamin	7.95 ± 2.06	5.03 ± 1.44	0.99 ± 0.66 *	3.34 ± 1.43	−1.80 ± 0.91	0.1428
Vitamin A, RE	41.3 ± 3.3	33.1 ± 2.2 *	35.1 ± 3.7	45.4 ± 2.7	1.42 ± 2.94	0.6629
Vitamin B_{12}	0.84 ± 0.59	2.12 ± 0.89	1.99 ± 1.09	12.4 ± 3.3 *	3.44 ± 1.57	0.1156
Vitamin B_6	1.79 ± 1.05	4.11 ± 1.61	4.55 ± 1.81	14.2 ± 3.1 *	3.74 ± 1.27	0.0608
Vitamin C	45.4 ± 3.6	30.1 ± 3.2 *	31.4 ± 3.3 *	31.0 ± 4.4 *	−4.18 ± 2.48	0.1907
Vitamin D	88.0 ± 2.2	90.6 ± 2.4	98.3 ± 0.8 *	98.8 ± 0.5 *	4.02 ± 0.65	0.0084
Vitamin E, ATE	91.8 ± 2.3	78.7 ± 3.6 *	86.2 ± 3.1	64.0 ± 3.2 *	−7.55 ± 2.65	0.0654
Zinc	11.1 ± 3.0	16.1 ± 3.4	16.7 ± 3.5	34.4 ± 3.7 *	7.00 ± 2.26	0.0533
Nutrients with AI [2]	% Population with intakes above AI					
Dietary fiber	0.001 ± 0.01	0.04 ± 0.05	0.20 ± 0.22	7.47 ± 1.44 *	2.24 ± 1.20	0.1598
Potassium	33.6 ± 3.9	27.5 ± 3.8	16.9 ± 7.6	0.01 ± 8.93 *	−11.1 ± 1.7	0.0076
Sodium	99.6 ± 0.2	99.8 ± 0.1	99.8 ± 0.2	99.9 ± 1.6	0.10 ± 0.03	0.0459
Vitamin K	45.1 ± 3.8	59.9 ± 4.4 *	47.4 ± 3.8	58.7 ± 6.4	2.78 ± 2.27	0.3081
Choline	16.9 ± 2.8	4.76 ± 1.99 *	0.93 ± 0.77 *	1.64 ± 0.92 *	−4.97 ± 2.05	0.0940

Data are presented as mean ± SE. * significant differences from quartile 1 at $p < 0.05$. [1] EAR is the average daily intake of a nutrient to meet the requirements of 50% of healthy individuals. [2] AI is the intake level assumed to ensure nutritional adequacy when insufficient data were available to establish a recommended daily allowance. Abbreviations: AI, adequate intake; ATE, alpha-tocopherol equivalents; DFE, dietary folate equivalents; EAR, estimated average requirement; RE, retinol equivalents.

3.2.2. Adults Aged 19–50 Years

Table 5 shows the data for the percentages of the population below the EAR and above the AI (for fiber, choline, potassium, sodium, and vitamin K only) with increasing quartiles of plant protein intake in gender-combined adults aged 19–50 years. The mean usual intake of protein was 85.9 ± 0.7 g/day and 34.6% of this was from plant sources. With increasing quartiles of plant protein intakes, the percentage of the population below the EAR increased significantly ($P_{quartile\ trend} < 0.05$) for protein (beta = 1.55 ± 0.21% units per quartile), selenium (beta = 0.56 ± 0.12% units per quartile), vitamin B_{12} (beta = 4.52 ± 1.10% units per quartile), and zinc (beta = 4.26 ± 1.00% units per quartile) and decreased ($P_{quartile\ trend} < 0.05$) for copper (beta = −3.69 ± 0.27% units per quartile), folate (beta = −6.55 ± 1.27% units per quartile), iron (beta = −1.25 ± 0.13% units per quartile), magnesium (beta = −10.1 ± 2.2% units per quartile), thiamin (beta = −2.67 ± 0.60% units per quartile), and vitamin C (beta = −7.40 ± 1.53% units per quartile). With increasing quartiles of plant protein intakes, the percentage of the population above the AI decreased significantly ($P_{quartile\ trend} < 0.05$) for choline (beta = −5.50 ± 1.71% units per quartile). The percentages of the population below the EAR were numerically lowest for selenium, vitamin B_{12}, vitamin B_6, vitamin D, and zinc at quartile 1 (<27.7% plant protein), for calcium, niacin, and riboflavin at quartile 2 (27.7 to <31.4% plant protein), and for copper, folate, iron, magnesium, thiamin, vitamin A, vitamin C, and vitamin E at quartile 4 (>35.5%) of

plant protein intake. The percentages of the population above the AI were numerically highest for choline at quartile 1 (<27.7% plant protein), and for fiber, potassium, sodium, and vitamin K at quartile 4 (>35.5%) of plant protein intake.

Table 5. Percentages of adults aged 19–50 years with nutrient intakes below the estimated average requirement (EAR) or above the adequate intake (AI) across quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<27.7%)	**Quartile 2 (27.7% to <31.4%)**	**Quartile 3 (31.4% to <35.5%)**	**Quartile 4 (≥35.5%)**	**Beta**	***p***
Nutrients with EAR [1]	% Population with intakes below EAR					
Protein	0.14 ± 0.13	0.69 ± 0.32	2.81 ± 0.77 *	4.62 ± 1.27 *	1.55 ± 0.21	0.0049
Calcium	32.8 ± 1.9	28.9 ± 2.1	30.8 ± 1.8	34.1 ± 2.6	0.57 ± 1.13	0.6496
Copper	14.2 ± 1.5	8.92 ± 1.27 *	6.60 ± 0.90 *	2.65 ± 0.81 *	−3.69 ± 0.27	0.0008
Folate, DFE	25.2 ± 2.6	12.4 ± 1.9 *	9.62 ± 2.22 *	4.35 ± 1.38 *	−6.55 ± 1.27	0.0142
Iron	11.2 ± 0.9	10.2 ± 0.9	9.21 ± 0.83	7.39 ± 0.85 *	−1.25 ± 0.13	0.0026
Magnesium	63.6 ± 2.1	58.5 ± 2.0	51.2 ± 2.1 *	32.3 ± 2.6 *	−10.1 ± 2.2	0.0184
Niacin	1.27 ± 0.49	0.96 ± 0.41	1.68 ± 0.59	1.29 ± 0.57	0.07 ± 0.09	0.4665
Riboflavin	4.74 ± 1.02	3.55 ± 0.75	4.24 ± 0.98	3.69 ± 0.90	−0.25 ± 0.16	0.2153
Selenium	0.07 ± 0.06	0.20 ± 0.15	0.82 ± 0.37 *	1.72 ± 0.59 *	0.56 ± 0.12	0.0188
Thiamin	11.6 ± 1.8	5.51 ± 1.66 *	5.96 ± 1.40 *	2.62 ± 0.87 *	−2.67 ± 0.60	0.0207
Vitamin A, RE	48.3 ± 3.0	50.6 ± 2.3	51.3 ± 2.3	41.7 ± 2.6	−1.90 ± 1.87	0.3844
Vitamin B_{12}	0.83 ± 0.55	2.61 ± 0.82	5.94 ± 1.91 *	14.8 ± 2.6 *	4.52 ± 1.10	0.0263
Vitamin B_6	5.65 ± 1.46	6.38 ± 1.21	10.1 ± 2.1	6.30 ± 1.98	0.55 ± 0.81	0.5501
Vitamin C	59.7 ± 2.1	52.7 ± 2.4 *	51.2 ± 2.4 *	35.7 ± 3.1 *	−7.40 ± 1.53	0.0169
Vitamin D	88.9 ± 2.2	95.6 ± 1.5 *	98.0 ± 0.7 *	96.8 ± 0.7 *	2.63 ± 1.21	0.1186
Vitamin E, ATE	85.0 ± 2.2	81.8 ± 2.2	79.3 ± 2.2	61.5 ± 2.8 *	−7.35 ± 2.36	0.0528
Zinc	8.39 ± 1.70	15.8 ± 2.0 *	20.2 ± 2.1 *	21.1 ± 2.6 *	4.26 ± 1.00	0.0240
Nutrients with AI [2]	% Population with intakes above AI					
Dietary fiber	0.03 ± 0.04	0.38 ± 0.16 *	2.09 ± 0.61 *	17.1 ± 2.1 *	5.30 ± 2.31	0.1057
Potassium	22.7 ± 6.2	8.69 ± 9.93	19.2 ± 8.5	34.9 ± 3.0	4.67 ± 4.65	0.3894
Sodium	99.6 ± 0.3	99.5 ± 0.3	99.4 ± 0.3	100 ± 1	0.11 ± 0.10	0.3613
Vitamin K	41.2 ± 3.4	45.8 ± 3.2	45.9 ± 2.1	64.0 ± 4.0 *	6.89 ± 2.28	0.0564
Choline	22.2 ± 2.2	9.01 ± 1.71 *	7.02 ± 1.32 *	4.56 ± 1.11 *	−5.50 ± 1.71	0.0490

Data are presented as mean ± SE. * significant differences from quartile 1 at $p < 0.05$. [1] EAR is the average daily intake of a nutrient to meet the requirements of 50% of healthy individuals. [2] AI is the intake level assumed to ensure nutritional adequacy when insufficient data were available to establish a recommended daily allowance. Abbreviations: AI, adequate intake; ATE, alpha-tocopherol equivalents; DFE, dietary folate equivalents; EAR, estimated average requirement; RE, retinol equivalents.

When the data were analyzed across defined levels of plant protein intake (Supplementary Table S3), the percentages of the population below the EAR for calcium, iron, niacin, riboflavin, selenium, thiamin, vitamin A, vitamin B_{12}, vitamin B_6, vitamin D, and zinc were lowest in DFL 2. Similarly, the plant protein intakes between 25% and <50% (DFL2) facilitated the highest proportion of individuals consuming levels of potassium and choline above the AI. Furthermore, the percentage of adults with intakes of fiber above the AI (beta = 9.21 units per DFL) progressively increased ($P_{\text{quartile trend}} < 0.05$), from 1.67% in DFL 1 to 35.5% in DFL 4.

3.2.3. Adults Aged 51+ Years

Table 6 shows the data for the percentages of the population below the EAR and above the AI (for fiber, choline, potassium, sodium, and vitamin K only) with increasing quartiles of plant protein intake in gender-combined adults age 51+ years. The mean usual protein intake of the U. S. adults aged 51+ years was 78.8 ± 0.6 g/day, with 35.8% of the protein from plant sources. With increasing quartiles of plant protein intakes, the percentage of

the population below the EAR increased significantly ($P_{quartile\ trend} < 0.05$) for calcium (beta = 1.52 ± 0.16% per quartile), vitamin A (beta = 2.18 ± 0.53% per quartile), and zinc (beta = 4.57 ± 0.31% per quartile) and decreased ($P_{quartile\ trend} < 0.05$) for copper (beta = −3.43 ± 0.65% per quartile), folate (beta = −9.12 ± 1.17% per quartile), magnesium (beta = −9.71 ± 2.43% per quartile), thiamin (beta = −3.85 ± 0.94% per quartile), and vitamin C (beta = −5.00 ± 0.16% per quartile). The percentages of the population below the EAR were numerically lowest as follows: for calcium, vitamin A, vitamin B_{12}, vitamin B_6, vitamin D, and zinc at quartile 1 (<29.0% plant protein); for selenium at quartile 2 (29.0% to <33.0% plant protein); for niacin, riboflavin, and thiamin at quartile 3 (33.0% to <37.0% plant protein); and for copper, folate, iron, magnesium, vitamin C, and vitamin E at quartile 4 (>37.0%) of plant protein intake. The percentage of population above the AI was numerically highest for choline at quartile 1 (<29.0% plant protein), for sodium at quartile 3 (33.0% to <37.0% plant protein), and for fiber, potassium, and vitamin K at quartile 4 (>37.0%) of plant protein intake.

Table 6. Percentages of adults aged 51+ years with nutrient intakes below Estimated Average Requirement (EAR) or above Adequate Intake (AI) across quartiles of usual intakes of plant protein, NHANES 2013–2018 data.

	Quartiles of Plant Protein Usual Intake (%)				Quartile Trend	
	Quartile 1 (<29.0%)	**Quartile 2 (29.0% to <33.0%)**	**Quartile 3 (33.0% to <37.0%)**	**Quartile 4 (≥37.0%)**	**Beta**	***p***
Nutrients with EAR [1]	% Population with intakes below EAR					
Protein	0.35 ± 0.26	1.53 ± 0.63	2.22 ± 0.55 *	8.58 ± 1.06 *	2.58 ± 0.83	0.0532
Calcium	57.2 ± 2.6	59.2 ± 2.3	59.6 ± 2.7	62.1 ± 2.4	1.52 ± 0.16	0.0026
Copper	12.3 ± 1.8	12.6 ± 1.5	4.98 ± 0.85 *	3.45 ± 0.81 *	−3.43 ± 0.65	0.0135
Folate, DFE	32.4 ± 3.1	21.5 ± 1.8 *	9.44 ± 2.16 *	5.78 ± 1.51 *	−9.12 ± 1.17	0.0044
Iron	3.77 ± 0.97	1.37 ± 0.43 *	0.38 ± 0.23 *	0.34 ± 0.14 *	−1.11 ± 0.37	0.0564
Magnesium	67.7 ± 2.6	66.4 ± 2.0	56.0 ± 3.0 *	39.1 ± 2.2 *	−9.71 ± 2.43	0.0280
Niacin	2.25 ± 1.07	2.43 ± 0.70	2.07 ± 0.67	3.60 ± 0.94	0.38 ± 0.23	0.1892
Riboflavin	3.62 ± 0.92	3.78 ± 0.64	2.48 ± 0.67	4.38 ± 0.73	0.12 ± 0.32	0.7407
Selenium	0.40 ± 0.26	0.30 ± 0.30	0.77 ± 0.28	1.62 ± 0.64	0.42 ± 0.15	0.0659
Thiamin	16.4 ± 2.1	10.9 ± 1.6 *	4.94 ± 1.05 *	5.32 ± 1.24 *	−3.85 ± 0.94	0.0264
Vitamin A, RE	38.2 ± 3.6	41.6 ± 2.9	44.5 ± 3.4	44.6 ± 2.5	2.18 ± 0.53	0.0261
Vitamin B_{12}	1.94 ± 1.02	2.08 ± 0.97	3.64 ± 1.93	17.9 ± 2.2 *	5.07 ± 2.22	0.1069
Vitamin B_6	15.8 ± 2.6	22.1 ± 2.0	19.4 ± 3.0	23.9 ± 2.1 *	2.16 ± 0.72	0.0586
Vitamin C	56.0 ± 3.1	51.4 ± 2.5	45.3 ± 3.3 *	41.3 ± 2.3 *	−5.00 ± 0.16	0.0001
Vitamin D	88.8 ± 2.3	97.1 ± 1.0 *	98.7 ± 0.5 *	97.8 ± 0.6 *	2.80 ± 1.46	0.1508
Vitamin E, ATE	84.5 ± 2.3	87.4 ± 2.0	86.4 ± 2.5	68.6 ± 1.9 *	−5.05 ± 3.24	0.2171
Zinc	15.8 ± 2.0	19.8 ± 2.7	23.7 ± 2.5 *	29.7 ± 1.8 *	4.57 ± 0.31	0.0007
Nutrients with AI [2]	% Population with intakes above AI					
Dietary fiber	1.21 ± 0.64	3.48 ± 1.01	6.88 ± 1.34 *	34.4 ± 2.5 *	10.5 ± 4.0	0.0778
Potassium	30.6 ± 2.5	13.5 ± 5.7 *	30.2 ± 2.8	37.5 ± 2.0 *	3.88 ± 4.26	0.4299
Sodium	97.6 ± 0.7	98.9 ± 0.9	99.3 ± 0.3 *	98.7 ± 0.3	0.35 ± 0.30	0.3226
Vitamin K	52.4 ± 3.0	50.0 ± 2.7	47.9 ± 4.5	57.4 ± 2.5	1.37 ± 1.88	0.5200
Choline	15.9 ± 3.1	5.54 ± 1.26 *	3.08 ± 1.37 *	2.90 ± 0.68 *	−4.10 ± 1.61	0.0848

Data are presented as mean ± SE. * significant differences from quartile 1 at $p < 0.05$. [1] EAR is the average daily intake of a nutrient to meet the requirements of 50% of healthy individuals. [2] AI is the intake level assumed to ensure nutritional adequacy when insufficient data were available to establish a recommended daily allowance. Abbreviations: AI, adequate intake; ATE, alpha-tocopherol equivalents; DFE, dietary folate equivalents; EAR, estimated average requirement; RE, retinol equivalents.

Similar results were obtained when nutrient adequacy was analyzed across the DFL of the plant protein intake for the adults aged 51+ years (Supplementary Table S4). The lowest proportions of the population below the EAR or the highest proportions above the AI were noted for plant protein below 25% (DFL 1) for calcium, choline, niacin, potassium,

riboflavin, selenium, sodium, vitamin A, vitamin B_{12}, vitamin B_6, vitamin D, and zinc, plant protein between 25% to <50% for vitamin K; plant protein between 50% to <75% (DFL 2 to DFL 3) for copper, folate, iron, magnesium, thiamin, vitamin C, and vitamin E, and plant protein ≥75% (DFL 4) for fiber.

4. Discussion

The results of this cross-sectional analysis of the NHANES 2013–2018 data show that population nutrient adequacy varied with increasing proportions of plant protein. Depending on the age group, the lowest percentage below the EAR or the highest percentage above the AI for calcium, choline, niacin, riboflavin, selenium, vitamin A, vitamin B_{12}, vitamin B_6, vitamin D, and zinc were at quartile 1 and quartile 2 (and DFL 1 and DFL 2) of plant protein intake, while for fiber, copper, folate, iron, magnesium, thiamin, vitamin C, and vitamin E were at quartile 3 and quartile 4 (and DFL 3 and DFL 4) of plant protein intake.

To put our results into perspective, in both children and adults, many of the significant quartile-trend regression coefficients were mid-single digits for several nutrients (see Tables 4–6). In the 9–18-years-of-age group, the percentage of the population below the EAR for calcium increased from 58.5% in plant protein quartile 1 to 75.5% in quartile 4. Given that our sample represents about 42 million children aged 9–18 years, with about 10.5 million in each quartile, these results suggest that higher plant protein levels in the diet were associated with an additional 1.7 million children aged 9–18 years below the EAR for calcium. However, higher levels of plant protein in the diet were associated with 2 million fewer children aged 9–18 years below the EAR for magnesium. In adults 19–50 years of age, which represents about 127 million Americans (31.7 million Americans in each quartile of plant protein intake), the results suggest that higher plant protein intake was associated with an additional 4.0 and 4.4 million adults 19–50 years below the EAR for zinc and vitamin B_{12}, respectively. However, higher levels of plant protein in the diet were also associated with decreases of 7.6 and 9.9 million adults aged 19–50 years below the EAR for vitamin C and magnesium, respectively. Similarly, in adults aged 51+ years, representing 106 million Americans (26.6 in each quartile), the results from this study suggest that each additional quartile of intake was associated with an additional 1.3 and 4.2 million Americans below the EAR for calcium and vitamin B_{12}, respectively. Based on current food choices by Americans, the results indicate that the most nutritionally adequate diets comprise mixed protein sources, that is, from both animal and plant sources.

Similar heterogeneous relationships to those observed in this study between plant and animal protein sources and nutrient adequacy were also reported previously [17–19]. The results from this study show that, at lower quartiles (and DFL) of plant protein intake, the nutritional adequacy of certain nutrients was higher, but it was lower for other nutrients. This suggests that a diet with mixed food sources of protein, with plant protein at about the 50th percentile of the current intake (quartile 2 or DFL 2), would be nutritionally optimal. This suggestion aligns with a dietary-modeling analysis of French cross-sectional data, which also concluded that about 50% of total dietary protein should be from animal sources in nutritionally adequate and affordable diets [27]. In another dietary-modeling analysis, a 25% to 70% plant protein diet was proposed to be optimal proportion of plant protein for nutrient-adequate and healthy diets [14].

In the present analysis, the nutrient adequacies for fiber, copper, folate, iron, magnesium, thiamin, vitamin C, and vitamin E were higher at increased quartiles of intake and DFL of plant protein intake. Conversely, the nutrient adequacies for calcium, choline, niacin, riboflavin, selenium, vitamin A, vitamin B_{12}, vitamin B_6, vitamin D, and zinc were higher at lower quartiles and DFL of plant protein intake. Indeed, diets higher in plant foods are more abundant in fiber, folate, magnesium, vitamins E, vitamin C, and other antioxidants, while animal-based foods are more abundant in zinc, vitamin B_{12}, vitamin D, calcium, and phosphorus [11]. These results are corroborated by previous cross-sectional analysis of NHANES and the Canadian Community Healthy Survey, showing that intakes of copper, fiber, folate, iron, magnesium, potassium, thiamin, vitamin C, vitamin E, and vitamin K

increased, while intakes of niacin, selenium, sodium, choline, vitamin B_{12}, vitamin D, and zinc decreased with increasing quartiles of plant protein intake among adults [20,21,28].

Higher nutrient adequacies of folate, iron, and thiamine at increased plant protein intake quartiles are likely the result of the fortification of certain cereal-grain foods [29]. Globally, cereal grains represent the primary sources of plant protein intake [30], and this is also true among American adults [10]. However, cereal grains are not considered to be protein foods in the majority of the dietary guidelines from around the globe [1,31]. Furthermore, cereal grains also have lower protein density (protein amount per gram of food or per calorie) and protein quality compared to animal protein sources and plant foods designated as "plant proteins," such as legumes [32–35]. A reliance on cereal grains as primary sources of plant protein as animal proteins become more limited in diets may be problematic for meeting amino acid requirements, especially at increased quartiles of plant protein intake. The replacement of 50% of cereal grain amino acids with amino acids from lentils and legumes improved protein quality in our recent modeling analysis [21]. Moreover, another recent modeling analysis suggested that plant-based substitutes for animal products, including legumes, were more nutritionally adequate than other substitutes [12]. Increasing the utilization of legumes, such as beans, lentils, chickpeas, and soy foods as primary ingredients in new plant-based food platforms should be considered as consumers shift to plant-based dietary patterns that incorporate more foods meant to replace corresponding animal-derived products.

For further context, it is also important to highlight that the magnitude of the plant protein intakes in U. S. diets was fairly low. The majority of individuals consume diets containing less than 40% plant protein, as demonstrated across the range of plant protein intakes for quartiles 1–3 (0–27%). Furthermore, the range of the plant protein intakes in quartiles 2 and 3 was narrow, at 3.4% and 3.5%, respectively, with a substantially larger range encompassed by quartile 4 (36.1–100%). In contrast, the DFL analysis segregated the sample across equally distributed ranges of protein intakes, where fewer individuals were allocated to each progressively higher DFL group. For some nutrients within the age groups, the difference in the proportion of nutritional inadequacy was increased by >20 units for DFL 4 compared to quartile 4 for calcium, vitamin A, vitamin B_{12}, magnesium, selenium, and zinc. Across all the ages studied, vitamin D inadequacy was $\geq$87% at the lowest levels of the plant protein intakes (quartile 1 and DFL 1) and similar levels of inadequacy (>95%) were observed across quartiles 4 and DFL4. This suggests that, for some nutrients, such as vitamin D, nutritional challenges for adequacy are present irrespective of plant protein consumption levels.

Altogether, the results from this cross-sectional study reflect the diversity of nutrients that are provided by plant and animal protein foods in the diet. Based on current consumption patterns, there are nutritional implications when diets shift the amounts of plant protein in the diet and when the diversity of the foods that underpin these shifts is not considered. Previously discussed modeling assessments by Salome et al. [36] suggests that plant proteins can be incorporated in the diet at fairly high levels that would eliminate or reduce any adverse impact on nutrient adequacy. However, a careful selection of protein food choices is required, which is not reflected in current U.S. diets, in which an abundance of plant protein is provided by the cereal grains family (*Poaceae*). Increasing the use of legumes, nuts, and seeds aligns with Dietary Guidelines for Americans, 2020–2025 recommendations; these foods are nutrient-dense and inherently complement the proteins from cereal grains. Fortification can also play an important role for new foods meant to provide alternatives to those foods that have traditionally been manufactured from animal ingredients. Systematic reviews have demonstrated that few meat-and-dairy-alternative products are fortified with nutrients typically found in the corresponding animal foods (vitamin D, vitamin B_{12}, iron, calcium, and zinc) and could manifest as nutritional inadequacies over time if used exclusively as substitute products [36–41]. This has also become more important in view of the consistent and ongoing discussion over the increase in the proportion of plant-based foods (including plant protein foods) in diets to enhance environmental sustainability and

to decrease chronic-disease risk [42,43]. Our data also highlight nutritional challenges that require attention and provide salient nutritional targets for plant-based diets, as well as plant protein food innovation.

The major strengths of our study were the use of a large, nationally representative, population-based sample, which was achieved through combining several sets of NHANES data releases and the use of the NCI method to assess usual intake to examine the percentage of the population below the EAR/above the AI. The limitations of the current study, as with any cross-sectional investigation, include an inability to determine cause-and-effect relationships; furthermore, there is the potential for bias in the use of self-reported dietary recalls relying on memory [44]. We also need to acknowledge that the plant protein intake in the United States currently comes predominantly from food sources relatively low in protein. Further research might selectively evaluate individuals who routinely select foods that are higher in plant protein and assess the nutrient adequacy in this population. Conducting additional randomized, controlled trials would also help to decipher cause-and-effect relationships between nutritional adequacy and the increased consumption of plant protein in the context of traditional plant protein foods (legumes, nuts, and seeds) and innovative alternative products, with and without fortification. This future research may also help to determine whether there is an ideal range of intakes of animal and plant protein that optimizes nutrient adequacy.

5. Conclusions

The results of the current study showed that, based on current food choices in the U. S., diets of mixed protein sources, from both animals and plants, are likely the most nutritionally adequate. Additionally, the results highlight the potential nutritional challenges posed as plant protein intake increases beyond certain levels in both children and adults. Therefore, if changes in dietary recommendations, for whatever reason, lead to increased plant protein and reduced animal protein, care is needed to ensure that the adequacy of all the nutrients is achieved.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu16081158/s1. Supplementary Table S1. Participant flow chart. Supplementary Table S2. Percentage of adolescents aged 9–18 years with nutrient intakes below estimated average requirement (EAR) or above adequate intake (AI) across defined levels (DFL) of day 1 intake of plant protein, NHANES 2013–2018 data. Supplementary Table S3. Percentage of adults aged 19–50 years with nutrient intakes below estimated average requirement (EAR) or above adequate intake (AI) across defined levels (DFL) of day 1 intake of plant protein, NHANES 2013–2018 data. Supplementary Table S4. Percentage of adults aged 51+ years with nutrient intakes below estimated average requirement (EAR) or above adequate intake (AI) across defined levels (DFL) of day 1 intake of plant protein, NHANES 2013–2018 data.

Author Contributions: V.L.F.III participated in the formulation of the research question, the design of the analyses, the NHANES dietary data analysis, the statistical analysis, the interpretation of the data, the revision of the manuscript, and the approval of the final version; and S.A. participated in the interpretation of the data, the drafting of the manuscript, the revision of the manuscript, and the approval of the final version. C.P.F.M. and K.M. participated in the formulation of the research question, the design of the analyses, the revision of the manuscript, and the approval of the final version. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: The data used for this manuscript were from the National Health and Nutrition Examination Survey (NHANES) 2013–2018 and all the participants or proxies provided written informed consent.

Data Availability Statement: The datasets analyzed in this study are available in the Center for Disease Control and Prevention repository, available online: http://www.cdc.gov/nchs/nhanes/ (Accessed on 15 August 2021).

Conflicts of Interest: V.L.F.III, as Senior Vice President of Nutrition Impact LLC, performs consulting and database analyses for various food and beverage companies and related entities. S.A., as Principal of NutriScience LLC, performs consulting for various food and beverage companies and related entities. C.P.F.M. is an employee of Protein Industries Canada and is a former employee of Pulse Canada and Kellogg Canada. K.M. is an employee of The Bill and Melinda Gates Foundation and a former employee of General Mills. The authors declare that this study received funding from Protein Industries Canada and General Mills, Inc. The funder was not involved in the study design, collection, analysis, interpretation of data, the writing of this article or the decision to submit it for publication.

References

1. U.S. Department of Agriculture; U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025, 9th ed. 2020. Available online: https://dietaryguidelines.gov (accessed on 14 January 2023).
2. Melina, V.; Craig, W.; Levin, S. Position of the academy of nutrition and dietetics: Vegetarian diets. *J. Acad. Nutr. Diet.* **2016**, *116*, 1970–1980. [CrossRef] [PubMed]
3. Ruby, M.B. Vegetarianism. A blossoming field of study. *Appetite* **2012**, *58*, 141–150. [CrossRef] [PubMed]
4. Rosenfeld, D.L. The psychology of vegetarianism: Recent advances and future directions. *Appetite* **2018**, *131*, 125–138. [CrossRef] [PubMed]
5. Rosenfeld, D.L.; Burrow, A.L. Vegetarian on purpose: Understanding the motivations of plant-based dieters. *Appetite* **2017**, *116*, 456–463. [CrossRef] [PubMed]
6. Arenas-Jal, M.; Sune-Negre, J.M.; Perez-Lozano, P.; Garcia-Montoya, E. Trends in the food and sports nutrition industry: A review. *Crit. Rev. Food Sci. Nutr.* **2020**, *60*, 2405–2421. [CrossRef] [PubMed]
7. Hargreaves, S.M.; Rosenfeld, D.L.; Moreira, A.V.B.; Zandonadi, R.P. Plant-based and vegetarian diets: An overview and definition of these dietary patterns. *Eur. J. Nutr.* **2023**, *62*, 1109–1121. [CrossRef] [PubMed]
8. Food and Agriculture Organization of the United Nations Statistics Division. *Food Balance Sheets*; FAOSTAT: Rome, Italy, 2013.
9. Kerksick, C.M.; Jagim, A.; Hagele, A.; Jager, R. Plant Proteins and Exercise: What Role Can Plant Proteins Have in Promoting Adaptations to Exercise? *Nutrients* **2021**, *13*, 1962. [CrossRef] [PubMed]
10. Pasiakos, S.M.; Agarwal, S.; Lieberman, H.R.; Fulgoni, V.L., 3rd. Sources and Amounts of Animal, Dairy, and Plant Protein Intake of US Adults in 2007–2010. *Nutrients* **2015**, *7*, 7058–7069. [CrossRef]
11. Phillips, S.M.; Fulgoni, V.L.; Heaney, R.P.; Nicklas, T.A.; Slavin, J.L.; Weaver, C.M. Commonly consumed protein foods contribute to nutrient intake, diet quality, and nutrient adequacy. *Am. J. Clin. Nutr.* **2015**, *101*, 1346S–1352S. [CrossRef]
12. Salome, M.; Huneau, J.F.; Le Baron, C.; Kesse-Guyot, E.; Fouillet, H.; Mariotti, F. Substituting Meat or Dairy Products with Plant-Based Substitutes Has Small and Heterogeneous Effects on Diet Quality and Nutrient Security: A Simulation Study in French Adults (INCA3). *J. Nutr.* **2021**, *151*, 2435–2445. [CrossRef]
13. Hoy, M.K.; Murayi, T.; Moshfegh, A.J. Effect of Animal Protein Intake on Meeting Recommendations for Nutrient Intake among US Adults, What We Eat in America, NHANES 2015–2018. *Curr. Dev. Nutr.* **2022**, *7*, 100027. [CrossRef] [PubMed]
14. Fouillet, H.; Dussiot, A.; Perraud, E.; Wang, J.; Huneau, J.F.; Kesse-Guyot, E.; Mariotti, F. Plant to animal protein ratio in the diet: Nutrient adequacy, long-term health and environmental pressure. *Front. Nutr.* **2023**, *10*, 1178121. [CrossRef] [PubMed]
15. FAO. Food-Based Dietary Guidelines. 2023. Available online: https://www.fao.org/nutrition/education/food-based-dietary-guidelines (accessed on 7 March 2023).
16. Cámara, M.; Giner, R.M.; González-Fandos, E.; López-García, E.; Mañes, J.; Portillo, M.P.; Rafecas, M.; Domínguez, L.; Martínez, J.A. Food-Based Dietary Guidelines around the World: A Comparative Analysis to Update AESAN Scientific Committee Dietary Recommendations. *Nutrients* **2021**, *13*, 3131. [CrossRef]
17. Neufingerl, N.; Eilander, A. Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review. *Nutrients* **2022**, *14*, 29. [CrossRef]
18. Allès, B.; Baudry, J.; Méjean, C.; Touvier, M.; Péneau, S.; Hercberg, S.; Kesse-Guyot, E. Comparison of Sociodemographic and Nutritional Characteristics between Self-Reported Vegetarians, Vegans, and Meat-Eaters from the NutriNet-Santé Study. *Nutrients* **2017**, *9*, 1023. [CrossRef]
19. Cifelli, C.J.; Houchins, J.A.; Demmer, E.; Fulgoni, V.L. Increasing Plant Based Foods or Dairy Foods Differentially Affects Nutrient Intakes: Dietary Scenarios Using NHANES 2007-2010. *Nutrients* **2016**, *8*, 422. [CrossRef]
20. Marinangeli, C.P.F.; Fabek, H.; Ahmed, M.; Sanchez-Hernandez, D.; Foisy, S.; House, J.D. The effect of increasing intakes of plant protein on the protein quality of Canadian diets. *Appl. Physiol. Nutr. Metab.* **2021**, *46*, 771–780. [CrossRef] [PubMed]
21. Marinangeli, C.P.F.; Miller, K.; Fulgoni, V.L. Effect of increasing plant protein intake on protein quality and nutrient intake of US adults. *Appl. Physiol. Nutr. Metab.* **2023**, *48*, 49–61. [CrossRef]

22. Centers for Disease Control and Prevention; National Center for Health Statistics. *National Health and Nutrition Examination Survey*; NCHS: Hyattsville, MD, USA, 2021. Available online: https://www.cdc.gov/nchs/nhanes/index.htm (accessed on 15 August 2021).
23. Haytowitz, D.; Ahuja, J.; Wu, X.; Somanchi, M.; Nickle, M.; Nguyen, Q.A.; Roseland, J.; Williams, J.; Patterson, K.; Li, Y.; et al. USDA National Nutrient Database for Standard Reference, Legacy Release. Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, ARS, USDA. 2019. Available online: https://data.nal.usda.gov/dataset/usda-national-nutrient-database-standard-reference-legacy-release (accessed on 15 August 2021).
24. USDA/ARS. USDA Food Patterns Equivalents Database. Food Surveys Research Group. Available online: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group (accessed on 15 August 2021).
25. Tooze, J.A.; Kipnis, V.; Buckman, D.W.; Carroll, R.J.; Freedman, L.S.; Guenther, P.M.; Krebs-Smith, S.M.; Subar, A.F.; Dodd, K.W. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. *Stat. Med.* **2010**, *29*, 2857–2868. [CrossRef]
26. Institute of Medicine. *DRIs: Applications in Dietary Assessment*; National Academies Press: Washington, DC, USA, 2000.
27. Vieux, F.; Remond, D.; Peyraud, J.L.; Darmon, N. Approximately Half of Total Protein Intake by Adults Must be Animal-Based to Meet Nonprotein, Nutrient-Based Recommendations, With Variations Due to Age and Sex. *J. Nutr.* **2022**, *152*, 2514–2525. [CrossRef]
28. Fabek, H.; Sanchez-Hernandez, D.; Ahmed, M.; Marinangeli, C.P.F.; House, J.D.; Anderson, G.H. An examination of contributions of animal- and plant-based dietary patterns on the nutrient quality of diets of adult Canadians. *Appl. Physiol. Nutr. Metab.* **2021**, *46*, 877–886. [CrossRef] [PubMed]
29. Papanikolaou, Y.; Fulgoni, V.L., III. The role of fortified and enriched refined grains in the US dietary pattern: A NHANES 2009-2016 modeling analysis to examine nutrient adequacy. *Front. Nutr.* **2021**, *8*, 655464. [CrossRef] [PubMed]
30. Davies, R.W.; Jakeman, P.M. Separating the wheat from the chaff: Nutritional value of plant proteins and their potential contribution to human health. *Nutrients* **2020**, *12*, 2410. [CrossRef] [PubMed]
31. Herforth, A.; Arimond, M.; Álvarez-Sánchez, C.; Coates, J.; Christianson, K.; Muehlhoff, E. A Global Review of Food-Based Dietary Guidelines. *Adv. Nutr.* **2019**, *10*, 590–605. [CrossRef] [PubMed]
32. Nichele, S.; Phillips, S.M.; Boaventura, B.C. Plant-based food patterns to stimulate muscle protein synthesis and support muscle mass in humans: A narrative review. *Appl. Physiol. Nutr. Metab.* **2022**, *47*, 700–710. [CrossRef] [PubMed]
33. Nosworthy, M.G.; Neufeld, J.; Frohlich, P.; Young, G.; Malcolmson, L.; House, J.D. Determination of the protein quality of cooked Canadian pulses. *Food Sci. Nutr.* **2017**, *5*, 896–903. [CrossRef] [PubMed]
34. Nosworthy, M.G.; Franczyk, A.; Zimoch-Korzycka., A.; Appah, P.; Utioh, A.; Neufeld, J.; House, J.D. Impact of Processing on the Protein Quality of Pinto Bean (Phaseolus vulgaris) and Buckwheat (Fagopyrum esculentum Moench) Flours and Blends, As Determined by in Vitro and in Vivo Methodologies. *J. Agric. Food Chem.* **2017**, *65*, 3919–3925. [CrossRef] [PubMed]
35. Tomé, D. Digestibility issues of vegetable versus animal proteins: Protein and amino acid requirements--functional aspects. *Food Nutr. Bull.* **2013**, *34*, 272–274. [CrossRef] [PubMed]
36. Salome, M.; Mariotti, F.; Dussiot, A.; Kesse-Guyot, E.; Huneau, J.F.; Fouillet, H. Plant-based meat substitutes are useful for healthier dietary patterns when adequately formulated—An optimization study in French adults (INCA3). *Eur. J. Nutr.* **2023**, *62*, 1891–1901. [CrossRef]
37. Melville, H.; Shahid, M.; Gaines, A.; McKenzie, B.L.; Alessandrini, R.; Trieu, K.; Wu, J.H.Y.; Rosewarne, E.; Coyle, D.H. The nutritional profile of plant-based meat analogues available for sale in Australia. *Nutr. Diet.* **2023**, *80*, 211–222. [CrossRef]
38. van Vliet, S.; Provenza, F.D.; Kornberg, S.L. Health-Promoting Phytonutrients Are Higher in Grass-Fed Meat and Milk. *Front. Sustain. Food Syst.* **2021**, *4*, 555426. [CrossRef]
39. Ramsing, R.; Santo, R.; Kim, B.F.; Altema-Johnson, D.; Wooden, A.; Chang, K.B.; Semba, R.D.; Love, D.C. Dairy and Plant-Based Milks: Implications for Nutrition and Planetary Health. *Curr. Environ. Health Rep.* **2023**, *10*, 291–302. [CrossRef] [PubMed]
40. Clegg, M.E.; Tarrado Ribes, A.; Reynolds, R.; Kliem, K.; Stergiadis, S. A comparative assessment of the nutritional compo-sition of dairy and plant-based dairy alternatives available for sale in the UK and the implications for consumers' dietary intakes. *Food Res. Int.* **2021**, *148*, 10586. [CrossRef] [PubMed]
41. Singhal, S.; Baker, R.D.; Baker, S.S. A Comparison of the Nutritional Value of Cow's Milk and Nondairy Beverages. *J. Pediatr. Gastroenterol. Nutr.* **2017**, *64*, 799–805. [CrossRef] [PubMed]
42. Institute of Medicine. *Sustainable Diets: Food for Healthy People and a Healthy Planet*; Workshop Summary; National Academies Press: Washington, DC, USA, 2014.

43. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the Anthropocene: The EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet* **2019**, *393*, 447–492. [CrossRef]
44. Subar, A.F.; Freedman, L.S.; Tooze, J.A.; Kirkpatrick, S.I.; Boushey, C.; Neuhouser, M.L.; Thompson, F.E.; Potischman, N.; Guenther, P.M.; Tarasuk, V.; et al. Addressing Current Criticism Regarding the Value of Self-Report Dietary Data. *J. Nutr.* **2015**, *145*, 2639–2645. [CrossRef]

nutrients

MDPI

Article

Development and Validation of the Meiji Nutritional Profiling System (Meiji NPS) to Address Dietary Needs of Adults and Older Adults in Japan

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Abstract: This study introduces the Meiji Nutritional Profiling System (Meiji NPS), which was specifically designed to respond to age-related shifts in nutrient requirements among Japanese adults (<65 years old) and older adults (≥65 years old). Japan has one of the most aged societies in the world. The health issues of interest are malnutrition and lifestyle-related diseases among adults and frailty among older adults. Two versions of the NPS were developed based on nutrients to encourage (protein, dietary fibers, calcium, iron, and vitamin D), food groups to encourage (fruits, vegetables, nuts, legumes, and dairy), and nutrients to limit (energy, saturated fatty acids, sugars, and salt equivalents). The Meiji NPS for older adults did not include iron or saturated fatty acids. The algorithms were based on the Nutrient-Rich Foods Index (NRF). The convergent validity between the Meiji NPS and the existing NPSs for the same foods was confirmed using Spearman's correlation coefficients (NRF: r = 0.67 for adults and r = 0.60 for older adults; Health Star Rating: r = 0.64 for adults and r = 0.61 for older adults). The Meiji NPS may be useful for nutritional evaluation and reformulation of food products, tailored to adults and older adults to ameliorate health issues in Japan.

Keywords: nutrient profiling; nutrient-rich foods index; malnutrition; older adults; frailty; convergent validity; Japanese diet; hybrid nutrient density score; nutrients; food groups

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1. Introduction

Assessing the nutrient density of foods is a challenge, given that every food product contains multiple nutrients. Foods can include protein, fiber, vitamins, and minerals, as well as fats, sugar, and sodium [1]. Nutrient profiling (NP) methods are quantitative metrics designed to capture the overall nutrient contents of foods in relation to population nutrient needs [2–4]. In general, those foods that best satisfy population nutrient requirements receive the highest scores [4]. However, nutrient requirements, the foundation of NP methods, may differ depending on sex and age [5,6].

The Meiji Nutritional Profiling System (Meiji NPS) is one of the first attempts to tailor NP methods to the nutrient needs of adults (<65 years old) and older adults (≥65 years old). The World Health Organization (WHO) has specifically stated that NP models need to classify or rank foods according to their nutritional composition for reasons related to disease prevention and health promotion [7]. The two health conditions specifically addressed by the Meiji NPS are different forms of malnutrition among adults and excessive frailty among older adults in Japan.

The Meiji NPS has the potential to promote healthier dietary choices and drive the reformulation of food products to better align with public health objectives. There are

precedents for both approaches. NP models developed by governments are intended to encourage consumers to select healthier foods [8–10]. For example, the Australian Government developed the Health Star Rating (HSR) as the basis for front-of package labels. The HSR was mainly designed to address obesity as Australia has one of the highest rates of obesity in the world [11–13]. The HSR nutrients to encourage are protein and fiber, whereas energy, total sugar, saturated fatty acids (SFAs), and sodium are the components to limit. Among the food groups to encourage in the HSR are fruits, vegetables, nuts, and legumes. At the same time, food manufacturers have used their own NP models to reformulate their products [14–17], most notably to limit their energy, fat, sugar, and sodium contents. The two approaches are linked. The Global Access to Nutrition Index uses the HSR to motivate food manufacturers to improve the nutritional value of their products [18].

According to the WHO, NP models need to address an identified public health problem [19]. Health and nutritional issues vary based on regions, lifestyles, and life stages [20]. Among specific health issues identified for Japan are malnutrition, which manifests as underweight or excessive thinness among young women, as well as overweight [21–32]. Frailty among older adults is a particularly serious issue in Japan, which has one of the largest aging populations in the world [6,33,34]. The Meiji NPS was designed to address health issues at different life stages, taking a life-course approach to NP modeling throughout the human lifespan [20,35–39]. Given the super-aging society in Japan, an NP model designed for older adults was thought to be particularly useful.

The overall quality of Japanese dietary habits can be assessed in several ways [40–43]. The dietary nutrient density of older adults is a matter of special concern. As people age, they consume fewer calories daily, but their nutrient requirements remain largely the same or even increase. As a result, the diets of older adults need to incorporate more nutrients per calorie.

Existing NP models, largely intended for front-of-package labels, do not take changing nutrient needs across the life cycle into account. Health issues that vary according to life stage need to be considered, particularly those identified among older adults ≥65 years old who follow traditional eating habits in Japan. The Meiji NPS was tailored to the dietary habits, specific health issues at each life stage, and special demographic composition of the Japanese population. The objective of this study was to develop a new age-sensitive NPS for Japan and investigate its validity. We developed two versions of the Meiji NPS, one for adults and one for older adults (≥65 years old), with a focus on preventing lifestyle-related diseases, including extreme frailty in old age. The Meiji NPS may be useful for the nutritional evaluation and reformulation of food products tailored to adults and older adults to ameliorate the health issues in Japan.

2. Materials and Methods

2.1. Scope and Principles of the Meiji NPS

The Meiji NPS, developed to address age-related health issues in Japan, was used primarily to guide improvements in diet quality and the reformulation of food products. The population groups of interest were adults <65 years old and older adults ≥65 years old. Health issues were lifestyle-related diseases, such as overweight/obesity, hypertension, dyslipidemia, and type 2 diabetes in adults; thinness in young women; and frailty in older adults. The Meiji NPS was developed as follows: (1) selection of nutrients to encourage; (2) selection of food groups to encourage; (3) selection of nutrients to limit; (4) selection of Reference Daily Values (RDVs); (5) development of the Meiji NPS algorithm; and (6) validation and testing.

2.2. Overview of Nutrients to Encourage/Limit and Food Groups to Encourage

The Meiji NPS for adults was based on protein, dietary fiber, calcium, iron, and vitamin D as nutrients to encourage and energy, SFAs, sugar, and salt equivalents as the nutrients to limit in foods. The Meiji NPS for older adults was based on encouraging protein, dietary

fiber, calcium, and vitamin D and limiting energy, SFAs, sugar, and salt equivalents in foods. Food groups to encourage were the same for both Meiji NPS versions, fruits, vegetables, nuts, legumes, and dairy.

2.3. Selection of Nutrients to Encourage

Based on the Dietary Reference Intakes for Japanese (2020) [6], protein, dietary fiber, calcium, iron, and vitamin D are consumed in insufficient amounts in Japan, particularly by older adults [44]. Higher protein and dietary fiber intakes are reportedly associated with a lower obesity risk [45–47]. Calcium intake is reportedly related to a reduction in the rates of hypertension and type 2 diabetes among adults and a reduction in the rate of dementia among older adults [48–50]. Vitamin D intake is reportedly associated with a lower risk of dyslipidemia and type 2 diabetes and prediabetes [51–53]. A low level of vitamin D is reportedly associated with age-related health issues, such as sarcopenia, frailty, cognitive functional decline, and dementia [54–65]. Iron-deficiency anemia is a serious health issue due to the desire for thinness among young women in Japan [66]. Underweight young women in Japan also exhibit a low intake of dietary fiber, calcium, iron, and vitamin D [67]. Thus, protein, dietary fiber, calcium, iron, and vitamin D were deemed the main nutrients to encourage in the Meiji NPS. Iron was excluded from the Meiji NPS for older adults owing to its adequate intake among Japanese older adults and the lesser role it plays in frailty.

2.4. Selection of Food Groups to Encourage

Hybrid NP scores combine both nutrients and selected food groups. The Meiji NPS was designed to include food groups that are rich in additional nutrients of interest, such as potassium and vitamin C. In alignment with this philosophy, the Meiji NPS did not establish any food groups to discourage. The selection of food groups to encourage, as guided by the "Health Japan 21" [68] and "Healthy diet" [20] guidelines, was as follows: fruits, vegetables, nuts, legumes, and dairy. In the Meiji NPS, vegetables also included mushrooms, algae, and spices. We followed the lead of a previous study, in which the foods of the Japanese Food Standard Composition Table 2020 Edition (8th Edition) were grouped in terms of nutrient density [69] by including green teas, black teas, and coffee as vegetables and cocoa (pure powder) as legumes. These foods reportedly provide benefits in terms of obesity [70–77], hypertension [78–81], dyslipidemia [78,82–90], and diabetes [76,77,91]. The composition of food groups to encourage followed the coding scheme of the Japanese Food Standard Composition Table 2020 Edition (8th Edition) [92]. Fruits in the Meiji NPS corresponded to fruits in that table; vegetables corresponded to vegetables, mushrooms, and algae in that table; nuts corresponded to nuts in that table; legumes corresponded to pulses in that table; and dairy corresponded to milk and milk products in that table.

2.5. Selection of Nutrients to Limit

The selection of nutrients to limit closely followed other NP models. Nutrients to limit were SFAs, sugars, and salt equivalents (sodium content multiplied by 2.54). Energy was included in the list of nutrients to limit. The Dietary Reference Intakes for Japanese (2020) [6] suggested that energy, SFAs, and sodium are associated with hypertension and that energy, SFAs, and sugars are risk factors for obesity. Furthermore, a reduction in sugar has an effect on body weight [93]. In addition to a strong desire to become thin and to lose weight [94], unhealthy dietary intakes have been observed among young Japanese women [95]. The consumption of some confectionaries is higher compared to normal-weight women, and the consumption of soft drinks has increased among underweight women [95,96]. Thus, these nutrients to limit for young women should be considered. The Meiji NPS defines glucose, galactose, fructose, maltose, sucrose, and lactose as sugars.

The intake of dairy products is inversely associated with frailty in older adults, and it has been suggested that moderate intake of SFAs is effective at preventing frailty in Japan [97,98]. Additionally, SFA intake is reportedly not associated with sarcopenia [99].

Thus, SFAs were excluded from the nutrients to limit in the Meiji NPS for older adults. Table 1 summarizes the principal nutrients in the Meiji NPS for adults and older adults.

Table 1. Comparison between the Meiji NPS for adults and older adults, NRF9.3, and HSR.

Items	Meiji NPS for Adults	Meiji NPS for Older Adults	NRF9.3	HSR
Nutrients to encourage	Protein Dietary fiber Calcium Iron Vitamin D	Protein Dietary fiber Calcium Vitamin D	Protein Dietary fiber Calcium Iron Potassium Magnesium Vitamin A Vitamin E Vitamin C	Protein Dietary fiber
Food groups to encourage	Fruits Vegetables Nuts Legumes Dairy	Fruits Vegetables Nuts Legumes Dairy	NA [1]	Fruits Vegetables Nuts Legumes
Nutrients to limit	Energy SFAs Sugar Salt equivalents [2]	Energy Sugar Salt equivalents [2]	SFAs Added sugar Sodium	Energy SFAs Total sugar Sodium

[1] NRF9.3 does not set on any food groups to encourage. [2] Sodium content was multiplied by 2.54. NPS: Nutritional Profiling System; NRF: Nutrient-Rich Foods Index; HSR: Health Star Rating; SFA: saturated fatty acid; NA: not applicable.

2.6. Age-Appropriate RDVs

The two target population groups were adults (<65 years old) and older adults (≥65 years old). The age-appropriate nutrient standards are summarized in Table 2. The RDVs of protein, dietary fiber, calcium, iron, vitamin D, energy, and salt equivalents were selected according to the maximum values in the Dietary Reference Intakes for Japanese (2020) [6] for the age groups. The RDVs of SFAs and sugar were based on the WHO recommendation [100,101], the latter of which corresponds to 10% of the energy intake. The RDVs of fruits, vegetables, legumes, and dairy were based on values in "Health Japan 21" [68]. The RDV of nuts was obtained from the "EAT-Lancet planetary health diet" [102] and the "healthy diet for Japanese longevity" [103]. In the EAT-Lancet planetary health diet, the recommended median intake of peanuts is 50 g. Additionally, the tree nuts category has a separate allocation of 25 g. Therefore, the RDV of nuts was set at 75 g.

Table 2. RDVs of the Meiji NPS and NRF9.3.

Items		For Adults	For Older Adults
Nutrients to encourage	Protein	65 g	60 g
	Dietary fiber	21 g	20 g
	Calcium	1000 mg	750 mg
	Iron	12 mg	NA
	Vitamin D	9.5 μg	8.5 μg
Nutrients to limit	Energy	2800 kcal	2400 kcal
	SFAs	31.1 g	NA
	Sugar	70 g	60 g
	Salt equivalents	7.5 g	7.5 g

Table 2. *Cont.*

Items		For Adults	For Older Adults
Food groups to encourage	Fruits	200 g	200 g
	Vegetables	350 g	350 g
	Nuts	75 g	75 g
	Legumes	100 g	100 g
	Dairy	130 g	130 g

RDV: Reference Daily Value; NPS: Nutritional Profiling System; NRF: Nutrient-Rich Foods Index; SFA: saturated fatty acid; NA: not applicable.

2.7. The Meiji NPS Algorithm

The Meiji NPS algorithm was based on nutrients and food groups to encourage, balanced against nutrients to limit (including energy). The base of calculation was 100 g, in line with the HSR. The algorithm was based on Nutrient-Rich Foods Index 9.3 (NRF9.3) [2,3,104–106]. The NRF9.3 was the sum of the percentage of RDVs for the nine nutrients to encourage minus the sum of percentage of RDVs for the nutrients to limit. In the original NRF9.3, calculations were made per 100 kcal (rather than 100 g) and capped at 100% (Equation (1)). The NRF is a renowned composite measure of nutrient density, and its validity has been extensively verified [104,107,108]. In addition, it is reportedly positively correlated with overall dietary quality in the Japanese population [109].

$$\begin{aligned} NRF9.3 = {} & \textstyle\sum_{i=1-9}(nutrients\ to\ encourage_i / RDV_i) \times 100 \\ & - \textstyle\sum_{i=1-3}(nutrients\ to\ limit_i / RDV_i) \times 100 \end{aligned} \quad (1)$$

The Meiji NPS score is calculated as the sum of the percentages of RDVs for the nutrients to encourage plus the sum of the percentages of RDVs for food groups to encourage minus the sum of the percentages of RDVs for the nutrients to limit (Equations (2) and (3)). The Meiji NPS score for adults was calculated per 100 g. The caps of the Meiji NPS scores for adults and older adults are summarized in Table 3. In consideration of excess intake, caps are set for nutrients and food groups to encourage but not for the nutrients to limit. Therefore, nutrients to limit can score over 100%. The percentages of protein and dietary fiber in the Meiji NPS for adults and older adults were capped at 100%. An insufficient intake is defined as the gap between the RDV and the median intake of the Japanese population [6,110]. The percentage of micronutrients (calcium, iron, and vitamin D) in the Meiji NPS for adults was capped at the gap. However, vitamin D is an important nutrient for older adults, and its intake is associated with a reduction in the risk of sarcopenia and frailty [54–61]. Therefore, the percentage of vitamin D in the Meiji NPS for older adults was capped at 100%. The percentage of foods to encourage was capped at the gaps in the Meiji NPS for adults and older adults.

$$\begin{aligned} Meiji\ NPS\ for\ \ & adults \\ & = \textstyle\sum_{i=1-5}(nutrients\ to\ encourage_i / RDV_i) \times 100 \\ & - \textstyle\sum_{i=1-4}(nutrients\ to\ limit_i / RDV_i) \times 100 \\ & + \textstyle\sum_{i=1-5}(food\ groups\ to\ encourage_i / RDV_i) \times 100 \end{aligned} \quad (2)$$

$$\begin{aligned} Meiji\ NPS\ for\ \ & older\ adults \\ & = \textstyle\sum_{i=1-4}(nutrients\ to\ encourage_i / RDV_i) \times 100 \\ & - \textstyle\sum_{i=1-3}(nutrients\ to\ limit_i / RDV_i) \times 100 \\ & + \textstyle\sum_{i=1-5}(food\ groups\ to\ encourage_i / RDV_i) \times 100 \end{aligned} \quad (3)$$

Table 3. The caps of the Meiji NPS for adults and older adults.

Items		Meiji NPS for Adults		Meiji NPS for Older Adults	
		Cap	Percentage of RDV	Cap	Percentage of RDV
Nutrients to encourage	Protein	65 g	100%	60 g	100%
	Dietary fiber	21 g	100%	20 g	100%
	Calcium	423.9 mg	42%	389.4 mg	52%
	Iron	5.8 mg	48%	NA	NA
	Vitamin D	6.2 μg	65%	8.5 μg	100%
Nutrients to limit	Energy	NA	NA	NA	NA
	SFAs	NA	NA	NA	NA
	Sugar	NA	NA	NA	NA
	Salt equivalents	NA	NA	NA	NA
Food groups to encourage	Fruits	200 g	100%	113 g	57%
	Vegetables	157.7 g	45%	84.7 g	24%
	Nuts	75 g	100%	75 g	100%
	Legumes	90 g	90%	57 g	57%
	Dairy	108.5 g	83%	55 g	42%

RDVs refer to Dietary the Reference Intakes for Japanese (2020) [6]. The caps were set by the gaps between Dietary Reference Intakes for Japanese (2020) and the National Health and Nutrition Survey [110]. The median intakes of fruits and nuts in adults and the median intake of nuts in older adults were 0 g/day, as reported in the National Health and Nutrition Survey, resulting in the cap of 100%. NPS: Nutritional Profiling System, RDV: Reference Daily Value, NA: not applicable.

2.8. Nutrient Composition Database

Nutrient composition data came from the Japanese Food Standard Composition Table 2020 Edition (8th Edition) [92], released by the Ministry of Education, Culture, Sports, Science, and Technology, Japan. This open database lists 2478 foods and multiple macro- and micronutrients, all expressed per 100 g. As the Meiji NPS was designed for individual foods rather than meals, prepared foods were excluded, yielding a total sample size of 2428. Out of the 2428 food items, several of these had missing data, particularly for total sugar content. Total sugar content data were missing for the important category of fish and seafood (mollusks and crustaceans), as well as for meat that was either raw, minimally processed, or dried. The total sugar content for those categories was inferred in previous studies [40]. The present assumption was that the sugar content for those foods was zero [40,111,112]. For other processed foods in the fish and seafood and meat groups (e.g., fish cakes, fish boiled in soy sauce, and chicken nuggets), the amount of carbohydrates was calculated to represent the sugar content. After the inputting of missing sugar values for raw and processed seafood (n = 684 foods), a total of 1545 foods with complete data were available for analysis.

Foods were assigned into desirable food categories based on the product name in the food composition tables. Based on the food names, the foods described as cereals, potatoes and starches; sugars and sweeteners; fish and seafood; meat; eggs; fats and oils; and confectioneries were not the food groups to encourage. In contrast, items in the fruit category (except for juice-based beverages and nectars) were assumed to be 100% fruit. Juice-based beverages and nectar were assigned a 30% fruit value. The vegetable category in the Meiji NPS included vegetables, mushrooms, algae, and spices. Items in these categories were assumed to be 100% vegetables, unless it was clear from the product name that the product did not have 100% vegetable or fruit content. In general, nuts were deemed to be 100% nuts, pulses were deemed to be 100% pulses, and dairy products were deemed to be 100% dairy, with the exception of cream.

2.9. Statistical Analysis

Medians (interquartile ranges [IQRs]) and means ± standard deviations were used to express data. The convergent validity of the Meiji NPS for adults and older adults was tested with reference to NRF9.3. The RDVs for NRF9.3 were calculated according to the

Dietary Reference Intakes for Japanese (2020) [6]. Spearman's correlation [113] was used for comparisons between the Meiji NPS and NRF9.3 or HSR. All analyses in this study were performed using R software version 4.3.1 (The R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. The Meiji NPS for Adults and Older Adults

Complete data regarding nutrients and food groups were available for 1545 foods. Meiji NPS scores were calculated for adults and older adults and compared to NRF9.3 scores for the same items. Histograms displaying score distributions are presented in Figures 1 and 2. The Meiji NPS score for adults ranged from −760 to 292, and that for older adults ranged from −770 to 268. These results are summarized in Tables 4 and 5. The mean Meiji NPS score for adults and older adults was 38.9 and 39.3, respectively. The median Meiji NPS score for adults and older adults was 36.7 and 31.2, respectively. No foods were classified as sugars and sweeteners owing to the lack of nutrient data; thus, the mean, standard deviation, and median values for this item were not available.

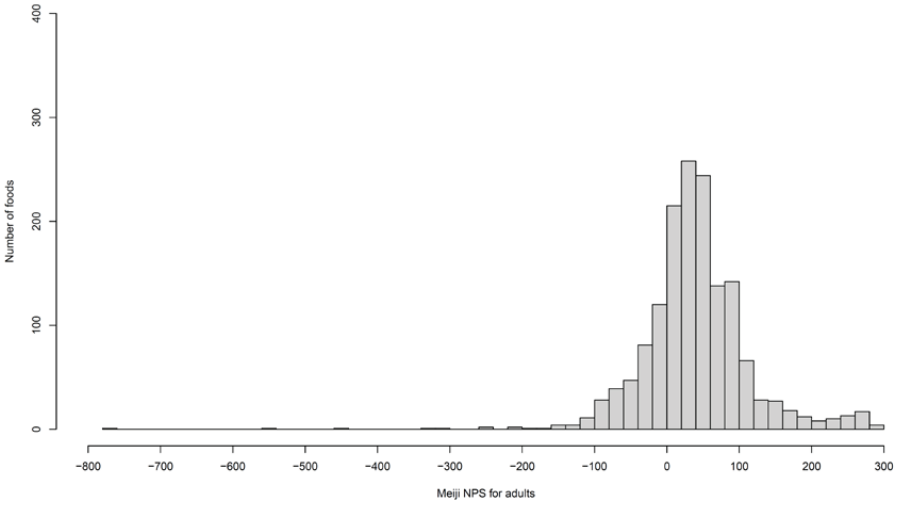

Figure 1. Distribution of the Meiji NPS score for adults. The highest score was 292, and the lowest score was −760. All the outliers (under −200) were seasonings and butters. NPS: Nutritional Profiling System.

Table 4. Summary results of the Meiji NPS for adults.

Items	n	Mean	SD	Median	Max	Min	IQR
Pulses	71	184.9	65.0	169.2	285.6	66.3	127.8 to 253.4
Nuts and seeds	40	163.5	60.6	147.3	292.4	−9.1	129.5 to 196.9
Algae	14	121.1	102.5	152.1	265.6	−73.9	79.0 to 176.0
Mushrooms	46	90.7	68.0	63.1	275.8	−10.9	55.7 to 84.5
Fish and seafood	430	59.7	46.6	63.0	229.3	−155.2	29.6 to 90.8
Vegetables	162	52.5	20.6	46.2	141.7	3.3	39.5 to 65.2
Beverages	10	44.4	102.8	−3.4	251.7	−6.6	−6.4 to −0.7
Milk and milk products	46	40.9	69.4	67.6	186.4	−140.1	15.8 to 83.1
Eggs	15	39.7	37.2	29.8	101.3	−13.2	8.3 to 66.5
Fruits	71	31.4	34.1	40.2	77.7	−165.6	31.2 to 46.4
Potatoes and starches	37	16.7	13.4	15.8	55.3	−12.6	11.1 to 19.7
Cereals	156	11.8	34.6	7.0	133.1	−100.3	−0.2 to 21.4
Meat	303	5.3	40.6	13.7	108.0	−119.3	−15.3 to 33.7
Confectionery	98	−34.6	31.0	−29.6	43.5	−152.2	−52.6 to −12.9
Seasonings and spices	42	−118.7	167.4	−81.3	219.1	−760.3	−127.1 to −43.4

Table 4. *Cont.*

Items	n	Mean	SD	Median	Max	Min	IQR
Fats and oils	4	−130.4	73.5	−134.8	−49.2	−202.9	−186.8 to −78.5
Sugars and sweeteners	0	NA	NA	NA	NA	NA	NA
Total	1545	38.9	75.8	36.7	292.4	−760.3	3.2 to 73.1

The Meiji NPS score for adults was calculated for 1545 foods. The food categories followed the food groups in the Japanese Food Standard Composition Table 2020 Edition (8th Edition) [92]. NPS: Nutritional Profiling System; n: number of foods; SD: standard deviation; Max: maximum; Min: minimum; IQR: interquartile range; NA: not applicable.

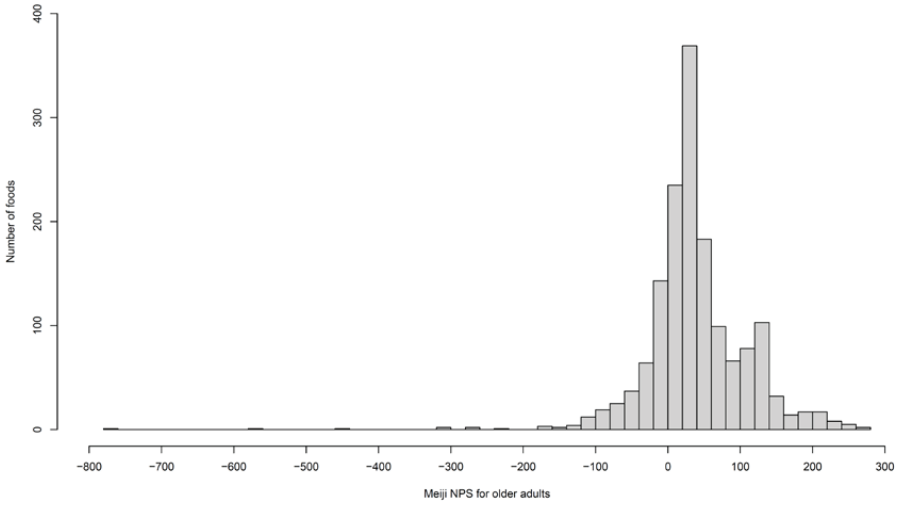

Figure 2. Distribution of the Meiji NPS score for older adults. The highest score was 268, and the lowest score was −770. All the outliers (under −200) were seasoning and butters.

Table 5. Summary results of the Meiji NPS for older adults.

Items	n	Mean	SD	Median	Max	Min	IQR
Nuts and seeds	40	161.5	44.1	151.9	264.5	106.8	127.8 to 181.3
Pulses	71	132.5	55.8	125.7	220.3	15.2	90.7 to 186.2
Mushrooms	46	86.7	71.7	56.8	268.4	−22.6	50.7 to 81.6
Algae	14	85.9	98.0	110.0	226.7	−115.1	46.5 to 127.8
Fish and seafood	430	69.1	58.4	73.1	226.2	−161.1	26.3 to 119.7
Milk and milk products	46	47.3	44.9	56.3	184.7	−42.4	7.4 to 64.7
Eggs	15	47.0	48.1	28.4	130.5	−19.0	9.4 to 84.2
Vegetables	162	43.5	17.3	39.6	100.8	−6.2	32.1 to 53.8
Beverages	10	35.8	87.5	−6.3	213.1	−7.7	−7.5 to −0.8
Fruits	71	25.2	38.9	36.1	78.8	−173.0	26.6 to 43.2
Meat	303	17.3	19.7	23.3	77.0	−76.9	5.7 to 30.3
Potatoes and starches	37	11.0	14.3	12.0	49.2	−37.6	7.5 to 16.6
Cereals	156	7.5	27.6	3.7	94.5	−106.8	−1.0 to 17.6
Fats and oils	4	−8.1	43.7	−21.8	55.4	−44.4	−29.4 to −0.4
Confectionery	98	−36.3	36.8	−37.3	38.5	−161.3	−60.5 to −9.3
Seasonings and spices	42	−126.1	166.1	−92.1	180.3	−770.2	−131.1 to −45.3
Sugars and sweeteners	0	NA	NA	NA	NA	NA	NA
Total	1545	39.3	70.9	31.2	268.4	−770.2	5.4 to 69.6

The Meiji NPS score for older adults was calculated for 1545 foods. The food categories followed the food groups in the Japanese Food Standard Composition Tables 2020 Edition (8th Edition) [92]. NPS: Nutritional Profiling System; n: number of foods; SD: standard deviation; Max: maximum; Min: minimum; IQR: interquartile range; NA: not applicable.

3.2. Convergent Validity between the Meiji NPS and NRF9.3

The convergent validity was assessed using the Meiji NPS and NRF9.3. Spearman's correlation coefficients between the Meiji NPS for adults or older adults and NRF9.3 were 0.67 and 0.60, respectively (Table 6). In the Meiji NPS for adults and older adults, the correlation coefficients of mushrooms, algae, and fish and seafood were relatively low and not significant (mushrooms: r = 0.14 for adults and r = 0.07 for older adults; algae: r = 0.24 for adults and r = 0.20 for older adults; fish and seafood: r = 0.07 for adults and r = −0.05 for older adults; all $p > 0.05$).

Table 6. Spearman's correlation coefficients between the Meiji NPS and NRF9.3.

Items		For Adults		For Older Adults	
	n	r	*p*-Values	r	*p*-Values
Milk and milk products	46	0.91	<0.001	0.81	<0.001
Meat	303	0.91	<0.001	0.72	<0.001
Cereals	156	0.91	<0.001	0.89	<0.001
Beverages	10	0.90	<0.001	0.90	<0.001
Eggs	15	0.84	<0.001	0.79	<0.001
Fats and oils	4	0.80	0.3333	0.40	0.7500
Seasonings and spices	42	0.79	<0.001	0.78	<0.001
Confectionery	98	0.75	<0.001	0.82	<0.001
Fruits	71	0.74	<0.001	0.74	<0.001
Pulses	71	0.68	<0.001	0.68	<0.001
Nuts and seeds	40	0.52	<0.001	0.45	0.0043
Potatoes and starches	37	0.42	0.0110	0.49	0.0019
Vegetables	162	0.39	<0.001	0.41	<0.001
Algae	14	0.24	0.3998	0.20	0.4827
Mushrooms	46	0.14	0.3521	0.07	0.6666
Fish and seafood	430	0.07	0.1239	−0.05	0.2625
Sugars and sweeteners	0	NA	NA	NA	NA
Total	1545	0.67	<0.001	0.60	<0.001

Data for sugars and sweeteners were not available. NPS: Nutritional Profiling System; NRF: Nutrient-Rich Foods Index; NA: not available.

3.3. Convergent Validity of the Meiji NPS with HSR

Meiji NPS scores were compared to HSR scores for the same foods to provide additional validation of the convergent validity of the Meiji NPS. The HSR score was calculated using the Health Star Rating Calculator [114]. The HSR evaluates foods along a 10-point scale. The Meiji NPS scores were accordingly split into deciles. Spearman's correlation [113] was used to compare these systems.

Spearman's correlation coefficients were 0.64 for adults and 0.61 for older adults (Table 7). All foods categorized as algae by the HSR scored 10 points (5 stars). Scores of all foods categorized as fats and oils by the Meiji NPS for adults were 10 percentiles. Thus, the correlation coefficients were not available for these two items. The correlation coefficients for eggs were relatively low and not significant (r = −0.36 for adults and r = −0.37 for older adults; all $p > 0.05$).

Table 7. Spearman's correlation coefficients between the Meiji NPS and HSR.

Items	For Adults		For Older Adults	
	r	*p*-Values	r	*p*-Values
Cereals	0.89	<0.001	0.84	<0.001
Meat	0.89	<0.001	0.83	<0.001
Beverages	0.82	0.004	0.79	0.0068
Potatoes and starches	0.75	<0.001	0.64	<0.001
Vegetables	0.74	<0.001	0.72	<0.001
Mushrooms	0.74	<0.001	0.75	<0.001

Table 7. *Cont.*

Items	For Adults		For Older Adults	
	r	*p*-Values	r	*p*-Values
Seasonings and spices	0.73	<0.001	0.67	<0.001
Algae	0.71	<0.001	0.82	<0.001
Confectionery	0.71	<0.001	0.39	<0.001
Milk and milk products	0.68	<0.001	0.53	<0.001
Pulses	0.60	<0.001	0.75	<0.001
Fruits	0.59	<0.001	0.62	<0.001
Nuts and seeds	0.60	<0.001	0.75	<0.001
Fish and seafood	0.35	<0.001	0.32	<0.001
Eggs	−0.36	0.194	−0.37	0.181
Fats and oils	NA	NA	0.11	0.895
Sugars and sweeteners	NA	NA	NA	NA
Total	0.64	<0.001	0.61	<0.001

NPS: Nutritional Profiling System; HSR: Health Star Rating; NA: not applicable.

4. Discussion

This is the first NPS that is age-dependent and focused on nutrient requirements of older adults ≥65 years old. The goal of this study was to address changing nutrient requirements at different stages of the life cycle. Some of the Meiji NPS scores differed between adults and older adults. The mean Meiji NPS score for meat was 5.3 for adults and 17.3 for older adults. The corresponding IQR shifted from −15.3–33.7 to 5.7–30.3. In a previous study, meat intake was negatively associated with frailty [98]. In addition, the Meiji NPS score for cheese differed greatly between adults and older adults. The mean score for cheese for adults was 56.2, whereas that for older adults was 80.1. The IQR shifted from 41.1–71.1 to 50.7–98.9. Previous studies revealed that the consumption of cheese presents health benefits in older adults [115–119]. These results indicate that the Meiji NPS for older adults is more suitable for the assessment of foods that prevent frailty than the Meiji NPS for adults.

The Meiji NPS was specifically designed to address identified health issues, and we plan to validate the relationships between diets consistent with the Meiji NPS and the selected health outcomes. The Meiji NPS was developed deductively by referring to the existing NPS, Health Japan 21, the Dietary Reference Intakes for Japanese (2020), and epidemiological studies. We set the RDVs according to the actual nutrient intake of the Japanese population and the national standards, in response to age-dependent health issues in Japan. Moreover, we selected nutritional factors and food factors related to health issues based on the actual intake of the Japanese population. The Meiji NPS is focused on the health issues of Japanese adults and older adults. However, the same approach can be applied to different countries or different age groups. When the health targets were changed, the algorithm of the Meiji NPS could be applied for other life stages, for example, children <12 years old.

In this study, the nutritional values in the Meiji NPS were evaluated per 100 g. For adults, the foods scoring under −200 were seasonings and butter. Japanese people do not usually consume these items in quantities of 100 g at a time. Indeed, it is necessary to develop a scoring system that reflects the actual dietary habits. In terms of epidemiological studies, both food quality and quantity may affect health outcomes [120–125]. For example, a higher intake of comfort foods may be associated with rates of obesity or overweight [126,127]. However, a moderate intake of such foods has less of an effect on health outcomes [128–131]. The algorithm of the Meiji NPS can also be applied for evaluation per serving size. Evaluating nutritional values both per serving size and per 100 g will ensure a more accurate approach to nutritional intake and health management. Further study is needed to develop and validate the Meiji NPS per serving size.

Spearman's correlation coefficients for all foods between the Meiji NPS and NRF9.3 were 0.67 for adults and 0.60 for older adults, indicating a moderate correlation [113].

Further, its convergent validity with the HSR also indicated a moderate correlation (r = 0.67 for adults, r = 0.64 for older adults). These results indicate that the Meiji NPSs for adults and older adults are valid NPSs. However, regarding each food group, the correlations between mushrooms, algae, and fish and seafood between the Meiji NPS and NRF9.3 were weak or negligible. This may be explained by the fact that scores in NRF9.3 are calculated per 100 kcal, whereas those in the Meiji NPS are calculated per 100 g. Many foods categorized as mushrooms, fish and seafood, and algae have high water contents, and many others have lower water contents, such as dried mushrooms, dried kelp, and dried horse mackerel. NRF9.3 is not affected by water content, unlike the Meiji NPS, which is demonstrated in these food groups with large variability in water content. In addition, the correlations of eggs between the Meiji NPS and HSR were negligible. In the categories of eggs, processed foods with high sugar content, such as processed sweetened eggs, had high scores in the HSR and low scores in the Meiji NPS. The median scores of pulses, nuts and seeds, vegetables, fruits, mushrooms, algae, fish and seafood, and milk and milk products in the Meiji NPS for adults and older adults were higher than the median scores of total the foods. Diets high in these products have been associated with a lower risk of all-cause and cardiovascular disease-related mortality, as well as dementia, in Japan [132–134]. Hence, the Meiji NPS identified foods associated with better health outcomes.

The Meiji NPS may be improved in several ways. Firstly, adding factors such as the quality of nutrients (e.g., amino acid score) and the degree and/or types of food processing (e.g., sterilization, fermentation), which also play important roles in nutritional value [135–137], may improve the assessment of foods. NPSs that incorporate such factors have already been proposed [138–140]. Secondly, existing NPSs, such as the Nutri-Score and HSR, express scores in an easy-to-understand, 5- or 10-point scale from the perspective of changing consumer behavior [141]. When implementing the Meiji NPS, the score should preferably be expressed in an easy-to-understand manner. For example, the score can be converted into a scale of 0 (least healthful) to 100 (most healthful), improving its interpretability. In fact, we performed this conversion and demonstrated good correlations between the Meiji NPS before and after conversion (Appendix A). Thirdly, additional validation studies can increase the robustness of the Meiji NPS. Specifically, the predictive validity should be determined, that is, the relationship between the Meiji NPS score and the targeted health issues. In addition, affordable and nutrient-rich food products may have an impact on consumers' health. Nutritional disparities associated with socioeconomic status are also one of the significant issues in Japan [30,31]. Thus, food affordability could be important to consider when using the Meiji NPS. Finally, appropriate revisions may be needed for alignment with changes in Dietary Reference Intakes, official guidelines, and new evidence.

Limitations

This study has several limitations. Firstly, not all foods were evaluated via the Meiji NPS owing to the lack of nutrient data for a number of foods in the Japanese Food Standard Composition Table 2020 Edition (8th Edition). Secondly, we estimated the volumes of food groups to encourage, as those data are not available in the nutrient composition database. We might have overestimated the nutritional values of the food groups to encourage. Finally, we tested only the convergent validity of the Meiji NPS for adults and older adults.

5. Conclusions

The Meiji NPS for adults and older adults was developed based on Japanese health issues that depend on a person's life stage. The convergent validity between the NRF, HSR, and the Meiji NPS was confirmed. The Meiji NPS may be useful for nutritional evaluation and the reformulation of food products tailored to adults and older adults to ameliorate health issues in Japan.

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Conflicts of Interest: Ryota Wakayama, Tomohito Horimoto, Yoshie Saito, Tao Yu, and Satoshi Takasugi are full-time employees of Meiji Co, Ltd. Adam Drewnowski and Takao Suzuki have academic consulting agreements with Meiji Co., Ltd. Adam Drewnowski has received grants, contracts, and honoraria from numerous public and private entities with an interest in the nutrient profiling of foods.

Appendix A

The 0–100 Scaled Meiji NPS

Based on the score distribution of the Meiji NPS for adults, scores below −100 were converted to 0 on the 0–100 scaled Meiji NPS, and scores above 100 were converted to 100 on the 0–100 scaled Meiji NPS. In the case of the Meiji NPS for adults, 85% of the foods were within the range of 0 to 100 points. The Meiji NPS for older adults was also converted to a 0–100 scale using the same criteria as the Meiji NPS for adults. The results of the convergent validity, as determined via Spearman's correlation coefficient between the Meiji NPS and the 0–100 scaled Meiji NPS, are shown in Table A1. The correlation coefficients were 1.0 for adults and older adults in total foods. The correlation coefficients in pulses and nuts and seeds were below 0.5. This may have been influenced by the fact that most of these foods scored 100 on the 0–100 scale Meiji NPS.

Table A1. Spearman's correlation coefficients between the Meiji NPS and the 0–100-scaled Meiji NPS.

Items	For Adults		For Older Adults	
	r	*p*-Values	r	*p*-Values
Total	1.00	<0.001	1.00	<0.001
Cereals	1.00	<0.001	1.00	<0.001
Potatoes and starches	1.00	<0.001	1.00	<0.001
Sugars and sweeteners	NA	NA	NA	NA
Pulses	0.48	<0.001	0.82	<0.001
Nuts and seeds	0.46	0.0030	NA	NA
Vegetables	1.00	<0.001	1.00	<0.001
Fruits	1.00	<0.001	1.00	<0.001
Mushrooms	0.99	<0.001	0.99	<0.001
Algae	0.86	<0.001	0.90	<0.001
Fish and seafood	1.00	<0.001	0.98	<0.001
Meat	1.00	<0.001	1.00	<0.001
Eggs	1.00	<0.001	0.99	<0.001
Milk and milk products	1.00	<0.001	1.00	<0.001
Fats and oils	0.95	0.0513	1.00	0.0833

Table A1. *Cont.*

Items	For Adults		For Older Adults	
	r	*p*-Values	r	*p*-Values
Confectionaries	1.00	<0.001	1.00	<0.001
Beverages	1.00	<0.001	1.00	<0.001
Seasonings and spices	0.97	<0.001	0.95	<0.001

NA: Not Applicable.

References

1. Drewnowski, A.; Nicklas, T.A.; O'Neil, C.E. The nutrient density approach to healthy eating: Challenges and opportunities. *Public Health Nutr.* **2014**, *17*, 2626–2636. [CrossRef]
2. Drewnowski, A.; Fulgoni, V., 3rd. Nutrient profiling of foods: Creating a nutrient-rich food index. *Nutr. Rev.* **2008**, *66*, 23–39. [CrossRef]
3. Drewnowski, A.; Fulgoni, V.L., 3rd. Nutrient density: Principles and evaluation tools. *Am. J. Clin. Nutr.* **2014**, *99*, 1223s–1228s. [CrossRef]
4. Drewnowski, A. Uses of nutrient profiling to address public health needs: From regulation to reformulation. *Proc. Nutr. Soc.* **2017**, *76*, 220–229. [CrossRef] [PubMed]
5. Prentice, A. Sex differences in requirements for micronutrients across the lifecourse. *Proc. Nutr. Soc.* **2021**, *80*, 356–364. [CrossRef] [PubMed]
6. Dietary Reference Intakes for Japanese. 2020. Available online: https://www.mhlw.go.jp/content/001151422.pdf (accessed on 7 June 2023).
7. WHO Regional Office for Europe. Use of Nutrient Profile Models for Nutrition and Health Policies: Meeting Report on the Use of Nutrient Models in the WHO Europian Region. Available online: https://www.who.int/europe/publications/i/item/WHO-EURO-2022-6201-45966-66383 (accessed on 2 February 2024).
8. Dubois, P.; Albuquerque, P.; Allais, O.; Bonnet, C.; Bertail, P.; Combris, P.; Lahlou, S.; Rigal, N.; Ruffieux, B.; Chandon, P. Effects of front-of-pack labels on the nutritional quality of supermarket food purchases: Evidence from a large-scale randomized controlled trial. *J. Acad. Mark. Sci.* **2021**, *49*, 119–138. [CrossRef]
9. Ahn, C.; Lee, C.G. Effect of NUTRI-SCORE labeling on sales of food items in stores at sports and non-sports facilities. *Prev. Med. Rep.* **2022**, *29*, 101919. [CrossRef] [PubMed]
10. Egnell, M.; Boutron, I.; Péneau, S.; Ducrot, P.; Touvier, M.; Galan, P.; Fezeu, L.; Porcher, R.; Ravaud, P.; Hercberg, S.; et al. Impact of the Nutri-Score front-of-pack nutrition label on purchasing intentions of individuals with chronic diseases: Results of a randomised trial. *BMJ Open* **2022**, *12*, e058139. [CrossRef] [PubMed]
11. About Health Star Ratings. Available online: http://healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/Content/About-health-stars (accessed on 2 February 2024).
12. Australia's Health. 2014. Available online: https://www.aihw.gov.au/reports/australias-health/australias-health-2014/overview (accessed on 2 February 2024).
13. Australian Dietary Guidelines. Available online: https://www.nhmrc.gov.au/adg (accessed on 2 February 2024).
14. Nijman, C.A.; Zijp, I.M.; Sierksma, A.; Roodenburg, A.J.; Leenen, R.; van den Kerkhoff, C.; Weststrate, J.A.; Meijer, G.W. A method to improve the nutritional quality of foods and beverages based on dietary recommendations. *Eur. J. Clin. Nutr.* **2007**, *61*, 461–471. [CrossRef] [PubMed]
15. Lehmann, U.; Charles, V.R.; Vlassopoulos, A.; Masset, G.; Spieldenner, J. Nutrient profiling for product reformulation: Public health impact and benefits for the consumer. *Proc. Nutr. Soc.* **2017**, *76*, 255–264. [CrossRef]
16. Vlassopoulos, A.; Masset, G.; Charles, V.R.; Hoover, C.; Chesneau-Guillemont, C.; Leroy, F.; Lehmann, U.; Spieldenner, J.; Tee, E.S.; Gibney, M.; et al. A nutrient profiling system for the (re)formulation of a global food and beverage portfolio. *Eur. J. Nutr.* **2017**, *56*, 1105–1122. [CrossRef] [PubMed]
17. Greenberg, D.; Drewnowski, A.; Black, R.; Weststrate, J.A.; O'Shea, M. A Progressive nutrient profiling system to guide improvements in nutrient density of foods and beverages. *Front. Nutr.* **2021**, *8*, 774409. [CrossRef]
18. Global Access to Nutrition Index 2021: Methodology. Available online: https://accesstonutrition.org/app/uploads/2020/06/Global-Index-2021-Methodology-FINAL.pdf (accessed on 2 February 2024).
19. Nutrient Profiling: Report of a WHO/IASO Technical Meeting. Available online: https://www.yumpu.com/en/document/view/49710124/nutrient-profiling-world-health-organization (accessed on 2 February 2024).
20. Healthy Diet. Available online: https://www.who.int/news-room/fact-sheets/detail/healthy-diet (accessed on 2 February 2024).
21. Nutrition Policy in Japan to Leave No One Behind. Available online: https://www.mhlw.go.jp/nutrition_policy/en (accessed on 2 February 2024).
22. Hu, F.B. Diet strategies for promoting healthy aging and longevity: An epidemiological perspective. *J. Intern. Med.* **2023**, *295*, 508–531. [CrossRef] [PubMed]
23. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **2019**, *393*, 1958–1972. [CrossRef] [PubMed]

24. Fukasawa, T.; Tanemura, N.; Kimura, S.; Urushihara, H. Utility of a Specific Health Checkup database containing lifestyle behaviors and lifestyle diseases for employee health insurance in Japan. *J. Epidemiol.* **2020**, *30*, 57–66. [CrossRef]
25. Kadoya, Y.; Hara, M.; Takahari, K.; Ishida, Y.; Tamaki, M. Disease control status and safety of telemedicine in patients with lifestyle diseases—A multicenter prospective observational study in Japan. *Circ. Rep.* **2020**, *2*, 351–356. [CrossRef]
26. Katoch, O.R. Determinants of malnutrition among children: A systematic review. *Nutrition* **2022**, *96*, 111565. [CrossRef]
27. Christian, P.; Smith, E.R. Adolescent undernutrition: Global burden, physiology, and nutritional risks. *Ann. Nutr. Metab.* **2018**, *72*, 316–328. [CrossRef]
28. Wells, J.C.K.; Briend, A.; Boyd, E.M.; Berkely, J.A.; Hall, A.; Isanaka, S.; Webb, P.; Khara, T.; Dolan, C. Beyond wasted and stunted-a major shift to fight child undernutrition. *Lancet Child. Adolesc. Health* **2019**, *3*, 831–834. [CrossRef]
29. Gallagher, P.G. Anemia in the pediatric patient. *Blood* **2022**, *140*, 571–593. [CrossRef]
30. Summary of the Report of the Committee Meeting on the Promotion of a Healthy and Sustainable Food Environment. Available online: https://www.mhlw.go.jp/content/10900000/000836945.pdf (accessed on 2 February 2024).
31. Strategic Initiative for a Healthy and Sustainable Food Environment (HSFE). Available online: https://sustainable-nutrition.mhlw.go.jp/en (accessed on 2 February 2024).
32. Kurabayashi, T.; Nagai, K.; Morikawa, K.; Kamimura, N.; Yanase, T.; Hayashi, K. Prevalence of osteoporosis and osteopenia assessed by densitometry in Japanese puerperal women. *J. Obstet. Gynaecol. Res.* **2021**, *47*, 1388–1396. [CrossRef]
33. Annual Report on the Ageing Society. Available online: https://www8.cao.go.jp/kourei/english/annualreport/index-wh.html (accessed on 2 February 2024).
34. Chang, A.Y.; Skirbekk, V.F.; Tyrovolas, S.; Kassebaum, N.J.; Dieleman, J.L. Measuring population ageing: An analysis of the Global Burden of Disease Study 2017. *Lancet Public Health* **2019**, *4*, e159–e167. [CrossRef] [PubMed]
35. Puri, S.; Shaheen, M.; Grover, B. Nutrition and cognitive health: A life course approach. *Front. Public Health* **2023**, *11*, 1023907. [CrossRef] [PubMed]
36. Azzolino, D.; Spolidoro, G.C.I.; Saporiti, E.; Luchetti, C.; Agostoni, C.; Cesari, M. Musculoskeletal changes across the lifespan: Nutrition and the life-course approach to prevention. *Front. Med.* **2021**, *8*, 697954. [CrossRef] [PubMed]
37. Darnton-Hill, I.; Nishida, C.; James, W.P. A life course approach to diet, nutrition and the prevention of chronic diseases. *Public Health Nutr.* **2004**, *7*, 101–121. [CrossRef] [PubMed]
38. Kac, G.; Pérez-Escamilla, R. Nutrition transition and obesity prevention through the life-course. *Int. J. Obes. Suppl.* **2013**, *3*, S6–S8. [CrossRef]
39. Rodríguez-Mañas, L.; Murray, R.; Glencorse, C.; Sulo, S. Good nutrition across the lifespan is foundational for healthy aging and sustainable development. *Front. Nutr.* **2022**, *9*, 1113060. [CrossRef] [PubMed]
40. Kashino, I.; Mizoue, T.; Yoshita, K.; Uenishi, K.; Hasegawa, Y.; Saito, H.; Aoyagi, S.; Kuranuki, S.; Nakamura, T. Evaluation of foods by using nutrient profile model. *J. Jpn. Diet. Assoc.* **2018**, *61*, 445–450. [CrossRef]
41. Yokoyama, Y.; Yoshizaki, T.; Tada, Y.; Okada, E.; Takebayashi, J.; Takimoto, H.; Ishimi, Y. A study on the characteristics of nutrient profile models in other countries for the development of a Japanese nutrient profile model. *Jpn. J. Nutr. Diet.* **2021**, *79*, 162–173. [CrossRef]
42. Furuta, C.; Jinzu, H.; Cao, L.; Drewnowski, A.; Okabe, Y. Nutrient profiling of Japanese dishes: The development of a novel Ajinomoto Group Nutrient Profiling System. *Front. Nutr.* **2022**, *9*, 912148. [CrossRef]
43. Oono, F.; Murakami, K.; Fujiwara, A.; Shinozaki, N.; Adachi, R.; Asakura, K.; Masayasu, S.; Sasaki, S. Development of a Diet Quality Score for Japanese and comparison with existing diet quality scores regarding inadequacy of nutrient intake. *J. Nutr.* **2023**, *153*, 798–810. [CrossRef] [PubMed]
44. Shinozaki, N.; Murakami, K.; Masayasu, S.; Sasaki, S. Usual nutrient intake distribution and prevalence of nutrient intake inadequacy among Japanese children and adults: A nationwide study based on 8-day dietary records. *Nutrients* **2023**, *15*, 5113. [CrossRef] [PubMed]
45. Hansen, T.T.; Astrup, A.; Sjödin, A. Are dietary proteins the key to successful body weight management? A systematic review and meta-analysis of studies assessing body weight outcomes after interventions with increased dietary protein. *Nutrients* **2021**, *13*, 3193. [CrossRef] [PubMed]
46. Huwiler, V.V.; Schönenberger, K.A.; Segesser von Brunegg, A.; Reber, E.; Mühlebach, S.; Stanga, Z.; Balmer, M.L. Prolonged isolated soluble dietary fibre supplementation in overweight and obese patients: A systematic review with meta-analysis of randomised controlled trials. *Nutrients* **2022**, *14*, 2627. [CrossRef] [PubMed]
47. Jovanovski, E.; Mazhar, N.; Komishon, A.; Khayyat, R.; Li, D.; Blanco Mejia, S.; Khan, T.; Jenkins, A.L.; Smircic-Duvnjak, L.; Sievenpiper, J.L.; et al. Effect of viscous fiber supplementation on obesity indicators in individuals consuming calorie-restricted diets: A systematic review and meta-analysis of randomized controlled trials. *Eur. J. Nutr.* **2021**, *60*, 101–112. [CrossRef] [PubMed]
48. Hajhashemy, Z.; Rouhani, P.; Saneei, P. Dietary calcium intake in relation to type-2 diabetes and hyperglycemia in adults: A systematic review and dose-response meta-analysis of epidemiologic studies. *Sci. Rep.* **2022**, *12*, 1050. [CrossRef]
49. Cormick, G.; Ciapponi, A.; Cafferata, M.L.; Cormick, M.S.; Belizán, J.M. Calcium supplementation for prevention of primary hypertension. *Cochrane Database Syst. Rev.* **2022**, *1*, Cd010037. [CrossRef]
50. Ozawa, M.; Ninomiya, T.; Ohara, T.; Hirakawa, Y.; Doi, Y.; Hata, J.; Uchida, K.; Shirota, T.; Kitazono, T.; Kiyohara, Y. Self-reported dietary intake of potassium, calcium, and magnesium and risk of dementia in the Japanese: The Hisayama Study. *J. Am. Geriatr. Soc.* **2012**, *60*, 1515–1520. [CrossRef]

51. Zhang, Y.; Xue, Y.; Zhang, D.; Liu, Y.; Xu, Z.; Gao, J.; Li, W.; Li, X. Effect of vitamin D supplementation on glycemic control in prediabetes: A meta-analysis. *Nutrients* **2021**, *13*, 4464. [CrossRef]
52. Bahadorpour, S.; Hajhashemy, Z.; Saneei, P. Serum 25-hydroxyvitamin D levels and dyslipidemia: A systematic review and dose-response meta-analysis of epidemiologic studies. *Nutr. Rev.* **2022**, *81*, 1–25. [CrossRef]
53. Mohammadi, S.; Hajhashemy, Z.; Saneei, P. Serum vitamin D levels in relation to type-2 diabetes and prediabetes in adults: A systematic review and dose-response meta-analysis of epidemiologic studies. *Crit. Rev. Food Sci. Nutr.* **2022**, *62*, 8178–8198. [CrossRef] [PubMed]
54. Mori, H.; Tokuda, Y. Differences and overlap between sarcopenia and physical frailty in older community-dwelling Japanese. *Asia Pac. J. Clin. Nutr.* **2019**, *28*, 157–165. [CrossRef] [PubMed]
55. Kuwabara, A.; Tsugawa, N.; Kondo, H.; Ao, M.; Fujiwara, H.; Hosokawa, N.; Matsumoto, S.; Tanaka, K.; Nakano, T. Associations between serum 25-hydroxyvitamin D(3) level and skeletal muscle mass and lower limb muscle strength in Japanese middle-aged subjects. *Osteoporos. Sarcopenia* **2017**, *3*, 53–58. [CrossRef]
56. Mizuno, T.; Hosoyama, T.; Tomida, M.; Yamamoto, Y.; Nakamichi, Y.; Kato, S.; Kawai-Takaishi, M.; Ishizuka, S.; Nishita, Y.; Tange, C.; et al. Influence of vitamin D on sarcopenia pathophysiology: A longitudinal study in humans and basic research in knockout mice. *J. Cachexia Sarcopenia Muscle* **2022**, *13*, 2961–2973. [CrossRef] [PubMed]
57. Asakura, K.; Etoh, N.; Imamura, H.; Michikawa, T.; Nakamura, T.; Takeda, Y.; Mori, S.; Nishiwaki, Y. Vitamin D status in Japanese adults: Relationship of serum 25-hydroxyvitamin D with simultaneously measured dietary vitamin D intake and ultraviolet ray exposure. *Nutrients* **2020**, *12*, 743. [CrossRef]
58. Weiler, H.A.; Sarafin, K.; Martineau, C.; Daoust, J.L.; Esslinger, K.; Greene-Finestone, L.S.; Loukine, L.; Dorais, V. Vitamin D status of people 3 to 79 years of age from the Canadian Health Measures Survey 2012–2019. *J. Nutr.* **2023**, *153*, 1150–1161. [CrossRef]
59. Nasimi, N.; Sohrabi, Z.; Nunes, E.A.; Sadeghi, E.; Jamshidi, S.; Gholami, Z.; Akbarzadeh, M.; Faghih, S.; Akhlaghi, M.; Phillips, S.M. Whey protein supplementation with or without vitamin D on sarcopenia-related measures: A systematic review and meta-analysis. *Adv. Nutr.* **2023**, *14*, 762–773. [CrossRef] [PubMed]
60. Mesinovic, J.; Rodriguez, A.J.; Cervo, M.M.; Gandham, A.; Xu, C.L.H.; Glavas, C.; de Courten, B.; Zengin, A.; Ebeling, P.R.; Scott, D. Vitamin D supplementation and exercise for improving physical function, body composition and metabolic health in overweight or obese older adults with vitamin D deficiency: A pilot randomized, double-blind, placebo-controlled trial. *Eur. J. Nutr.* **2023**, *62*, 951–964. [CrossRef]
61. Zhou, J.; Huang, P.; Liu, P.; Hao, Q.; Chen, S.; Dong, B.; Wang, J. Association of vitamin D deficiency and frailty: A systematic review and meta-analysis. *Maturitas* **2016**, *94*, 70–76. [CrossRef]
62. Jia, J.; Hu, J.; Huo, X.; Miao, R.; Zhang, Y.; Ma, F. Effects of vitamin D supplementation on cognitive function and blood Aβ-related biomarkers in older adults with Alzheimer's disease: A randomised, double-blind, placebo-controlled trial. *J. Neurol. Neurosurg. Psychiatry* **2019**, *90*, 1347–1352. [CrossRef]
63. Sommer, I.; Griebler, U.; Kien, C.; Auer, S.; Klerings, I.; Hammer, R.; Holzer, P.; Gartlehner, G. Vitamin D deficiency as a risk factor for dementia: A systematic review and meta-analysis. *BMC Geriatr.* **2017**, *17*, 16. [CrossRef]
64. Kalra, A.; Teixeira, A.L.; Diniz, B.S. Association of vitamin D levels with incident all-cause dementia in longitudinal observational studies: A systematic review and meta-analysis. *J. Prev. Alzheimers Dis.* **2020**, *7*, 14–20. [CrossRef]
65. Jayedi, A.; Rashidy-Pour, A.; Shab-Bidar, S. Vitamin D status and risk of dementia and Alzheimer's disease: A meta-analysis of dose-response (†). *Nutr. Neurosci.* **2019**, *22*, 750–759. [CrossRef] [PubMed]
66. Tateishi, Y.; Ichikawa, R.; Suzuki, K.; Kitahara, Y.; Someya, Y.; Tamura, Y. Effect of imbalance in dietary macronutrients on blood hemoglobin levels: A cross-sectional study in young underweight Japanese women. *Front. Nutr.* **2023**, *10*, 1121717. [CrossRef] [PubMed]
67. Iizuka, K.; Sato, H.; Kobae, K.; Yanagi, K.; Yamada, Y.; Ushiroda, C.; Hirano, K.; Ichimaru, S.; Seino, Y.; Ito, A.; et al. Young Japanese underweight women with "Cinderella weight" are prone to malnutrition, including vitamin deficiencies. *Nutrients* **2023**, *15*, 2216. [CrossRef] [PubMed]
68. [List of Health Japan 21 Target Values] Kenkou Nihon 21 Mokuhyouchi Ichiran. Available online: https://www.mhlw.go.jp/www1/topics/kenko21_11/t2a.html (accessed on 2 February 2024). (In Japanese)
69. Wakayama, R.; Takasugi, S.; Honda, K.; Kanaya, S. Application of a two-dimensional mapping-based visualization technique: Nutrient-value-based food grouping. *Nutrients* **2023**, *15*, 5006. [CrossRef] [PubMed]
70. Jiang, K.; Zhang, Z.; Fullington, L.A.; Huang, T.T.; Kaliszewski, C.; Wei, J.; Zhao, L.; Huang, S.; Ellithorpe, A.; Wu, S.; et al. Dietary patterns and obesity in Chinese adults: A systematic review and meta-analysis. *Nutrients* **2022**, *14*, 4911. [CrossRef] [PubMed]
71. Eslami, O.; Khorramrouz, F.; Sohouli, M.; Bagheri, N.; Shidfar, F.; Fernandez, M.L. Effect of nuts on components of metabolic syndrome in healthy adults with overweight/obesity: A systematic review and meta-analysis. *Nutr. Metab. Cardiovasc. Dis.* **2022**, *32*, 2459–2469. [CrossRef] [PubMed]
72. Jayedi, A.; Ge, L.; Johnston, B.C.; Shahinfar, H.; Safabakhsh, M.; Mohamadpur, S.; Ghorbaninejad, P.; Abyadeh, M.; Zeraattalab-Motlagh, S.; Soltani, S.; et al. Comparative effectiveness of single foods and food groups on body weight: A systematic review and network meta-analysis of 152 randomized controlled trials. *Eur. J. Nutr.* **2023**, *62*, 1153–1164. [CrossRef] [PubMed]
73. Asbaghi, O.; Sadeghian, M.; Rahmani, S.; Mardani, M.; Khodadost, M.; Maleki, V.; Pirouzi, A.; Talebi, S.; Sadeghi, O. The effect of green coffee extract supplementation on anthropometric measures in adults: A comprehensive systematic review and dose-response meta-analysis of randomized clinical trials. *Complement. Ther. Med.* **2020**, *51*, 102424. [CrossRef]

74. Fernández-Rodríguez, R.; Mesas, A.E.; Garrido-Miguel, M.; Martínez-Ortega, I.A.; Jiménez-López, E.; Martínez-Vizcaíno, V. The relationship of tree nuts and peanuts with adiposity parameters: A systematic review and network meta-analysis. *Nutrients* **2021**, *13*, 2251. [CrossRef] [PubMed]
75. Nishi, S.K.; Viguiliouk, E.; Blanco Mejia, S.; Kendall, C.W.C.; Bazinet, R.P.; Hanley, A.J.; Comelli, E.M.; Salas Salvadó, J.; Jenkins, D.J.A.; Sievenpiper, J.L. Are fatty nuts a weighty concern? A systematic review and meta-analysis and dose-response meta-regression of prospective cohorts and randomized controlled trials. *Obes. Rev.* **2021**, *22*, e13330. [CrossRef]
76. Feng, Y.; Zhao, Y.; Liu, J.; Huang, Z.; Yang, X.; Qin, P.; Chen, C.; Luo, X.; Li, Y.; Wu, Y.; et al. Consumption of dairy products and the risk of overweight or obesity, hypertension, and type 2 diabetes mellitus: A dose-response meta-analysis and systematic review of cohort studies. *Adv. Nutr.* **2022**, *13*, 2165–2179. [CrossRef] [PubMed]
77. Mullins, A.P.; Arjmandi, B.H. Health benefits of plant-based nutrition: Focus on beans in cardiometabolic diseases. *Nutrients* **2021**, *13*, 519. [CrossRef] [PubMed]
78. Hirahatake, K.M.; Astrup, A.; Hill, J.O.; Slavin, J.L.; Allison, D.B.; Maki, K.C. Potential cardiometabolic health benefits of full-fat dairy: The evidence base. *Adv. Nutr.* **2020**, *11*, 533–547. [CrossRef] [PubMed]
79. Alissa, E.M.; Ferns, G.A. Dietary fruits and vegetables and cardiovascular diseases risk. *Crit. Rev. Food Sci. Nutr.* **2017**, *57*, 1950–1962. [CrossRef] [PubMed]
80. Bae, Y.J.; Kim, M.H.; Choi, M.K. Dietary mineral intake from nuts and its relationship to hypertension among Korean adults. *Biol. Trace Elem. Res.* **2022**, *200*, 3519–3528. [CrossRef]
81. Schwingshackl, L.; Schwedhelm, C.; Hoffmann, G.; Knüppel, S.; Iqbal, K.; Andriolo, V.; Bechthold, A.; Schlesinger, S.; Boeing, H. Food groups and risk of hypertension: A systematic review and dose-response meta-analysis of prospective studies. *Adv. Nutr.* **2017**, *8*, 793–803. [CrossRef]
82. Vimaleswaran, K.S.; Zhou, A.; Cavadino, A.; Hyppönen, E. Evidence for a causal association between milk intake and cardiometabolic disease outcomes using a two-sample Mendelian Randomization analysis in up to 1,904,220 individuals. *Int. J. Obes.* **2021**, *45*, 1751–1762. [CrossRef]
83. Wilunda, C.; Sawada, N.; Goto, A.; Yamaji, T.; Iwasaki, M.; Tsugane, S.; Noda, M. Soy food and isoflavones are not associated with changes in serum lipids and glycohemoglobin concentrations among Japanese adults: A cohort study. *Eur. J. Nutr.* **2020**, *59*, 2075–2087. [CrossRef]
84. Wong, T.H.T.; Burlutsky, G.; Gopinath, B.; Flood, V.M.; Mitchell, P.; Louie, J.C.Y. The longitudinal association between coffee and tea consumption and the risk of metabolic syndrome and its component conditions in an older adult population. *J. Nutr. Sci.* **2022**, *11*, e79. [CrossRef]
85. Wang, N.; Deng, Z.; Wen, L.; Ding, Y.; He, G. Relationships between maternal dietary patterns and blood lipid levels during pregnancy: A prospective cohort study in Shanghai, China. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3701. [CrossRef]
86. Buscemi, S.; Corleo, D.; Buscemi, C.; Randazzo, C.; Borzì, A.M.; Barile, A.M.; Rosafio, G.; Ciaccio, M.; Caldarella, R.; Meli, F.; et al. Influence of Habitual Dairy Food Intake on LDL Cholesterol in a Population-Based Cohort. *Nutrients* **2021**, *13*, 593. [CrossRef]
87. Ushula, T.W.; Mamun, A.; Darssan, D.; Wang, W.Y.S.; Williams, G.M.; Whiting, S.J.; Najman, J.M. Dietary patterns and the risk of abnormal blood lipids among young adults: A prospective cohort study. *Nutr. Metab. Cardiovasc. Dis.* **2022**, *32*, 1165–1174. [CrossRef]
88. Lee, K.; Kim, H.; Rebholz, C.M.; Kim, J. Association between different types of plant-based diets and risk of dyslipidemia: A prospective cohort study. *Nutrients* **2021**, *13*, 220. [CrossRef]
89. Kim, J.; Hoang, T.; Bu, S.Y.; Kim, J.M.; Choi, J.H.; Park, E.; Lee, S.M.; Park, E.; Min, J.Y.; Lee, I.S.; et al. Associations of dietary intake with cardiovascular disease, blood pressure, and lipid profile in the Korean population: A systematic review and meta-analysis. *J. Lipid Atheroscler.* **2020**, *9*, 205–229. [CrossRef]
90. Xu, L.; Tian, Z.; Chen, H.; Zhao, Y.; Yang, Y. Anthocyanins, anthocyanin-rich berries, and cardiovascular risks: Systematic review and meta-analysis of 44 randomized controlled trials and 15 prospective cohort studies. *Front. Nutr.* **2021**, *8*, 747884. [CrossRef] [PubMed]
91. Pearce, M.; Fanidi, A.; Bishop, T.R.P.; Sharp, S.J.; Imamura, F.; Dietrich, S.; Akbaraly, T.; Bes-Rastrollo, M.; Beulens, J.W.J.; Byberg, L.; et al. Associations of total legume, pulse, and soy consumption with incident type 2 diabetes: Federated meta-analysis of 27 studies from diverse world regions. *J. Nutr.* **2021**, *151*, 1231–1240. [CrossRef] [PubMed]
92. Japanese Food Standard Composition Table 2020 Edition (8th Edition). Available online: https://www.mext.go.jp/a_menu/syokuhinseibun/mext_01110.html (accessed on 2 February 2024). (In Japanese)
93. McGlynn, N.D.; Khan, T.A.; Wang, L.; Zhang, R.; Chiavaroli, L.; Au-Yeung, F.; Lee, J.J.; Noronha, J.C.; Comelli, E.M.; Blanco Mejia, S.; et al. Association of low- and no-calorie sweetened beverages as a replacement for sugar-sweetened beverages with body weight and cardiometabolic risk: A systematic review and meta-analysis. *JAMA Netw. Open* **2022**, *5*, e222092. [CrossRef]
94. Baba, A.; Sugawara, K. Drive for thinness in adolescent women. *Jpn. J. Educ. Psychol.* **2000**, *48*, 267–274. [CrossRef] [PubMed]
95. Matsumoto, M.; Tajima, R.; Fujiwara, A.; Yuan, X.; Okada, E.; Takimoto, H. Trends in food group intake according to body size among young Japanese women: The 2001–2019 National Health and Nutrition Survey. *Nutrients* **2022**, *14*, 4078. [CrossRef] [PubMed]
96. Mori, N.; Asakura, K.; Sasaki, S. Differential dietary habits among 570 young underweight Japanese women with and without a desire for thinness: A comparison with normal weight counterparts. *Asia Pac. J. Clin. Nutr.* **2016**, *25*, 97–107. [CrossRef] [PubMed]

97. Otsuka, R.; Zhang, S.; Tange, C.; Nishita, Y.; Tomida, M.; Kinoshita, K.; Kato, Y.; Ando, F.; Shimokata, H.; Arai, H. Association of dietary intake with the transitions of frailty among Japanese community-dwelling older adults. *J. Frailty Aging* **2022**, *11*, 26–32. [CrossRef] [PubMed]
98. Otsuka, R.; Tange, C.; Tomida, M.; Nishita, Y.; Kato, Y.; Yuki, A.; Ando, F.; Shimokata, H.; Arai, H. Dietary factors associated with the development of physical frailty in community-dwelling older adults. *J. Nutr. Health Aging* **2019**, *23*, 89–95. [CrossRef] [PubMed]
99. Jyväkorpi, S.K.; Urtamo, A.; Kivimäki, M.; Strandberg, T.E. Macronutrient composition and sarcopenia in the oldest-old men: The Helsinki Businessmen Study (HBS). *Clin. Nutr.* **2020**, *39*, 3839–3841. [CrossRef]
100. Saturated Fatty Acid and Trans-Fatty Acid Intake for Adults and Children: WHO Guideline. Available online: https://www.who.int/publications/i/item/9789240073630 (accessed on 2 February 2024).
101. Guideline: Sugars Intake for Adults and Children. Available online: https://www.who.int/publications/i/item/9789241549028 (accessed on 2 February 2024).
102. Beal, T.; Ortenzi, F.; Fanzo, J. Estimated micronutrient shortfalls of the EAT-Lancet planetary health diet. *Lancet Planet. Health* **2023**, *7*, e233–e237. [CrossRef]
103. Sasaki, S. *[Consideration of Standards for a "Healthy Diet" from the Perspective of Ensuring the Nutritional Balance Necessary to Maintain and Improve Health] Kenkou no iji Zoushin ni Hitsuyou to Sareru Eiyou Baransu no Kakuho Kara Mita "Kenkou na Shokuji" no Kijun ni Tuite no Kentou*; Ministry of Health, Labour and Welfare: Tokyo, Japan, 2014. (In Japanese)
104. Fulgoni, V.L., 3rd; Keast, D.R.; Drewnowski, A. Development and validation of the nutrient-rich foods index: A tool to measure nutritional quality of foods. *J. Nutr.* **2009**, *139*, 1549–1554. [CrossRef]
105. Drewnowski, A. The Nutrient Rich Foods Index helps to identify healthy, affordable foods. *Am. J. Clin. Nutr.* **2010**, *91*, 1095s–1101s. [CrossRef]
106. Drewnowski, A.; Amanquah, D.; Gavin-Smith, B. Perspective: How to develop nutrient profiling models intended for global use: A manual. *Adv. Nutr.* **2021**, *12*, 609–620. [CrossRef]
107. Drewnowski, A. Defining nutrient density: Development and validation of the nutrient rich foods index. *J. Am. Coll. Nutr.* **2009**, *28*, 421s–426s. [CrossRef]
108. Zhai, J.; Ma, B.; Lyu, Q.; Guo, L.; Khatun, P.; Liang, R.; Cong, M.; Kong, Y. Validation of the nutrient-rich foods index estimated by 24-h dietary recall method among adults in Henan province of China. *Public Health Nutr.* **2022**, *25*, 1–9. [CrossRef]
109. Murakami, K.; Livingstone, M.B.E.; Fujiwara, A.; Sasaki, S. Application of the Healthy Eating Index-2015 and the Nutrient-Rich Food Index 9.3 for assessing overall diet quality in the Japanese context: Different nutritional concerns from the US. *PLoS ONE* **2020**, *15*, e0228318. [CrossRef]
110. National Health and Nutrition Survey. Available online: https://www.nibiohn.go.jp/eiken/kenkounippon21/en/eiyouchousa/ (accessed on 2 February 2024).
111. Merchant, A.T.; Dehghan, M. Food composition database development for between country comparisons. *Nutr. J.* **2006**, *5*, 2. [CrossRef] [PubMed]
112. Pennington, J.A.T. Food composition databases for bioactive food components. *J. Food Compos. Anal.* **2002**, *15*, 419–434. [CrossRef]
113. Schober, P.; Boer, C.; Schwarte, L.A. Correlation coefficients: Appropriate use and interpretation. *Anesth. Analg.* **2018**, *126*, 1763–1768. [CrossRef]
114. Excel Calculator. Available online: http://www.healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/Content/excel-calculator (accessed on 2 February 2024).
115. Suzuki, T.; Kojima, N.; Osuka, Y.; Tokui, Y.; Takasugi, S.; Kawashima, A.; Yamaji, T.; Hosoi, E.; Won, C.W.; Kim, H. The effects of mold-fermented cheese on brain-derived neurotrophic factor in community-dwelling older Japanese women with mild cognitive impairment: A randomized, controlled, crossover trial. *J. Am. Med. Dir. Assoc.* **2019**, *20*, 1509–1514.e2. [CrossRef]
116. Kim, H.; Osuka, Y.; Kojima, N.; Sasai, H.; Nakamura, K.; Oba, C.; Sasaki, M.; Suzuki, T. Inverse association between cheese consumption and lower cognitive function in Japanese community-dwelling older adults based on a cross-sectional study. *Nutrients* **2023**, *15*, 3181. [CrossRef] [PubMed]
117. Cuesta-Triana, F.; Verdejo-Bravo, C.; Fernández-Pérez, C.; Martín-Sánchez, F.J. Effect of milk and other dairy products on the risk of frailty, sarcopenia, and cognitive performance decline in the elderly: A systematic review. *Adv. Nutr.* **2019**, *10*, S105–S119. [CrossRef]
118. Huang, L.; Chen, H.; Gao, M.; Shen, J.; Tao, Y.; Huang, Y.; Lv, R.; Xie, R.; Lv, X.; Xu, X.; et al. Dietary factors in relation to the risk of cognitive impairment and physical frailty in Chinese older adults: A prospective cohort study. *Eur. J. Nutr.* **2024**, *63*, 267–277. [CrossRef]
119. Duan, Y.; Qi, Q.; Cui, Y.; Yang, L.; Zhang, M.; Liu, H. Effects of dietary diversity on frailty in Chinese older adults: A 3-year cohort study. *BMC Geriatr.* **2023**, *23*, 141. [CrossRef]
120. Sievenpiper, J.L. Low-carbohydrate diets and cardiometabolic health: The importance of carbohydrate quality over quantity. *Nutr. Rev.* **2020**, *78*, 69–77. [CrossRef]
121. Miller, V.; Mente, A.; Dehghan, M.; Rangarajan, S.; Zhang, X.; Swaminathan, S.; Dagenais, G.; Gupta, R.; Mohan, V.; Lear, S.; et al. Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): A prospective cohort study. *Lancet* **2017**, *390*, 2037–2049. [CrossRef]

122. Sakurai, M.; Ishizaki, M.; Morikawa, Y.; Kido, T.; Naruse, Y.; Nakashima, Y.; Okamoto, C.; Nogawa, K.; Watanabe, Y.; Suwazono, Y.; et al. Frequency of consumption of balanced meals, bodyweight gain and incident risk of glucose intolerance in Japanese men and women: A cohort study. *J. Diabetes Investig.* **2021**, *12*, 763–770. [CrossRef]
123. Kanehara, R.; Goto, A.; Sawada, N.; Mizoue, T.; Noda, M.; Hida, A.; Iwasaki, M.; Tsugane, S. Association between sugar and starch intakes and type 2 diabetes risk in middle-aged adults in a prospective cohort study. *Eur. J. Clin. Nutr.* **2022**, *76*, 746–755. [CrossRef]
124. Lu, Y.; Sugawara, Y.; Matsuyama, S.; Fukao, A.; Tsuji, I. Association of dairy intake with all-cause, cancer, and cardiovascular disease mortality in Japanese adults: A 25-year population-based cohort. *Eur. J. Nutr.* **2022**, *61*, 1285–1297. [CrossRef]
125. Okada, E.; Shirakawa, T.; Shivappa, N.; Wakai, K.; Suzuki, K.; Date, C.; Iso, H.; Hébert, J.R.; Tamakoshi, A. Dietary inflammatory index is associated with risk of all-cause and cardiovascular disease mortality but not with cancer mortality in middle-aged and older Japanese adults. *J. Nutr.* **2019**, *149*, 1451–1459. [CrossRef] [PubMed]
126. Jakobsen, D.D.; Brader, L.; Bruun, J.M. Association between food, beverages and overweight/obesity in children and adolescents-a systematic review and meta-analysis of observational studies. *Nutrients* **2023**, *15*, 764. [CrossRef] [PubMed]
127. Jia, P.; Luo, M.; Li, Y.; Zheng, J.S.; Xiao, Q.; Luo, J. Fast-food restaurant, unhealthy eating, and childhood obesity: A systematic review and meta-analysis. *Obes. Rev.* **2021**, *22* (Suppl. 1), e12944. [CrossRef] [PubMed]
128. Dallman, M.F.; Pecoraro, N.; Akana, S.F.; La Fleur, S.E.; Gomez, F.; Houshyar, H.; Bell, M.E.; Bhatnagar, S.; Laugero, K.D.; Manalo, S. Chronic stress and obesity: A new view of "comfort food". *Proc. Natl. Acad. Sci. USA* **2003**, *100*, 11696–11701. [CrossRef] [PubMed]
129. van Strien, T.; Gibson, E.L.; Baños, R.; Cebolla, A.; Winkens, L.H.H. Is comfort food actually comforting for emotional eaters? A (moderated) mediation analysis. *Physiol. Behav.* **2019**, *211*, 112671. [CrossRef] [PubMed]
130. Dong, J.Y.; Iso, H.; Yamagishi, K.; Sawada, N.; Tsugane, S. Chocolate consumption and risk of stroke among men and women: A large population-based, prospective cohort study. *Atherosclerosis* **2017**, *260*, 8–12. [CrossRef] [PubMed]
131. Lee, J.; Allen, J. Gender differences in healthy and unhealthy food consumption and its relationship with depression in young adulthood. *Community Ment. Health J.* **2021**, *57*, 898–909. [CrossRef]
132. Matsuyama, S.; Sawada, N.; Tomata, Y.; Zhang, S.; Goto, A.; Yamaji, T.; Iwasaki, M.; Inoue, M.; Tsuji, I.; Tsugane, S. Association between adherence to the Japanese diet and all-cause and cause-specific mortality: The Japan Public Health Center-based Prospective Study. *Eur. J. Nutr.* **2021**, *60*, 1327–1336. [CrossRef]
133. Ozawa, M.; Ninomiya, T.; Ohara, T.; Doi, Y.; Uchida, K.; Shirota, T.; Yonemoto, K.; Kitazono, T.; Kiyohara, Y. Dietary patterns and risk of dementia in an elderly Japanese population: The Hisayama Study. *Am. J. Clin. Nutr.* **2013**, *97*, 1076–1082. [CrossRef] [PubMed]
134. Kimura, Y.; Yoshida, D.; Ohara, T.; Hata, J.; Honda, T.; Hirakawa, Y.; Shibata, M.; Oishi, E.; Sakata, S.; Furuta, Y.; et al. Long-term association of vegetable and fruit intake with risk of dementia in Japanese older adults: The Hisayama study. *BMC Geriatr.* **2022**, *22*, 257. [CrossRef] [PubMed]
135. Loveday, S.M. Protein digestion and absorption: The influence of food processing. *Nutr. Res. Rev.* **2023**, *36*, 544–559. [CrossRef] [PubMed]
136. Sumi, K.; Tagawa, R.; Yamazaki, K.; Nakayama, K.; Ichimura, T.; Sanbongi, C.; Nakazato, K. Nutritional value of yogurt as a protein source: Digestibility/absorbability and effects on skeletal muscle. *Nutrients* **2023**, *15*, 4366. [CrossRef] [PubMed]
137. Zhang, T.; Geng, S.; Cheng, T.; Mao, K.; Chitrakar, B.; Gao, J.; Sang, Y. From the past to the future: Fermented milks and their health effects against human diseases. *Food Front.* **2023**, *4*, 1747–1777. [CrossRef]
138. Mozaffarian, D.; El-Abbadi, N.H.; O'Hearn, M.; Erndt-Marino, J.; Masters, W.A.; Jacques, P.; Shi, P.; Blumberg, J.B.; Micha, R. Food Compass is a nutrient profiling system using expanded characteristics for assessing healthfulness of foods. *Nat. Food* **2021**, *2*, 809–818. [CrossRef]
139. O'Hearn, M.; Erndt-Marino, J.; Gerber, S.; Lauren, B.N.; Economos, C.; Wong, J.B.; Blumberg, J.B.; Mozaffarian, D. Validation of Food Compass with a healthy diet, cardiometabolic health, and mortality among U.S. adults, 1999-2018. *Nat. Commun.* **2022**, *13*, 7066. [CrossRef]
140. Drewnowski, A. Adjusting for protein quality by food source may affect nutrient density metrics. *Nutr. Rev.* **2021**, *79*, 1134–1144. [CrossRef] [PubMed]
141. Hercberg, S.; Touvier, M.; Salas-Salvado, J. The Nutri-Score nutrition label. *Int. J. Vitam. Nutr. Res.* **2022**, *92*, 147–157. [CrossRef] [PubMed]

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Building Capacity and Advancing Regulatory Measures to Improve Food Environments in the Region of the Americas

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Abstract: Noncommunicable diseases (NCDs) are the main cause of death globally (70%) and in the Region of the Americas (80%), and poor diets are a leading driver of NCDs. In response, the Pan American Health Organization (PAHO)/World Health Organization (WHO) introduced a set of evidence-based regulatory measures to help countries improve diets through the reduced consumption of processed and ultra-processed foods. This paper aims to describe the needs of and propose actions for key actors to advance these measures. A workshop was designed to assess member states' regulatory capacity. A thematic analysis was conducted to analyze regional needs, successes and challenges. Thereafter, the Government Capacity-Building Framework for the prevention and control of NCDs was used to examine findings. The findings were organized in two sets: (i) PAHO/WHO actions to support member states and (ii) key actors' actions to advance regulatory policies. The results show notable regulatory progress across the Region of the Americas. However, progress differs between countries, with opportunities to strengthen measures in most countries, mainly in conflict of interest management. The results identified important actions to strengthen the regulatory capacity of PAHO/WHO member states. To maximize momentum for these actions, timelines must be identified, and political commitment can be boosted by applying human rights-based and food system-wide approaches.

Keywords: food policy; capacity building; regulatory measures; Region of the Americas; nutrition; food environments

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1. Introduction

Globally, noncommunicable diseases (NCDs) and their risk factors are the main causes of morbidity, disability and mortality. NCDs cause greater than 70% of deaths worldwide and constitute one of the major public health challenges of the 21st century [1]. Specifically in the Region of the Americas, NCDs account for over 80% of all deaths, with diet-related NCDs, including ischemic heart disease and type 2 diabetes, being the leading drivers [2].

Food environments determine the type of dietary patterns people are able to follow [3]. On a global scale, the availability, affordability and marketing of ultra-processed food and drink products favor eating choices that increase the incidence and worsen outcomes of diet-related NCDs [4,5]. Ultra-processed food and drink products are industrial formulations

synthesized from food substrates or prepared with substances extracted from foods or food constituents. These formulations contain little or no whole natural food; are typically energy dense and lacking in nutrients that are key to health maintenance and healthy growth; and are generally high in added sugars, saturated fat, trans fat and/or sodium (e.g., soft drinks, sweetened yogurts, sweetened breakfast cereals, convenience foods, industrially produced baked goods, ice creams or savory snacks) [5,6]. Due to their nutrient profiles, the regular intake of these products can increase the risk of developing diet-related NCDs [5–20].

Given that ultra-processed foods have market advantages over less-processed items [21], and considering their role in the development of diet-related NCDs [4–20], a comprehensive and coherent strategy that spans across multiple sectors is needed [22]. Evidence has shown the cost-effectiveness of implementing certain regulatory measures that help reduce the demand for and offer of processed and ultra-processed products [21–23]. Key technical advisory documents have been issued globally and in the Region of the Americas to support countries to adopt, implement and strengthen these regulatory measures as part of the package of efforts to prevent and control diet-related NCDs [23–28]. Based on the best evidence available of cost-effective interventions, these documents call for (a) labeling and marketing regulations of processed and ultra-processed products high in critical nutrients; (b) the taxation of sugar-sweetened beverages (SSBs) and processed and ultra-processed products high in critical nutrients; and (c) the regulation of food in school environments and other settings where food is served or offered [23–26].

One of the most cost-effective interventions to address NCD risk factors from a population-level approach is the front-of-pack labeling (FOPL) system, which provides consumers with direct, fast-capturing information to easily identify products that contain excessive amounts of critical nutrients [29–34]. Among FOPL systems, research has provided evidence that those with nutrition warning signs are more effective in informing consumers of unhealthy food and drinks and contributing to healthier purchases [32,33,35].

Moreover, taxation on SSBs and food products high in critical nutrients is recommended to modify behavioral risk factors associated with NCDs. Taxation implies a triple-fold advantage because it (1) can improve consumption choices, (2) generates revenue and (3) has the potential to reduce long-term associated healthcare costs and productivity losses [36]. Furthermore, policies that restrict the marketing of processed and ultra-processed food and drinks can help reduce the demand for and consumption of these products [37]. Additionally, strategies to improve school food environments by removing less-healthy food and drink products can support the adoption of healthy eating habits from early ages [38,39].

Despite the potential benefits of these interventions, there is strong evidence that actors within and associated with the industry of ultra-processed food and drink products often attempt to weaken, distort, delay and/or impede public policies that promote dietary health and sustainability [27,28]. To combat this growing issue, in 2012, the Sixty-Fifth World Health Assembly adopted resolution WHA65.6, which, among other items, urged member states to introduce adequate mechanisms to safeguard against potential conflicts of interest (COI) in nutrition policy development and implementation. Following this request, the World Health Organization (WHO) developed a draft approach to guide countries for this purpose [27]. Next, in 2021, after consideration of the member states, PAHO/WHO launched a roadmap for the implementation of the approach in the Region of the Americas [28].

Many countries in the Region of the Americas have been seeking to adopt sound policies, actions, laws and regulations to reduce the demand for and offer of processed and ultra-processed products, in an attempt to reshape food environments in favor of healthier eating. For example, Argentina's Healthy Eating Law came into effect in 2022, establishing front-of-pack warning labels (FOPWLs) and regulating the marketing, promotion, sponsorship and offer of products high in critical nutrients in schools, according to PAHO/WHO's nutrient profile model [39]; Brazil developed a tool based on PAHO/WHO's COI tool to assist key actors in identifying and preventing COI within the scope of the

National School Meal Program (PNAE) [40]; and Mexico recently amended its General Health Law to include the internet and other digital platforms (e.g., social networks) in the list of advertising platforms subject to restrictions, in addition to prohibiting the use of child-targeted elements (among others) in the advertising of prepackaged food and non-alcoholic beverages [41].

Despite notable progress in the adoption of these cost-effective measures, significant barriers are often present, adversely impacting policy development and implementation [4,42–44]. Barriers include the interference of commercial actors in policy-making, the lack of political commitment to advance regulations and insufficient human and financial resources [42–44]. Therefore, there is an urgent need to generate support for countries in building their capacity to overcome such barriers [37].

Capacity building refers to the development of knowledge, skills, commitment, structures, systems and leadership to enable effective action [27,37]. Building the capacity of the Ministry of Health, policy-makers and civil society organizations (CSOs) to safeguard decision-making processes from the interference of opposing actors, and to best prevent and manage COI, is essential to attain effective and sustainable regulatory frameworks [27,37].

Recognizing the importance of building the capacity of countries to improve food environments in the region, PAHO/WHO developed a virtual workshop from March to July 2022 that sought to provide PAHO/WHO member states with an opportunity to identify capacity needs to adopt, implement and monitor regulatory nutrition measures and discuss possible actions to address such needs. The workshop was called "Regional Capacity Building of Regulatory Measures to Prevent and Manage Diet-Related Non Communicable Diseases in the Region of the Americas" and gathered insights from Ministry of Health officials, health and food policy-makers, CSO and non-governmental organization (NGO) representatives, public health advocates, academics, health practitioners and PAHO/WHO staff from country, subregional and headquarter offices. By means of a thematic analysis of participants' contributions, this article aims to propose an action route to advance evidenced-based regulatory measures that can improve food environments and help curb diet-related NCDs in the Region of the Americas.

2. Materials and Methods

2.1. The Workshop Design

A peer-review process was conducted to determine the design of the virtual workshop. A technical meeting with six international capacity-building and nutrition experts was convened to refine the workshop's concept note and agenda, including the number of days the workshop would take place for and the timing of each workshop session. Based on this process, the method of the workshop was defined: seven 150 min virtual sessions from 5 to 13 July 2022 (excluding the weekend), with actors from a variety of sectors, including Ministry of Health officials, health and food policy-makers, CSO and NGO representatives, public health advocates, such as academics, health practitioners and PAHO/WHO staff from country, sub-regional and headquarter offices. To identify potential participants to invite to the workshop, PAHO/WHO staff conducted purposeful sampling by choosing candidates based on their professional expertise. Workshop organizers sought candidates across PAHO/WHO member states whose work pertained to at least one of the five evidence-based regulatory measures to improve food systems: FOPL regulations of processed and ultra-processed products; the taxation of SSBs and processed and ultra-processed products; marketing regulations of processed and ultra-processed products; regulations on ultra-processed products in schools and other settings; and COI management and prevention. Additionally, a small number of individuals from outside the Region of the Americas were invited to participate in the workshop due to their expertise in global public health nutrition, governance and COI management. All individuals were sent an invitation to attend the workshop, which included a concept note with a registration link. Those who registered were sent a background technical paper to review and key questions to consider to support them in preparing for the workshop discussions.

The workshop methodology and content were designed following the Government Capacity-Building Framework by Patiño et al. (2021) to assess national capacity for the prevention and control of NCDs [37]. The framework (Figure 1) depicts three elements of capacity building that are often used to enhance the impact and performance of public health strategies, including (1) public health infrastructure (i.e., organizational development, workforce, multisectoral collaboration and human and financial resources); (2) policy efforts (i.e., policy-making and action plans); and (3) information systems (i.e., systems to collect, monitor, report and disseminate data; surveillance and surveys). This paper also uses the Capacity-Building Framework to assess and present the findings.

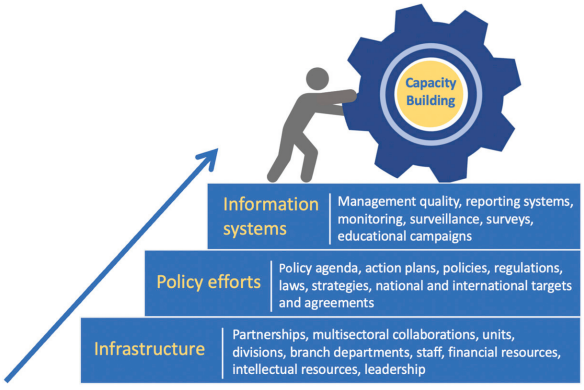

Figure 1. Redesigned diagram of the Government Capacity-Building Framework for the Prevention and Control of NCD proposed by Patiño et al. (2021) [38].

2.2. Workshop Description

Day one of the workshop focused on discussing the capacity-building needs and opportunities to adopt, implement and monitor regulatory measures that improve food environments in the Region of the Americas. The participants then moved into randomized pre-assigned English- or Spanish-speaking breakout rooms, consisting of five to ten people to ensure a variety of sectors, and participated in a collaborative dynamic activity using Jamboard 0.2. Jamboard 0.2 is a digital platform where different persons or groups can simultaneously add information in the form of sticky notes, drawings or graphics [45]. Each group was instructed to answer questions about the capacity-building needs of their countries to adopt, implement and monitor regulatory measures that reduce the demand for and offer of processed and ultra-processed products.

Days two to six were each dedicated to discussing the capacity of PAHO/WHO member states to adopt, implement and monitor specific regulatory measures, with a different topic assigned to each day. Day two focused on FOPL regulations of processed and ultra-processed products; day three, on the taxation of SSBs and processed and ultra-processed products; day four, on marketing regulations of processed and ultra-processed products; day five, on regulating processed and ultra-processed products in schools and other settings; and day six, on building the capacity of countries to prevent and manage COI related to the previously mentioned regulatory measures. During the first half of the workshop sessions on days two to six, the participants were organized into randomized breakout rooms based on the primary language of the country they were representing to answer three questions via Jamboard 0.2 about the capacity-building successes, challenges and needs of their country, following the same methodology as day one (described above). During the second half of the workshop sessions on days two to six, the participants were organized into breakout rooms to develop roadmaps on capacity-building strategies for countries to adopt, implement and monitor each of the regulatory measures discussed and on preventing and managing COI. On the final day of the workshop, the capacity-building roadmaps for each regulatory measure that were developed on previous workshop days were reviewed. The

participants outlined priority actions for PAHO/WHO and key actors to support member states to advance the regulatory measures discussed (Figure 2).

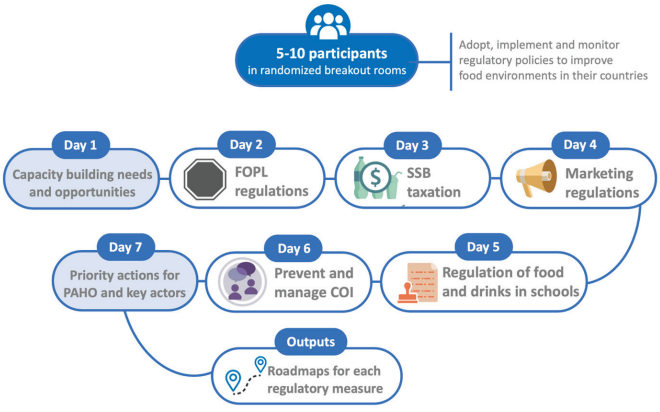

Figure 2. Visual synthesis of the themes discussed in the seven-day workshop.

2.3. Data Analysis

Two independent researchers examined the insights collected during the seven-day workshop, conducting a thematic analysis based on the methodology proposed by Gajaweera and Johnson [46]. The analysis was carried out in several steps. To begin, the workshop discussions and content of the Jamboard 0.2 sticky notes were carefully reviewed to identify capacity needs, related concepts and possible inter-relations between concepts and to remove repeated information. Thereafter, the concepts were organized in three categories based on the Government Capacity-Building Framework: infrastructure, policy efforts and information systems [37]. Subsequently, these categories were broken into five themes concerning the main regulatory measures to improve food environments in the Americas and a sixth theme concerning capacity-building needs that cross-cut each of the matters that need regulation. A table (Table A1) was created to match the workshop contributions with their corresponding themes and categories. Using this table, contributions were analyzed, identifying patterns, divergences and convergences across contributions and themes.

Next, the roadmaps developed by the workshop participants and the stemming recommendations were analyzed. Following this analysis, Table A2 was created by consolidating key actions identified for PAHO/WHO to support member states to address their capacity-building needs to advance regulatory measures to improve food environments. These actions were organized under the three categories of the Capacity-Building Framework. Since several of the key actions intersected with multiple categories, the authors placed each action into the one category they deemed to best correspond with the action to avoid repetition.

Next, Table A3 was created to present an action route with a set of capacity-building actions for key actors (i.e., government officials; policy-makers; CSO and NGO representatives; public health advocates, such as academics, health practitioners and PAHO/WHO staff from country, sub-regional and headquarter offices). Each actor's set of actions was identified by establishing key themes from both the five roadmaps developed during the workshop sessions and the final workshop discussion and recommendations. The resulting themes were considered priority actions for all actors and were sorted into the three categories of the Capacity-Building Framework: infrastructure, policy efforts and information systems [37]. Table A3 also includes information on the recommended stage of each action within the five-stage Public Policy Cycle model [47,48]. The five stages of the model are (1) agenda setting, (2) policy formulation, (3) adoption (or decision-making), (4) implementation and (5) evaluation. It is worth noting that these stages rarely follow one another in linear progression, but often occur simultaneously, appear in inverse or-

der or are rapidly skirted [47,48]. Figure 3 shows a diagram of the workshop's overall data analysis.

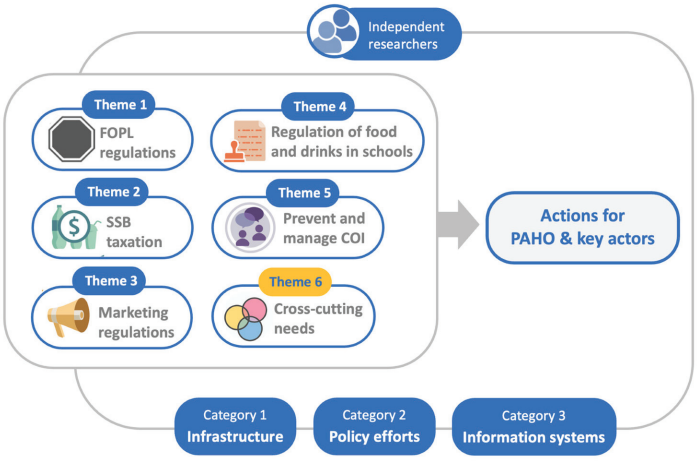

Figure 3. Visual synthesis of the thematic analysis of workshop results.

3. Results

The virtual setting of the workshop contributed to strong attendance, resulting in a total of 126 participants (Table 1), with country representation from 27 of the 35 PAHO/WHO member states, and 5 participants who attended from countries outside of the region (Australia, Italy, Spain, the United Kingdom and Vietnam). In total, 74 of the participants worked with government organizations, 20 with PAHO/WHO, 19 with CSOs and 13 with academia.

Table 1. Participants' characteristics.

Actors	Total (n = 126)
Government	74
PAHO/WHO	20
CSOs	19
Academia	13

Country participants attended from 27 PAHO/WHO member states, Australia, Italy, Spain, the U.K. and Vietnam.

3.1. Regional Capacity-Building Needs

The contributions of the workshop participants are shown in Appendix A, Table A1 regarding the regional and country capacity-building needs to adopt, implement and monitor key regulatory policies to improve food environments and prevent and manage diet-related NCDs in the Region of the Americas. Eight capacity-building needs were identified under the theme regulatory measures on FOPL and warning signs including education on the use of FOPL and related advocacy. Fifteen needs were identified under taxation on SSBs and ultra-processed foods, encompassing the need for local studies to predict the socioeconomic effects of taxation and strengthened intersectoral collaboration for tax enforcement. Ten needs emerged under the regulation of the marketing of ultra-processed food and drink products, where the need for increased civic advocacy stood out. Ten needs were obtained under regulatory measures of school food environments and other settings. In this category, one of the needs most underlined by the workshop participants was the insertion of a mandatory nutrition education course within the national school curriculum. Nineteen needs emerged under the prevention and management of COI, making this the category with the highest number of reported needs. Moreover, fourteen needs were identified as cross-cutting all of the aforementioned themes.

3.2. Regional Capacity-Building Actions

The initiatives that participants proposed for PAHO/WHO to support member states to advance or strengthen the aforementioned regulatory policies were summarized into twelve capacity-building actions under the three Capacity-Building Framework categories (infrastructure, policy efforts and information systems). As shown in Appendix B, Table A2, four actions were categorized into the infrastructure category: (1) providing support for financial and human resources; (2) identifying and sharing existing member states' government structures; (3) independent structures; and (4) hosting leadership programs. Five actions were categorized into the policy efforts category: (1) safeguarding against conflict of interest; (2) facilitating courses, workshops and webinars; (3) publishing policy guidelines and materials; (4) hosting retreats; and (5) providing technical support to member states. Lastly, three actions were identified in the information systems category: creating, managing and/or sharing: (1) observatories, (2) repositories and (3) databases.

To strengthen the capacity of PAHO/WHO member states to advance regulatory policies to help prevent diet-related NCDs in the Region of the Americas, priority actions for all relevant actors (government officials; policy-makers; CSO and NGO representatives; public health advocates, such as academics, health practitioners and PAHO/WHO staff from country, sub-regional and headquarter offices) were identified based on the roadmap results and workshop discussions. As shown in Appendix C, Table A3, the priority actions were organized into the categories of the Capacity-Building Framework, and key actors were identified for each action. Three actions were identified within the infrastructure category: (1) mapping key actors; (2) forming civil society coalitions; and (3) establishing a policy-overseeing body. Ten actions were identified within the policy efforts category: (1) creating advocacy campaigns; (2) banning industry involvement; (3) best-practice polices; (4) educational strategies for civil participation; (5) effective communication materials; (6) evidenced-based plans to face industry arguments; (7) mapping existing policies; (8) establishing legal resources; (9) identifying and mapping policy strategies; and (10) identifying and using existing resources. Six actions were identified within the information systems category: (1) obtaining country-level data; (2) developing databases; (3) evaluating policies; (4) utilizing food classification systems; (5) monitoring policy barriers; and (6) identifying monitoring systems and protocols. Furthermore, two priority challenges were identified as having the potential to hinder all of the proposed capacity-building actions: COI and financial constraints.

Although the five stages of the Public Policy Cycle model rarely follow one another in linear progression, it was determined that identifying best-practice policies, mapping existing policies, establishing policy strategies and determining an evidenced-based plan to face industry arguments are likely carried out in the agenda-setting and policy-formulation stages. Actions related to the mapping of key actors and the formation of civil society coalitions often take place during the agenda-setting, policy-formulation and implementation stages, while creating databases for processed and ultra-processed food and drink products and obtaining country-level data that identify dietary patterns and diet-related NCD rates are actions that take place during the agenda-setting, policy-formulation and evaluation stages. Monitoring systems and protocols, establishing a policy-overseeing body and evaluating policies are emphasized within the evaluation stage, while creating advocacy campaigns, banning industry from involvement in events and activities, developing effective communication materials and educational strategies for civil participation, establishing legal resources, using existing and developing new training materials and resources, monitoring policy barriers and utilizing food classification systems are actions that were identified as taking place in all stages of the policy cycle. Furthermore, it was identified that COI and limited financial resources are major challenges that could emerge in all stages of the policy process.

4. Discussion

This paper analyzed self-reported country needs and proposed actions for different key actors to support countries of the Region of the Americas to implement regulatory measures

to improve food environments and diet-related NCDs. The results identify ten key themes for country needs; sixteen capacity-building actions for PAHO/WHO to support member states to fulfil these needs; and nineteen overall capacity-building actions for all actors.

Although capacity-building actions were identified for the region, the results indicate there are still several needs to be addressed and actions to be advanced at the country level for PAHO/WHO member states to adopt, implement and monitor the suggested regulatory measures. This is emphasized by the fact that an insufficient number of PAHO/WHO member states have implemented policies to prevent or manage NCDs: 10/35 have implemented FOPL policies (with only 8/35 using best-practice FOPWL policies) [49–57], 21/35 have SSB taxation policies (although most of these taxes could be further leveraged to achieve best practices and improve their impact on SSB consumption and health) [58,59] and 13/35 have food marketing regulations [35]. Furthermore, COI prevention and management to safeguard public health policies stands out as an urgent gap to address, as workshop participants reported the highest number of capacity needs under this category.

As for schools, most countries within the region have implemented at least one school food policy targeting an element of the school food environment. However, these policies are most effective when they are implemented together as part of a comprehensive food and nutrition policies approach, because this can synergistically improve the impact of all policies [60,61]. Similarly, considering food environments beyond schools are multifaceted, integrating regulatory policies that comprehensively target different aspects of these environments can also increase the overall positive impact on food environments and diet-related NCDs [62].

Most of the capacity-building needs and actions to address them that were identified during the workshop fall into the infrastructure capacity-building category [37], with a focus on two areas: augmenting human capacity and increasing funding. These results add to prior research that found an insufficient amount of human resources and infrastructure to adopt and implement diet-related regulations to address NCDs in the Region of the Americas [37]. As other studies show, investments in workforce employment and training, partnership building, research, monitoring and evaluation can effectively improve country capacities to advocate, adopt, implement and surveil policies [63,64]. Moreover, as the workshop identified, the insufficiency of human capacity can be minimized by the identification and use of pre-existing training materials and resources that help advance regulatory measures (e.g., The Virtual Campus for Public Health [65]), in addition to the use of hybrid training tools, such as the Massive Open Online Courses (MOOC), webinars and strategies like "train the trainer".

Additionally, due to the cyclic nature of most actors and technical staff in governmental positions, it is of utmost importance to develop a sustainable system to build human capacity in order to regulate the food environment in the region. A multi-scalar approach, which incorporates inclusive planning and regular meetings to identify emerging needs and create momentum for action, can support effective collaboration on all scales, increasing human capacity in a sustainable way over time [66]. Furthermore, given that the capacity-building needs of countries and the actions to address them typically require various actors from multiple sectors (as outlined in Table A3), creating coalitions, technical advocacy and advisory groups (TAAGs) and working groups without industry interference, through the mapping of key actors who support the advancement of regulatory measures to improve food environments, could facilitate the achievement of consensus in policy development and implementation.

Another type of capacity need refers to the knowledge gap in law and jurisprudence specific to legal theories and provisions that endorse food environment regulatory initiatives. While this workshop did not explore such gaps in detail, workshop discussions revealed major knowledge gaps in this aspect across the region. First, there is a lack of clear understanding of the legal resources available at the country level that support policy development and protect food environments in defense of the human right to adequate food and nutrition, as well as children's rights and business obligations to respect and support children's rights in advertising and marketing. These knowledge gaps intersect with a lack of clear understanding that, first, when a risk factor is widespread in a country and affects most of the population, regulatory actions must be taken at an environmental level rather

than at the individual level. Second, governments have the right and legal duty to regulate commercial activities based on arguments that support population health, and these regulations can over-ride commercial rights and international trade agreements [67]. Addressing these gaps requires the development of spaces for interdisciplinary collaboration between law and public health nutrition experts.

In this regard, across all stages of the policy cycle, COI of commercial, academic and civil society actors were identified as a common barrier to all PAHO/WHO member states to achieving the adequate implementation of unbiased, best-practice policies to improve food environments and the status of diet-related NCDs. This was an expected result as there is unequivocal evidence showing that the influence of and opposition from industries producing processed and ultra-processed food and drinks have contributed to delaying or halting the development and implementation of nutrition programs and regulatory measures that improve food environments and help prevent diet-related NCDs in many countries [43,44]. Therefore, building the human capacity to sufficiently identify, prevent and manage COI is recommended, which can be accomplished through the use of available risk assessment, disclosure and management tools that help safeguard policy development, implementation, monitoring and evaluation against possible COI, including the WHO draft approach [26] and tool [68] for the prevention and management of conflicts of interest in the policy development and implementation of nutrition programs at the country level and PAHO/WHO's roadmap for implementing WHO's draft approach [28]. Furthermore, mapping key actors (e.g., academia, civil society and policy-makers) can help prevent COI as it allows for the identification of coalitions, influences and interests, which supports the design of targeted mechanisms to ensure that actors who benefit from the commercialization of unhealthy commodities remain outside food/nutrition policy agenda setting and formulation [43]. In turn, this can result in strengthened transparency, partnership productivity and governance [69].

Regarding the actions proposed by the workshop participants to address the needs outlined above, specific timelines must be identified. Assigning timelines to planned policy actions is key to success in their implementation [70,71]. Empirical experience has shown that timelines can help mobilize political will, for example, through the global trans-fatty acids (TFAs) elimination strategy, where the WHO established a clear timeline with supporting tools to accelerate action towards the elimination of TFAs from the global food supply by 2023 [71]. The Public Policy Cycle stages identified for each recommended capacity-building action within Table A3 can be used to help create realistic yet flexible timelines for country action. Moreover, coordinating country timelines across the region can increase momentum, through inertia from states with more advanced regulatory performance. State actions can align on the basis of global commitments and transnational and multisectoral agendas such as the United Nations Decade of Action on Nutrition and the Sustainable Development Goals. Therefore, PAHO/WHO and key actors should consider adding timelines to the priority actions at regional, national and local levels while utilizing relevant tools to help advance policy action.

Furthermore, grounding actions by PAHO/WHO and other key actors and timelines in human rights law could help mobilize political commitment throughout all Public Policy Cycle stages [37]. For example, integrating a human rights lens during the policy agenda-setting stage could help sensitize policy-makers to the urgency of formulating, implementing and evaluating regulatory measures [37]. This is because the human rights law system has significant relevance in the legal framework of most countries in the Region of the Americas [72]. Moreover, human rights seek to protect human dignity, a principle shared across different cultures and nations [73], and adequate food and nutrition is an area of human rights inherent to human dignity and essential for the realization of other rights [74,75]. Recognizing this, most of the countries in the Region of the Americas have signed and ratified the International Covenant of Economic, Social and Cultural Rights (ICESCR) [76], which is binding to its member parties and enshrines the human right to adequate food [Art. 11(1)] and the right to the highest attainable status of health [Art. 12] [77].

Strengths and Limitations

The main strength of this research was the data collection process. The virtual set-up of the workshop made it more accessible for actors to attend, with participation from approximately 80% of PAHO/WHO member states and eight countries outside of the Americas, including individuals from lower-funded countries. This allowed for the workshop discussions and suggestions to come from diverse country perspectives, enhancing the key learnings from the workshop and increasing the generalizability of the results. Additionally, the use of breakout rooms and activities, including the Jamboards 0.2 and roadmap templates, enabled plenty of rich discussion and information to be gathered from workshop participants, including those who were not as comfortable speaking in large groups. Furthermore, the format of the workshop—where the specific policy topics were each assigned to a different day—enabled individuals to only attend the sessions they found the most relevant to their expertise or interests. Moreover, the workshop design allowed actors to identify specific opportunities to strengthen member states' capacity-building efforts to adopt, implement and monitor regulatory measures that, according to the best available evidence, help prevent diet-related NCDs. Finally, the workshop was also based on methodology that allowed for the collection of information in a systematic, repeatable way across countries.

The limitations of this research relate to the theoretical framework utilized to plan and execute the workshop, the characteristics of the participant sample, the design of the workshop and the specificity of the results. Although the workshop was planned using the Capacity-Building Framework by Patiño et al. (2021), it is possible that using other human capacity-building frameworks that hold other factors constant could have yielded different results. The validity of our findings could therefore be tested in future workshops. Another limitation was that, although PAHO/WHO invited different types of actors from various sectors and different regions of the Americas, the sampling was biased towards government officials, with almost 60% of participants falling into this category. This could have resulted in unique perspectives being missed from actors working at different levels within sectors and in other areas related to the regulatory measures discussed previously. Furthermore, the seven-day workshop format with sessions lasting 2.5 h each may have led to fatigue and lower engagement for participants who attended multiple sessions. Thus, opportunities for future research include an exploration of the viewpoints and contributions of the member states and relevant sectors who were not represented during the workshop. Lastly, the results presented in this paper are specific to the Region of the Americas, which is advanced in the adoption and implementation of many of these regulatory measures. Caution should therefore be applied when applying the key actions and recommendations to other regions.

5. Conclusions

This research provides an initial overview of the needs and recommended capacity-building actions to support PAHO/WHO, member states and other actors to advance regulatory measures that, based on the best evidence available, curb diet-related NCDs, especially when implemented as a complimentary set of measures. The findings showed that COI prevention and management currently stands as the area of greatest capacity-building need in the Region of the Americas. Therefore, efforts must focus on safeguarding policies against COI interference in every stage of the policy cycle, from agenda setting to evaluation, so as to avoid policy delays and halts. Concurrently, national financial constraints were reported as a major capacity-building challenge for the region. Thus, key actors should seek to utilize the existing capacity-building resources available in each stage of the policy cycle to help mitigate this challenge. Prioritizing these major capacity-building needs and challenges could provide a clearer path forward for PAHO/WHO member states to develop and align regional and national regulatory strategies to reduce NCDs, including action on FOPL, taxation and marketing of processed and ultra-processed products. When these actions are implemented in a coordinated manner across sectors, through a food system- and human rights-based approach, with defined timelines, meaningful change

toward improving food environments and preventing diet-related NCDs can be achieved in the Region of the Americas.

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Informed Consent Statement: Not applicable because this study is not considered public health research involving human participants.

Data Availability Statement: Data supporting reporting results can be found here: https://drive.google.com/drive/folders/1aUvpULZ9ULm5rA3Bsl-bb6qtt2BZPROw?usp=drive_link (accessed on 10 December 2022).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Thematic analysis of the capacity needs discussed during the workshop, "Regional Capacity Building of Regulatory Measures to Prevent and Manage Diet-Related Non Communicable Diseases in the Region of the Americas" (5 to 13 July 2022).

CAPACITY-BUILDING NEEDS	
• Theme 1: Regulatory measures on front-of-package labeling (FOPL) and warning signs	
Category 1: Infrastructure	• Formal and informal educational programs, including strategies on mass and social media to instruct end-consumers, health staff, law practitioners and governmental officers on FOPL, its importance, advocacy and mechanisms for participation in policy-making and social accountability. • Create coalitions to demand evidence-based FOPL and octagonal warning signs.
Category 2: Policy efforts	• Establish regulations to reduce the content capacity of packages of foods high in sugar, sodium and fat. • Frontal warnings on artificially sweetened products. • Binding instruments to regulate FOPL on imports. • Agenda setting between neighboring countries.
Category 3: Informationsystems	• Mass- and social media educational materials to orient the civil society on how to interpret FOPL and warning signs. • Public regional repositories with related evidence, case examples, best practices and advocacy materials.
• Theme 2: Taxation on sugar-sweetened beverages (SSBs) and ultra-processed foods	
Category 1: Infrastructure	• Tax incentives and subsidies for fruit and vegetable production.
Category 2: Policy efforts	• Develop reader-friendly materials explaining to policy-makers the scientific evidence concerning the economic, social and health impacts of food and beverage taxation, clarifying fears regarding any negative effects on employment rates or regressivity. • Intersectoral collaboration for tax enforcement (which is still weak in many countries). • Establish measures to foresee and counterbalance negative readjustment strategies by the industry (i.e., despite the tax, some industries maintain the prices prior to tax in poor areas through compensations with the marginal revenue obtained with other products or sales in other territories). • Continued dialogue to align efforts between tax and health authorities at the national level and across countries of the region. • Label the tax on the front of the package of the levied products.
Category 3: Information systems	• Studies to foresee negative readjustment strategies of the industry and find mechanisms to counterbalance them. • Reader-friendly guidelines for decision-makers on how to use and allocate the resources collected through food and beverage taxation. • Forbid the sponsorship of unhealthy food and drink products by sports and wellness brands and during physical activity events. • Map the barriers to tax policies. • System-approach studies to measure the environmental impact of ultra-processed food and drink products. • Model studies to estimate the impact of including an environmental-footprint tax (i.e., based on plastic use, water, gas emissions or eutrophication footprint).

Table A1. *Cont.*

CAPACITY-BUILDING NEEDS	
Category 3: Information systems	• Social marketing materials to address cultural habits of the regular consumption of sugar-sweetened beverages. • Information campaigns to explain and promote the mechanisms by which civil society can monitor the transparency in the collection and use of tax revenues and lobbying by the private sector. • Regional information systems to exchange country taxation learning, research and experiences. • Impact assessment on the role of the Ministry of Finance in monitoring tax collection and utilization.
• Theme 3: Regulation of the marketing of ultra-processed food and drink products	
Category 1: Infrastructure	• Resources to halt industry strategies to convey that the regulatory measures and taxes will drive economic relapse (i.e., through massive job loss, domestic gross product decrease) and/or food shortages. • More law and advocacy experts familiar with food and food marketing regulation, including the demand and enforceability of the rights to food and health. • Guidelines for the preparation and sale of foods and beverages in schools, based on the PAHO/WHO nutrient profile model and the NOM-051-SCFI-1994—General labeling specifications for prepackaged foods and non-alcoholic beverages.
Category 2: Policy efforts	• Ban the use of cartoons and celebrities in the marketing and labeling of ultra-processed products. • Need for defined, strict sanctions for violations of the regulatory measures. • Need to broaden the scope of the regulatory measures not only to tackle marketing addressed to children but to include all audiences. • Mandatory availability of free water dispensers in food services and public spaces. • Subsidies to produce sustainably packaged water.
Category 3: Information systems	• Educational campaigns designed by population target, addressing children, youths, caregivers and civil society and informing about unhealthy food marketing strategies and inviting them to report uncompliant publicity and marketing messages. These campaigns should be created by marketing experts to be as eye-catching as the industry campaigns. • Educational strategies to instruct end-users on healthy, affordable food and lifestyle choices.
• Theme 4: Regulation of food and drinks in schools	
Category 1: Infrastructure	• Increase the offer of affordable fruits and vegetables in educational and collective settings (e.g., libraries, offices, entertainment facilities). • Mandate that every educational and work setting offers free drinkable water. • Establish a team of public servants to monitor regulatory compliance in educational institutions, as schools refuse to take this responsibility due to insufficient human resources and technical capacity. • Incentives for schools and environments that comply with regulations.
Category 2: Policy efforts	• Binding list of healthy products allowed to be sold in educational, sport and work environments. The list must establish a maximum content of calories per g/mL, sugar, saturated fats and salt and exclude all products containing artificial sweeteners and trans fats. • Make malnutrition prevention programs mandatory for all schools. • Align the regulations on food environments with the national dietary guidelines.
Category 3: Information systems	• Workshops and easy-to-read materials clarifying industry arguments and school concerns that food-environment regulations will cause budget shortfalls to schools and school cafeterias. • Studies and scientific communication materials measuring the efficiency of food-environment regulations in reducing malnutrition rates. • An epidemiology unit to assess changes in the nutritional status of children in schools after regulatory implementation.
• Theme 5: Prevention and management of conflicts of interest (COI)	
Category 1: Infrastructure	• Form coalitions that include civil society and support them to surveil for and report incidents of COI. • Divulge the "make it make sense" campaign of the Healthy Caribbean Coalition as a case example of best practices. • Educational strategies in negotiation and assertive mediation addressed to advocates. • Prepare universities to train students and staff in COI prevention and management. • Compulsory course on COI management for high schools and universities. • Strategies to strengthen the participation of non-industry multisectoral stakeholders to outnumber the representatives of the industry of unhealthy commodities. • Map existing food, health and nutrition regulations to identify and denounce COI.
Category 2: Policy efforts	• Establish a unique official national and regional code of conduct for COI management and prevention. • National and subnational agendas specific for COI prevention and management. • Binding instruments to regulate the interference of the industry through recruiting academics to publish content that contradicts the benefits of regulations on FOPL, the taxation of unhealthy products, the marketing of unhealthy foods and drinks and food environments. • Reader-friendly, evidence-based resources for decision-makers and the public clarifying distorted arguments from the industry that taxes on ultra-processed products will result in unemployment, food shortages and national economic relapse. • Ensure mechanisms to maintain the strategies for COI management regardless of the rotation of government officials. • Legal resources to protect public officers, technicians and scholars from intimidation. • Prohibit beverage and ultra-processed food companies from sponsoring sport-, education- and health-related activities and infrastructure. • Regulations and legal resources to blind the design and adoption stages of a policy from private intervention, allowing the private sector to participate only until the public consultation stage. • Binding regulation that defines and limits the level of industry involvement in dietary and health guidelines, programs and educational content.

Table A1. *Cont.*

CAPACITY-BUILDING NEEDS	
Category 3: Informationsystems	• Educational resources to help decision-makers and other stakeholders understand what COI are, their potential impact and how to recognize, foresee and manage them. • Awareness-raising media campaigns. • Evidence-based resources to address the extended perception that COI are a "difficult" matter. • Map decision-makers, decision influencers and health champions to identify existing and potential COI.
• Theme 6: Cross-cutting Needs *	
Category 1: Infrastructure	• Human resources to (1) raise evidence-based awareness on the benefits of the regulations and taxation; (2) design, implement, monitor, adjust and evaluate policies, plans and programs; (3) oversee tax collection, allocation and use; (4) communicate the progress and findings to the community; (5) lead the educational strategies; (6) work in advocacy. • Funding for national research on the impact and benefits of tax regulations. • Funding and research incentives to produce national evidence in support of the regulations. Use this evidence to advocate before the legislative branch and industry lobbyists. • Funding to inform research findings at local, national and regional levels. • Funding to implement and monitor regulations and programs. • Gather government and international cooperation funding. • Regional and national platforms to synergize regulation at the regional and national levels and align the actions of the stakeholders, institutions and countries involved. The industry should not take part in the design phase of the regulations. Establish an independent body to lead this platform. • Partnerships between healthcare personnel, NGO advocates, academics, grassroots organizations, multilateral organizations and government agencies.
Category 2: Policy efforts	• The regulatory instruments to improve nutrition at the country level must be binding. • Aligning the regulations across countries to ensure synergy at the regional level. • Adopting a binding regional covenant to improve nutrition. • Establish national plans to orient the industry on how to reformulate its portfolio to align with the regulations. • Establish independent national and regional bodies that monitor the implementation and compliance of the regulations.
Category 3: Information systems	• Educational strategies and short reader-friendly materials: (I) for decision-makers, institutional staff and civil society to learn about the importance, planning, steps to implementation and monitoring of regulatory measures to improve nutrition; (II) to improve civil society's understanding of policy, legislation and pathways for political incidence; (III) to empower civil society to engage in policy-making and monitoring; (V) to equip professionals from areas outside health with tools to participate in health-related advocacy and policy. • Information systems to educate the civic society to participate in food, nutrition and health decision-making.

* NOTE: The "cross-cutting needs" theme corresponds to all the needs referred to by the workshop participants that apply to all the themes previously analyzed (Theme 1, regulatory measures on front-of-package labeling (FOPL) and warning signs; Theme 2, taxation on sugar-sweetened beverages (SSBs) and unhealthy foods; Theme 3, regulation of the marketing of unhealthy food and drink products; Theme 4, regulatory measures of school food environments and other settings; Theme 5: prevention and management of conflicts of interest).

Appendix B

Table A2. PAHO/WHO capacity-building actions to improve nutrition in the Region of the Americas.

CAPACITY-BUILDING FRAMEWORK CATEGORIES	
Category 1: Infrastructure	Financial and human resources • To increase capacity to advance regulatory measures. Government structures • Identify and coordinate existing government structures at all levels (national, provincial and local) which can support the formulation, adoption, implementation, monitoring and evaluation of regulatory measures. Independent structure • Assist the member states in the creation of a national independent body composed of law and public health experts to map food, health and nutrition regulations; identify loopholes; advise the legislative branch to fill the gaps; monitor compliance and denounce violations. Leadership programs • Provide a leadership program where regional leaders are identified and learn by experience about a given topic for a year term.
Category 2: Policy efforts	Conflict of interests • Establish unified international parameters that guide the national codes of conduct to prevent and manage conflicts of interest. Courses, workshops and webinars • Develop online or in-person workshops and virtual webinars on topics such as intersectoral cooperation; sensitizing ministries to these policies; and the sharing of policy success stories and good practices from various countries. • Develop educational courses, such as the capacity-building course PAHO/WHO will be launching in 2023, which focuses on each of the regulatory measures highlighted in this paper.

Table A2. *Cont.*

CAPACITY-BUILDING FRAMEWORK CATEGORIES	
Category 2: Policy efforts	Policy guidelines and materials • Reader-friendly, evidenced-based guidelines and tools that can help policy-makers draft legislation. • Guidelines to help health authorities, advocates and civil society to identify and counterbalance industry interferences in regulatory drafting, implementation, monitoring and evaluation. Retreats • Dedicated to a specific regulatory measure (e.g., FOPL, the taxation of ultra-processed products, COI management, etc.). Technical support • Meet with member states to provide technical support on (among other topics): • Drafting regulations and action plans, based on evidence and best practices. • Coupling regulations on food environments with regulations on other public spaces and with other norms on food labeling, advertisement and taxation. • Devising a strategy to help schools implement new regulations. • Assisting the ministries of education and health within the region to design and implement a compulsory subject on healthy, sustainable living in the national education plan.
Category 3: Information systems	Observatories • Facilitating collaboration between academia, civil society and governments. • Track and advance the regulatory agenda discussed in this workshop. • Coordinate nutrition regulations with strategies beyond food-related policies, such as tobacco- and alcohol-related policies. Repositories • Share existing repositories: • RIS is consolidated as the digital library of PAHO/WHO. • Examples of external repositories include the World Public Health Nutrition Association (WPHNA) (international) and the Latin American and Caribbean Nutrition and Health Community of Practice's (COLANSA's) group repository (Latin America and the Caribbean). Databases • Create and share databases with materials addressed to civil society, advocates, private, public and nonprofit organizations.

Appendix C

Table A3. Capacity-building actions for all actors to improve nutrition in the Region of the Americas, with actors' roles and stages of the Public Policy Cycle identified for each capacity-building action.

CAPACITY-BUILDING FRAMEWORK CATEGORIES		
	Capacity-Building Actions	**Actors' Roles ***
Category 1: Infrastructure	Key actors and connections [1,2,4]	
	• Map key policy actors (e.g., government, policy-makers, civil society, academics) and opposers throughout the policy process specific to each of the regulatory measures.	Government officials, PAHO/WHO, CSOs, NGOs, academia
	• Identify key members from other sectors to strengthen the internal integration of the institutions involved in the implementation of the regulation(s).	Government officials, PAHO/WHO, CSOs, NGOs, academia
	• Map the decision-makers and actors with influential power that support or might support COI regulation.	Government officials, PAHO, CSOs, NGOs, academia
	• Map the non-food/nutrition industry actors that can be affected by or interested in nutrition, food and health regulation and the links and alliances between them.	Government officials, PAHO/WHO, CSOs, NGOs, academia
	• Make the maps publicly available.	
	• Promote the maps as a resource to support actors to make informed choices when partnering with industry actors or when buying from them.	Government officials, PAHO/WHO
	Civil society [1,2,4]	Government officials, PAHO/WHO, CSOs, NGOs
	• Create coalitions or working groups without industry interference to develop harmonized strategies across sectors.	Government officials, CSOs, NGOs
	• Ensure that sufficient budget is allocated to strengthen civil society initiatives.	Government officials, PAHO/WHO, CSOs

Table A3. *Cont.*

CAPACITY-BUILDING FRAMEWORK CATEGORIES		
	Capacity-Building Actions	**Actors' Roles ***
	Bans [1,2,3,4,5]	
	• Ban industries of ultra-processed products from funding or sponsoring educational and sporting events, nutrition and health activities.	Government officials
	Best practices [1,2]	
	• Identify global regulatory policies to prevent diet-related NCDs with the highest standards that protect health over commercial interests.	Government officials, PAHO/WHO, CSOs, NGOs, academia
	• Seize momentum of political opportunity by adopting a regulatory measure when other countries are also adopting or implementing it or by proposing a bill while another one is in progress (i.e., Chile and Peru could have negotiated the package of regulations on food labeling, advertisement and school environments all at once).	Government officials, public health advocates
	Educational strategies for civil participation [1,2,3,4,5]	
	• Formal and informal education strategies addressed to the general public to instruct civil society on the use of the constitutional mechanisms to engage in policy-making and monitoring.	Government officials, CSOs, public health advocates
	• Formal and informal education strategies addressed to the general public to instruct on how to monitor advertisements and denounce violations of ad hoc regulations.	Government officials, CSOs, public health advocates
	Effective communication materials [1,2,3,4,5]	
	• Work with marketing experts to create promotional campaigns using appropriate language for the intended audience.	Government officials, PAHO/WHO, CSOs
	• Plan and design campaigns in mass and digital media.	
	Evidenced-based plans to face industry arguments [1,2]	
	• Evidence-based plans that civil society can adopt to its context to combat communications and publications by industry claiming that regulatory and tax measures on the labeling, expenditure and advertisement of ultra- processed foods and beverages will drive to loss of job sources, domestic food shortages and economic relapse.	Government officials, PAHO/WHO, CSOs
Category 2: Policy efforts	Map existing policies [1,2]	Government officials, PAHO/WHO, CSOs, academia
	• Identify and map existing regulatory measures that are being discussed and are implemented nationally and regionally to understand where to prioritize work.	Government officials, PAHO/WHO, CSOs
	• Identify regulations beyond the ones focused on ultra-processed products regulatory policies (e.g., tobacco and alcohol policies) to find key learnings that can be transferred over to promote policy coherence and increase engagement across sectors.	Government officials, PAHO/WHO, academia
	Legal Resources [1,2,3,4,5]	Government officials, PAHO/WHO, academia
	• Establish resources for legal defense to combat industry arguments regarding intellectual property (a recurrent type of argument to limit emerging marketing restrictions).	Government officials, PAHO/WHO
	• Define legal protections from misleading advertisements.	Government officials, PAHO/WHO
	• Establish legal instruments to protect public officers, technicians and scholars from being threatened, intimidated or dismissed when they refuse to yield to private interests.	Government officials, PAHO/WHO, academia
	Policy strategies [1,2]	Government officials, PAHO/WHO
	• Track regulatory agendas and strategies that have already been developed and implemented beyond food-related policies and across sectors, to learn from successful experiences and failures, such as tobacco and alcohol.	Government officials, PAHO/WHO
	• Develop specific binding frameworks that define the stages of the policy cycle at which the private sector can and cannot participate and establish monetary and non-monetary heavy sanctions for violations.	Government officials, PAHO/WHO
	• Establish measures to regulate marketing addressed to both children and all audiences [6].	Government officials, PAHO/WHO
	• Establish regulations that cover all mass media including YouTube and social media.	Government officials, PAHO/WHO, public health advocates
	• Establish regional, cross-border regulatory frameworks for food labeling, marketing and advertisement.	Government officials, CSOs
	• Harmonize and synergize the regulations on food taxation, labeling, marketing, school environments and other settings.	

Table A3. *Cont.*

	CAPACITY-BUILDING FRAMEWORK CATEGORIES	
	Capacity-Building Actions	**Actors' Roles ***
Category 2: Policy efforts	Training and resources [1,2,3,4,5] • Identify and use existing tools to strengthen actors' capacity to support regulatory measures (e.g., PAHO/WHO's nutrient profile model, the REPLACE TRANS FAT online course and PAHO/WHO's publications such as FOPL as a Policy Tool for the Prevention of NCD). • Develop continuing education materials and courses as needed to train students, policy-makers and practitioners in (I) food nutrient profiles; (II) choices for affordable healthy lifestyles; (III) how to monitor food environments for regulatory compliance; (IV) how to denounce irregularities.	
Category 3: Information Systems	Country level data [1,2,5] • Design and disseminate national surveys with dietary patterns and health indicators to estimate the economic costs of ultra-processed product consumption. When a lack of country data exist, data from other countries could be used. Databases [1,2,5] • Identify and/or develop up-to-date national, sub-regional and regional databases on regulatory measures on ultra-processed food and drink products. Evaluation [5] • To establish a system to assess the results of the implementation of the regulatory measures. Food classification systems [1,2,3,4,5] • Utilize food guidelines, nutrient profile models and classification systems in tools for governments to identify processed and ultra-processed products. Monitor policy barriers [1,2,3,4,5] • To monitor and map existing policy barriers that delay or halt the advancement of the regulations in order to plan targeted strategies. Monitor systems and protocols [5] • Identify monitoring systems and protocols (e.g., INFORMAS) that have science-based frameworks and indicators in place that could be replicated across policies and countries and could be compared within the region over time. • Create entities in charge and/or delegate to existing entities with adequate safeguards for the prevention of COI.	Government officials, PAHO/WHO PAHO/WHO, government officials, CSOs Government officials, PAHO/WHO, academia Government officials, PAHO/WHO, CSO Government officials, PAHO/WHO, CSOs, academia PAHO/WHO, CSOs, academia Government officials, NGOs, CSOs
Priority challenges that can hinder all actions		
	Conflicts of interest [1,2,3,4,5] • Industry interference in all stages of the policy process due to financial power and other sources of power. Financial constraints [1,2,3,4,5] • A common barrier for many countries, so it is important for countries to have an awareness of the existing capacity-building tools available in order to maximize and utilize pre-existing resources. For example, some countries already have national product labeling databases that could be utilized by other countries that have similar markets as an option to move forward through the policy process.	

* Actors' Roles: For each capacity-building action, the key actors that are commonly involved in that work were listed. However, depending on the specific country and context, the actors involved may vary. [1] Agenda setting: This step refers to the process through which a policy and the problem it is intended to address are acknowledged to be of public interest. [2] Formulation: In this step, the public administration concerned examines the various policy options it considers to be possible solutions. [3] Adoption: Adoption is the stage during which decisions are made at the governmental level, resulting in a decision that favors one or more approaches to addressing a given problem. [4] Implementation: At this stage, the policy's implementation parameters are established, which can directly affect the eventual outcome of the policy. [5] Evaluation: This is the stage during which a policy is evaluated, to verify whether its implementation and its effects are aligned with the objectives that were explicitly or implicitly set out (NCCHPP, 2013). [6] To avoid the country-to-country differences in the legal age to define children or minors. These differences create legal gaps that can be used by the industry to advertise unhealthy commodities.

References

1. NCD Countdown 2030 Collaborators. NCD Countdown 2030: Worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. *Lancet* **2018**, *392*, 1072–1088. [CrossRef] [PubMed]
2. World Health Organization. Leading Causes of Death and Disability A Visual Summary of Global and Regional Trends 2000–2019. Available online: https://www.who.int/data/stories/leading-causes-of-death-and-disability-2000-2019-a-visual-summary (accessed on 30 May 2023).
3. United Nations Children's Fund; United Nations Special Rapporteur on the Right to Food. *Protecting Children's Right to a Healthy Food Environment*; UNICEF and United Nations Human Rights Council: Geneva, Switzerland, 2019. Available online: https://www.unicef.org/media/96101/file/Protecting-Childrens-Right-Healthy-Food-Environment.pdf (accessed on 24 November 2023).
4. Swinburn, B.A.; Kraak, V.I.; Allender, S.; Atkins, V.J.; Baker, P.I.; Bogard, J.R.; Brinsden, H.; Calvillo, A.; De Schutter, O.; Devarajan, R.; et al. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *Lancet* **2019**, *393*, 791–846. [CrossRef] [PubMed]
5. Monteiro, C.A.; Cannon, G.; Levy, R.B.; Moubarac, J.C.; Louzada, M.L.; Rauber, F.; Khandpur, N.; Cediel, G.; Neri, D.; Martinez-Steele, E.; et al. Ultra-processed foods: What they are and how to identify them. *Public Health Nutr.* **2019**, *22*, 936–941. [CrossRef] [PubMed]
6. Monteiro, C.; Cannon, G.; Moubarac, J.; Levy, R.; Louzada, M.; Jaime, P. The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. *Public Health Nutr.* **2018**, *21*, 5–17. [CrossRef] [PubMed]
7. Köncke, F.; Toledo, C.; Berón, C.; Klaczko, I.; Carriquiry, A.; Cediel, G.; Gomes, F.S. Estimation of intake of critical nutrients associated with noncommunicable diseases according to the PAHO/WHO criteria in the diet of school-age children in Montevideo, Uruguay. *Nutrients* **2022**, *14*, 528. [CrossRef]
8. Neri, D.; Steele, E.M.; Khandpur, N.; Cediel, G.; Zapata, M.E.; Rauber, F.; Marrón-Ponce, J.A.; Machado, P.; da Costa Louzada, M.L.; Andrade, G.C.; et al. NOVA Multi-Country Study Group on Ultra-Processed Foods, Diet Quality and Human Health. Ultraprocessed food consumption and dietary nutrient profiles associated with obesity: A multicountry study of children and adolescents. *Obes. Rev.* **2022**, *23* (Suppl. S1), e13387. [CrossRef]
9. Martínez Steele, E.; Popkin, B.M.; Swinburn, B.; Monteiro, C.A. The share of ultra-processed foods and the overall nutritional quality of diets in the US: Evidence from a nationally representative cross-sectional study. *Popul. Health Metr.* **2017**, *15*, 6–16. [CrossRef] [PubMed]
10. Costa, C.S.; Del-Ponte, B.; Assunção, M.C.F.; Santos, I.S. Consumption of ultra-processed foods and body fat during childhood and adolescence: A systematic review. *Public Health Nutr.* **2018**, *21*, 148–159. [CrossRef] [PubMed]
11. Costa, C.S.; Rauber, F.; Leffa, P.S.; Sangalli, C.N.; Campagnolo, P.D.B.; Vitolo, M.R. Ultra-processed food consumption and its effects on anthropometric and glucose profile: A longitudinal study during childhood. *Nutr. Metab. Cardiovasc. Dis.* **2019**, *29*, 177–184. [CrossRef] [PubMed]
12. Chang, K.; Khandpur, N.; Neri, D.; Touvier, M.; Huybrechts, I.; Millett, C.; Vamos, E.P. Association between Childhood Consumption of Ultraprocessed Food and Adiposity Trajectories in the Avon Longitudinal Study of Parents and Children Birth Cohort. *JAMA Pediatr.* **2021**, *175*, e211573. [CrossRef]
13. Costa, C.D.S.; Assunção, M.C.F.; Loret de Mola, C.; Cardoso, J.S.; Matijasevich, A.; Barros, A.J.D.; Santos, I.S. Role of ultra-processed food in fat mass index between 6 and 11 years of age: A cohort study. *Int. J. Epidemiol.* **2021**, *50*, 256–265. [CrossRef]
14. Machado, P.P.; Steele, E.M.; Levy, R.B.; Sui, Z.; Rangan, A.; Woods, J.; Gill, T.; Scrinis, G.; Monteiro, C.A. Ultra-processed foods and recommended intake levels of nutrients linked to non-communicable diseases in Australia: Evidence from a nationally representative cross-sectional study. *BMJ Open* **2019**, *9*, e029544. [CrossRef] [PubMed]
15. Marrón-Ponce, J.A.; Flores, M.; Cediel, G.; Monteiro, C.A.; Batis, C. Associations between Consumption of Ultra-Processed Foods and Intake of Nutrients Related to Chronic Non-Communicable Diseases in Mexico. *J. Acad. Nutr. Diet.* **2019**, *119*, 1852–1865. [CrossRef] [PubMed]
16. Rauber, F.; da Costa Louzada, M.L.; Steele, E.M.; Millett, C.; Monteiro, C.A.; Levy, R.B. Ultra-Processed Food Consumption and Chronic Non-Communicable Diseases-Related Dietary Nutrient Profile in the UK (2008–2014). *Nutrients* **2018**, *10*, 587. [CrossRef] [PubMed]
17. Hall, K.D.; Ayuketah, A.; Brychta, R.; Cai, H.; Cassimatis, T.; Chen, K.Y.; Chung, S.T.; Costa, E.; Courville, A.; Darcey, V.; et al. Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metab.* **2019**, *30*, 67–77. [CrossRef] [PubMed]
18. Khandpur, N.; Neri, D.A.; Monteiro, C.; Mazur, A.; Frelut, M.-L.; Boyland, E.; Weghuber, D.; Thivel, D. Ultra-Processed Food Consumption among the Paediatric Population: An Overview and Call to Action from the European Childhood Obesity Group. *Ann. Nutr. Metab.* **2020**, *76*, 109–113. [CrossRef] [PubMed]
19. Bawaked, R.A.; Fernández-Barrés, S.; Navarrete-Muñoz, E.M.; González-Palacios, S.; Guxens, M.; Irizar, A.; Lertxundi, A.; Sunyer, J.; Vioque, J.; Schröder, H.; et al. Impact of lifestyle behaviors in early childhood on obesity and cardiometabolic risk in children: Results from the Spanish INMA birth cohort study. *Pediatr. Obes.* **2020**, *5*, e12590. [CrossRef] [PubMed]
20. Juul, F.; Vaidean, G.; Parekh, N. Ultra-processed foods and cardiovascular diseases: Potential mechanisms of action. *Adv. Nutr.* **2021**, *12*, 1673–1680. [CrossRef] [PubMed]

21. Popkin, B.M.; Barquera, S.; Corvalan, C.; Hofman, K.J.; Monteiro, C.; Ng, S.W.; Swart, E.C.; Taillie, L.S. Towards unified and impactful policies to reduce ultra-processed food consumption and promote healthier eating. *Lancet Diabetes Endocrinol.* **2021**, *9*, 462–470. [CrossRef] [PubMed]
22. Geissler, C. Capacity building in public health nutrition. *Proc. Nutr. Soc.* **2015**, *74*, 430–436. [CrossRef]
23. World Health Organization. Global Action Plan for the Prevention and Control of NCDs 2013–2020. Available online: https://www.who.int/publications/i/item/9789241506236 (accessed on 30 April 2023).
24. Pan American Health Organization. Strategic Plan of the Pan American Health Organization 2020–2025: Equity at the Heart of Health. Available online: https://www.paho.org/en/documents/paho-strategic-plan-2020-2025 (accessed on 29 May 2023).
25. Pan American Health Organization. Plan of Action for the Prevention and Control of Noncommunicable Diseases in the Americas 2013–2019. Available online: https://www.paho.org/hq/dmdocuments/2015/action-plan-prevention-control-ncds-americas.pdf (accessed on 27 May 2023).
26. Pan American Health Organization. Plan of Action for the Prevention of Obesity in Children and Adolescents. Available online: https://www.paho.org/hq/dmdocuments/2015/Obesity-Plan-Of-Action-Child-Eng-2015.pdf (accessed on 5 June 2023).
27. Executive Board 142. *Safeguarding against Possible Conflicts of Interest in Nutrition Programmes: Draft Approach for the Prevention and Management of Conflicts of Interest in the Policy Development and Implementation of Nutrition Programmes at Country Level: Report by the Director-General*; World Health Organization: Geneva, Switzerland, 2018. Available online: https://apps.who.int/iris/handle/10665/274165 (accessed on 1 September 2023).
28. Pan American Health Organization. Preventing and Managing Conflicts of Interest in Country-Level Nutrition Programs: A Roadmap for Implementing the World Health Organization's Draft Approach in the Americas. 2021. Available online: https://iris.paho.org/bitstream/handle/10665.2/55055/PAHONMHRF210014_eng.pdf?sequence=1&isAllowed=y (accessed on 1 September 2023).
29. Cabrera, M.; Machín, L.; Arrúa, A.; Antúnez, L.; Curutchet, M.R.; Giménez, A.; Ares, G. Nutrition warnings as front-of-pack labels: Influence of design features on healthfulness perception and attentional capture. *Public Health Nutr.* **2017**, *2*, 29. [CrossRef]
30. Franco-Arellano, B.; Vanderlee, L.; Ahmed, M.; Oh, A.; L'Abbé, M. Influence of front-of-pack labelling and regulated nutrition claims on consumers' perceptions of product healthfulness and purchase intentions: A randomized controlled trial. *Appetite* **2020**, *149*, 104629. [CrossRef]
31. Machín, L.; Aschemann-Witzel, J.; Curutchet, M.R.; Giménez, A.; Ares, G. Traffic Light System Can Increase Healthfulness Perception: Implications for Policy Making. *J. Nutr. Educ. Behav.* **2018**, *50*, 668–674. [CrossRef] [PubMed]
32. Deliza, R.; de Alcántara, M.; Pereira, R.; Ares, G. How do different warning signs compare with the guideline daily amount and traffic-light system? *Food Qual. Prefer.* **2020**, *80*, 103821. [CrossRef]
33. Khandpur, N.; de Morais Sato, P.; Mais, L.A.; Bortoletto Martins, A.P.; Spinillo, C.G.; Garcia, M.T.; Urquizar Rojas, C.F.; Jaime, P.C. Are Front-of-Package Warning Labels More Effective at Communicating Nutrition Information than Traffic-Light Labels? A Randomized Controlled Experiment in a Brazilian Sample. *Nutrients* **2018**, *10*, 688. [CrossRef] [PubMed]
34. Goodman, S.; Vanderlee, L.; Acton, R.; Mahamad, S.; Hammond, D. The Impact of Front-of-Package Label Design on Consumer Understanding of Nutrient Amounts. *Nutrients* **2018**, *10*, 1624. [CrossRef]
35. Crosbie, E.; Gomes, F.S.; Olvera, J.; Rincon-Gallardo Patino, S.; Hoeper, S.; Carriedo, A. A policy study on front–of–pack nutrition labeling in the Americas: Emerging developments and outcomes. *Health Policy* **2022**, *18*, 100400. [CrossRef] [PubMed]
36. Pan American Health Organization. Sugar-Sweetened Beverage Taxation in the Region of the Americas. Available online: https://iris.paho.org/handle/10665.2/53252 (accessed on 13 June 2023).
37. Patiño, S.R.; Da Silva Gomes, F.; Constantinou, S.; Lemaire, R.; Hedrick, V.E.; Serrano, E.L.; Kraak, V.I. An assessment of government capacity building to restrict the marketing of unhealthy food and non-alcoholic beverage products to children in the region of the Americas. *Int. J. Environ. Res. Public Health* **2021**, *18*, 8324. [CrossRef] [PubMed]
38. World Health Organization. Action Framework for Developing and Implementing Public Food Procurement and Service Policies for a Healthy Diet. Available online: https://apps.who.int/iris/handle/10665/338525 (accessed on 15 June 2023).
39. Argentina Presidencia. Promoción de la Alimentación Saludable: Decreto 151/2022. Available online: https://www.boletinoficial.gob.ar/detalleAviso/primera/259690/20220323 (accessed on 18 July 2023).
40. Fundo Nacional De Desenvolvimento Da Educacoa. Nota Tecnica Nº 3228950/2022/Cosan/Cgpae/Dirae. Processo Nº 23034.035777/2022-17. Available online: https://www.gov.br/fnde/pt-br/acesso-a-informacao/acoes-e-programas/programas/pnae/NTCOIVERSOFINAL.pdf (accessed on 1 September 2023).
41. Diario Oficial de la Federación. Decreto por el que se Reforman, Adicionan y Derogan Diversas Disposiciones del Reglamento de Control Sanitario de Productos y Servicios y del Reglamento de la Ley General de Salud en Materia de Publicidad. Available online: https://www.dof.gob.mx/nota_detalle.php?codigo=5332691&fecha=14/02/2014#gsc.tab=0 (accessed on 18 July 2023).
42. Popkin, B.; Schneider, P.; Shekar, M. Addressing overweight/obesity: Lessons for future actions. In *Obesity: Health and Economic Consequences of an Impending Global Challenge*, 1st ed.; World Bank Publications: Washington, DC, USA, 2020; pp. 109–159.
43. Mialon, M.; Julia, C.; Hercberg, S. The policy dystopia model adapted to the food industry: The example of the Nutri-Score saga in France. *World Nutr.* **2018**, *9*, 109–120. [CrossRef]
44. Mialon, M.; Gomes, F. Public health and the ultra-processed food and drink products industry: Corporate political activity of major transnationals in Latin America and the Caribbean. *Public Health Nutr.* **2019**, *22*, 1898–1908. [CrossRef]

45. Bring Learning to Life with Jamboard. Available online: https://edu.google.com/intl/ALL_ca/jamboard/ (accessed on 3 November 2022).
46. Gajaweera, N.; Johnson, A. Qualitative Methodologies for Studying Religious Communities. Available online: https://crcc.usc.edu/report/studying-faith-qualitative-methodologies-for-studying-religious-communities/how-do-i-analyze-my-interview-data/ (accessed on 2 December 2022).
47. National Collaborating Centre for Healthy Public Policy. Public Policy Models and Their Usefulness in Public Health: The Stages Model. 2013. Available online: http://www.ncchpp.ca/docs/ModeleEtapesPolPubliques_EN.pdf#:~:text=Various%20authors%20have%20developed%20stages%20models,%20with%20the,briefly%20examine%20each%20of%20these%20stages.%20AGENDA%20SETTING (accessed on 19 November 2022).
48. Howlett, M.; Ramesh, M. *Studying Public Policy: Policy Cycles and Policy Subsystems*; Oxford University Press: Oxford, UK, 2003.
49. Gaceta Oficial de la República Bolivariana de Venezuela. Ministerio del Poder Popular para la Salud. Resolución no. 137. Caracas: Gaceta Oficial de la República Bolivariana de Venezuela No. 42271. 2021. Available online: https://drive.google.com/file/d/1WE91XKwo9JRyqI3hShy98kJOsIV7YFPr/view (accessed on 10 November 2022).
50. Government of Canada. Front-of-Package Nutrition Labelling. 2022. Available online: https://www.canada.ca/en/health-canada/news/2022/06/front-of-package-nutrition-labelling.html (accessed on 15 November 2022).
51. Republica Colombia. Ministerio de Salud y Proteccion Social: Resolucion Numero 2492 De 2022. 2022. Available online: https://www.minsalud.gov.co/Normatividad_Nuevo/Resoluci%C3%B3n%20No.%202492de%202022.pdf (accessed on 8 November 2023).
52. Ministério da Saúde de Brazil. Instrução Normativa-in N. 75: Estabelece os Requisitos Técnicos para Declaração da Rotulagem Nutricional nos Alimentos Embalados. 2020. Available online: https://www.in.gov.br/en/web/dou/-/instrucao-normativa-in-n-75-de-8-de-outubro-de-2020-282071143 (accessed on 24 November 2022).
53. Poder Ejecutivo Nacional. Decreto 151/2022: Apruébase la Reglamentación de la ley Nº 27.642. 2022. Available online: https://www.argentina.gob.ar/normativa/nacional/decreto-151-2022-362577/texto.ar (accessed on 5 November 2022).
54. República de Chile. Decreto 13: Modifica Decreto Supremo Nº 977, de 1996, Reglamento Sanitario de los Alimentos. 2015. Available online: https://www.bcn.cl/leychile/navegar?idNorma=1078836&buscar=20606 (accessed on 4 November 2022).
55. República del Perú. Aprueban Manual de Advertencias Publicitarias en el Marco de lo Establecido en la Ley No 30021, Ley de Promoción de la Alimentación Saludable para Niños, Niñas y Adolescentes, y su Reglamento Aprobado por Decreto Supremo No 017-2017-AS. 2018. Available online: https://busquedas.elperuano.pe/dispositivo/NL/1660606-1 (accessed on 9 November 2022).
56. República Oriental del Uruguay. Decreto N° 272/018: Modificació n del Reglamento Bromatoló Gico Nacional, Relativo al Rotulado de Alimentos. 2018. Available online: https://www.impo.com.uy/bases/decretos/272-2018/1 (accessed on 11 November 2022).
57. Secretaria de Economia de Mexico. Modificación a la Norma Oficial Mexicana nom051-Scfi/Ssa1-2010: Especificaciones Generales de Etiquetado para Alimentos y Bebidas no Alcohólicas Preenvasados-Información Comercial y Sanitaria. 2020. Available online: http://dof.gob.mx/2020/SEECO/NOM_051.pdf (accessed on 7 November 2022).
58. Sandoval, R.C.; Roche, M.; Belausteguigoitia, I.; Alvarado, M.; Galicia, L.; Gomes, F.S.; Paraje, G. Excise taxes on sugar-sweetened beverages in Latin America and the Caribbean. *Am. J. Public Health* **2021**, *45*, 21. [CrossRef]
59. World Health Organization. Assessing National Capacity for the Prevention and Control of Noncommunicable Diseases: Report of the 2019 Global Survey. 2020. Available online: www.who.int/publications-detail/ncd-ccs-2019 (accessed on 9 November 2022).
60. *Global Nutrition Policy Review 2016–2017: Country Progress in Creating Enabling Policy Environments for Promoting Healthy Diets and Nutrition*; World Health Organization: Geneva, Switzerland, 2018. Available online: https://www.who.int/publications/i/item/9789241514873 (accessed on 24 February 2023).
61. World Health Organization. Assessing the Existing Evidence Base on School Food and Nutrition Policies: A Scoping Review. 2021. Available online: https://apps.who.int/iris/bitstream/handle/10665/341097/9789240025646-eng.pdf?sequence=1&isAllowed=y (accessed on 12 November 2022).
62. Duran, A.C.; Mialon, M.; Crosbie, E.; Jensen, M.L.; Harris, J.L.; Batis, C.; Corvalán, C.; Taillie, L.S. Food environment solutions for childhood obesity in Latin America and among Latinos living in the United States. *Obes. Rev.* **2021**, *22*, 13237. [CrossRef] [PubMed]
63. Magnusson, R.S.; McGrady, B.; Gostin, L.; Patterson, D.; Taleb, H.A. Legal capacities required for preventing and control of noncommunicable diseases. *Bull. World Health Organ.* **2019**, *97*, 108–117. [CrossRef] [PubMed]
64. Mensah, G.; Rempel, B.; Manson, H. Theories, models and frameworks used in capacity building interventions relevant to public health: A systematic review. *BMC Public Health* **2017**, *17*, 914. [CrossRef]
65. Pan American Health Organization. The Virtual Campus for Public Health. Available online: https://campus.paho.org/en (accessed on 1 January 2024).
66. Ojo, M.; Jieutsa, L.; Orekoya, H.; Eke-okocha, P.N. Digital Public Service: Multi-Scalar Approach to Inclusive Planning for Sustainable Development. United Nations Sustainable Development Solution Network Youth, Bangkok, Thailand. 2023; *to be submitted*.
67. Mitchell, A.D.; Samlidis, T. The implications of the WTO tobacco plain packaging disputes for public health measures. *Int. Comp. Law Q.* **2021**, *70*, 1011–1027. [CrossRef]
68. Pan American Health Organization. WHO Tool—Prevention and Management of Conflicts of Interest in the Policy Development and Implementation of Nutrition Programs at Country Level. 2021. Available online: https://www.smartsurvey.co.uk/s/ONGA5 (accessed on 15 November 2022).

69. Kraak, V.I.; Rincón-Gallardo Patiño, S.; Sacks, G. An accountability evaluation for the International Food & Beverage Alliance's Global Policy on marketing communications to children to reduce obesity: A narrative review to inform policy. *Obes. Rev. Off. J. Int. Assoc. Study Obes.* **2019**, *20*, 90–106. [CrossRef]
70. Sheikh, K.; Sriram, V.; Rouffy, B.; Lane, B.; Soucat, A.; Bigdeli, M. Governance roles and capacities of ministries of health: A multidimensional framework. *Int. J. Health Policy Manag.* **2020**, *5*, 237–243. [CrossRef]
71. World Health Organization (WHO). WHO Plan to Eliminate Industrially Produced Trans-Fatty Acids from Global Food Supply. Available online: https://www.who.int/news/item/14-05-2018-who-plan-to-eliminate-industriallyproduced-trans-fatty-acids-from-global-food-supply (accessed on 23 May 2023).
72. Inter-American Court of Human Rights. Inter-American Human Rights System. Available online: https://www.corteidh.or.cr/que_es_la_corte.cfm?lang=en (accessed on 1 January 2024).
73. United Nations. The Foundation of International Human Rights Law. 2022. Available online: https://www.un.org/en/about-us/udhr/foundation-of-international-human-rights-law (accessed on 13 December 2022).
74. United Nations Committee on Economic, Social and Cultural Rights (CESCR) (20TH Sess.: 1999: Geneva). The Right to Adequate Food (art.11): General Comment 12 (20th session, 1999). Available online: https://digitallibrary.un.org/record/1491194 (accessed on 15 June 2023).
75. Mejía Toro, C.; Carriedo, A.; Pérez Tamayo, E.M.; Crosbie, E. Barriers to Overcoming Child Hunger and Malnutrition: Applying a Human Rights Approach to Improve Policy and Action. *Int. J. Public Health* **2023**, *68*, 1605969. [CrossRef]
76. United Nations; United Nations Treaty Collection. International Covenant on Economic, Social and Cultural Rights New York, 16 December 1966. Status as at: 09-04-2024 11:16:07 EDT. Available online: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=IV-3&chapter=4 (accessed on 10 April 2024).
77. United Nations. International Covenant on Economic, Social and Cultural Rights. Available online: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=IV-3&chapter=4 (accessed on 10 April 2024).

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Review

The Intersection of Food Security and Mental Health in the Pursuit of Sustainable Development Goals

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Abstract: Food insecurity, a multifaceted global challenge, intertwines with mental health concerns, necessitating nuanced strategies for sustainable solutions. The intricate web of challenges posed by these intersections has made it imperative to delineate a strategic way forward, incorporating solutions and robust policy recommendations. This study aims to comprehensively examine the intricate relationship between food security and its intersection with mental health on a global scale, offering insights into case studies, responses, and innovative approaches to inform effective strategies for addressing these pressing challenges. This study involved an analysis of a literature search, mainly between 2013 and 2023, with an updated addition of relevant 2024 studies. Examining responses across regions unveils varied interventions, from targeted social safety net programs in West Africa to technology-driven solutions in Asia. Success stories, such as Ghana's sustainable agricultural practices and Canada's income transfer programs, underscore the efficacy of multifaceted approaches. Innovative initiatives like community food programs offer promising alternatives to traditional food banks. Furthermore, international cooperation and policy innovations, exemplified by the European Union's "Farm to Fork Strategy", demonstrate the potential for collective action in addressing food insecurity. By prioritizing integrated strategies, global collaboration, and evidence-based policymaking, we lay the groundwork for sustainable development where communities thrive nutritionally and mentally. We emphasize continuous research and evaluation and incorporating mental health support into community programs to pave the way for a future where communities are not only food-secure but also mentally resilient.

Keywords: food insecurity; mental health; sustainable solutions; food security; mental well-being; sustainable agricultural practices; community food programs; traditional food banks; policy innovations; sustainable development

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1. Introduction

Food insecurity is regarded as the unavailability of food required for well-being and affects mental health [1]. Where there is food insecurity, public health is greatly affected, which is why the United Nations included zero hunger in its Sustainable Development Goals (SDGs). The SDGs' number two goal is to end hunger and achieve food security by

2030. Food security in our context is considered as access to safe and nutritious food [2] and the opposite of food insecurity defined above. Data from the UN [3] show that one in three people worldwide suffer moderate to severe food insecurity, translating to over two billion humans. Also, in that report, it was highlighted that more than 600 million people may face hunger globally by the year 2030 and that malnutrition lingers worldwide and jeopardizes the well-being and future of children under the age of five. In addition to this, recent data from the State of Food Insecurity Report for 2023 also show that about 29.6 percent of the global population—2.4 billion people—were moderately or severely food-insecure in 2022, of which about 900 million (11.3 percent of people in the world) were severely food-insecure.

There is an old saying that a hungry man is an angry man, and the data from the UN report [3] suggest that there are many angry people worldwide. The target year of 2030 set by the UN in its SDGs to achieve food security appears unattainable when their updated progress report [3] is considered. This suggests that millions worldwide will not have the desired nourished minds and bodies and good mental health in the future. Despite this gloomy outlook, some communities have experienced an improvement in their food security by implementing the recommendations of the UN [4]. The link between mental health and food security [4] or vice versa has not been properly established despite numerous studies; hence, it is very important to explore the nexus further, so that the factors that prevent good mental health due to food insecurity can be identified for further action.

A comprehensive survey [5] of up to 160 countries worldwide found that the well-being, food insecurity, and mental health of young persons were strongly related. The survey highlighted that, in less food-insecure environments, those facing chronic hunger and meal skipping are denied resources vital for mental health. Other investigators also found that deprivation of basic needs (food source, access, availability, and nutritional status) can affect mental health [6]. In Africa, where basic need deprivation is rife and prevalent in more than half of the population, a systematic review by Trudell et al. in 2021 [7] highlighted that the consequences of food insecurity on mental health are more prevalent among the elderly and women. Also, another study by Aguiar et al. in 2022, comprising mainly women (72% of 882) in Portugal, found that individuals from food-insecure households had more anxiety and depression symptoms [8]. Based on the observations so far, addressing food insecurity without dealing with mental health issues brings about a reductive intervention, and an integrative approach may be better. Reducing food scarcity can promote better mental health [4].

Studies of the effect of food insecurity on mental health using other population groups like the youth [5] and adolescents with a medical condition like diabetes [9] have also been investigated, and the mental predicament from worrying about food sufficiency was highlighted. Other investigations involving parents and children [10] have also been carried out elsewhere, and other reports elucidating the deleterious effect of food insecurity on mental health during uncertain situations like the COVID-19 pandemic [11] or being a refugee [12] have been shown.

This paper aims to comprehensively examine the intricate relationship between food insecurity and mental health globally, offering insights into case studies, responses, and innovative approaches to inform effective strategies for addressing these pressing challenges.

2. Methodology

This study employs a comprehensive and systematic methodology to investigate the intersection of food insecurity and mental health across various regions and socioeconomic contexts. The methodology comprises several key stages: a literature review, data collection, case study selection, and data analysis until May 2024. Each stage is detailed below to clarify the parameters and processes involved.

2.1. Literature Review

A thorough literature review was conducted to establish a foundational understanding of the existing research on food insecurity and mental health. The review focused on identifying key themes, trends, and gaps in the literature. The following databases were utilized:

PubMed: For peer-reviewed articles related to public health and epidemiology.
Google Scholar: For a broad range of scholarly articles, including grey literature.
Scopus: For comprehensive coverage of interdisciplinary studies.

Keywords and search terms included "food insecurity", "mental health", "social protection policies", "nutritional interventions", "case studies", and "regional analysis". Boolean operators (AND, OR, NOT) were used to refine searches and ensure relevant results. The criteria for the inclusion of articles were relevance to the intersection of food insecurity and mental health, publication in peer-reviewed journals, and empirical data or robust theoretical discussions. Exclusion criteria included articles that did not directly address the connection between food insecurity and mental health or lacked methodological rigor. The literature search initially covered articles published from 2013 to 2023 to capture recent developments and trends, with an updated analysis and inclusion of 2024 studies and literature searches up to May 2024.

2.2. Data Collection

Data collection involved gathering quantitative and qualitative data from multiple sources to gain a holistic view of the subject matter. The primary sources of data included the following:

Peer-Reviewed Journals: Articles providing empirical evidence and theoretical discussions.
Government Reports: Documents from national and international bodies, such as the Food and Agriculture Organization (FAO) and the World Health Organization (WHO).
NGO Reports: Publications from non-governmental organizations actively involved in addressing food insecurity and mental health issues.
Case Studies: Detailed examinations of specific regions or programs implementing notable interventions.

To ensure journal quality, only peer-reviewed journals indexed in recognized databases such as PubMed and Scopus were included. Articles were assessed for methodological rigor, relevance, and impact.

2.3. Case Study Selection

Case studies were selected based on their relevance, diversity, and the availability of detailed documentation. The selection criteria included the following:

Geographical Diversity: Ensuring representation from different continents, including Africa, Europe, North America, and Asia.
Intervention Types: Covering various approaches, such as social safety nets, technology-driven solutions, and community-based programs.
Outcome Data: Availability of data on the impact of interventions on food insecurity and mental health outcomes.

Selected case studies include interventions in West and Central Africa, Somalia, Kenya, Nigeria, the European Union, the United States, Canada, and Asia. Each case study provided insights into different strategies' effectiveness and contextual challenges.

3. Understanding Food Security

Almost a billion people worldwide lack access to sufficient, high-quality food in a manner that is socially acceptable for them to lead active lives, making food security a global concern [13,14].

According to the FAO, food security exists when the global human population always has physical and socioeconomic access to safe, adequate, and nutritious food capable of

meeting their dietary needs and food preferences for an active and healthy lifestyle [14]. This robust definition of food security was crafted to include critical dimensions of food availability, accessibility, and utilization. Over time, other concepts were included, such as the stability and sustainability of food systems [15].

The term "food availability" refers to the steady and unbroken supply of enough quantity and quality—to support a healthy lifestyle [16]. Food availability also considers sociocultural acceptability and food safety, ensuring that food is provided in a manner that respects human dignity and is devoid of microbial or toxic substances that could endanger human health [16]. Food availability is a crucial aspect of food security and has often been the focus of many initiatives to increase global food production [17]. It also involves building efficient transportation systems to ensure that food is available even in remote areas from their sources [18].

Food availability is closely related to food access; however, availability does not necessarily predict access. Food access encompasses the measures and resources required to guarantee that an adequate quantity of safe, nourishing, and socially acceptable food is within an individual's reach. These resources span various aspects, including economic status (finances) and sociocultural (indigenous food practices) and physical (dependable transportation networks) aspects [19]. Access as a social science concept also describes the food choices available to individuals based on their socioeconomic status, education, and geographical location [20]. Utilization relates to how individual and household knowledge, food preferences, and health status affect the consumption and absorption of a balanced diet capable of meeting all their nutritional dietary needs [20]. Utilization also encompasses food processing and storage practices, sanitation and hygiene, and child care (FANTA 2006). The concepts of stability and sustainability were included much later in the definition of food security [21]. Stability refers to the ability of food agrosystems to withstand man-made or natural shocks or disruptions and food's availability, access, and utilization [22]. Sustainability describes the need for efforts and measures to ensure the long-term ability of food systems to provide adequate food while preserving the environment, natural resources, and agro-ecosystems [15,22].

After years of decline, there has been an increase in global hunger since 2014 [23]. Globally, the percentage of undernourished individuals rose to 10.6% in 2015 and, subsequently, 11% in 2016 [23]. The FAO estimates that 821 million people worldwide, or almost one in nine people, were undernourished in 2017 [23]. The 2018 food insecurity statistics by the FAO also report that up to 60% of hungry people worldwide are women, and up to 5 million children below the age of 5 die from malnutrition-related causes annually [24]. The rise in food insecurity suggests that the Sustainable Development Goal (SDG) aim of ending hunger by 2030 may not be met [24].

Food insecurity is most evident in developing countries, characterized by low per capita income [25]. A study by Jones in 2016, which analyzed cross-sectional data from the 2014 Gallup World Poll across 149 countries, determined the prevalence of severe food insecurity to be as high as 33.8% in Sub-Saharan Africa and the prevalence of any form (mild, moderate or severe) to be as high as 76.1% in Sub-Saharan Africa [26]. This was further validated by a 2017 study by the ERS suggesting that up to 31.7% of Sub-Saharan Africa's population is food-insecure [27]. Forecasts also indicate that this figure will likely remain higher than 20% by 2027. Asia has the most significant number of food-insecure people. In Asia and the Pacific, a projected 460.2 million people suffered from extreme food insecurity in 2021—a rise of 170.6 million, or 58.9%, from 2014. In 2021, the region comprised 49.8% of the 923.7 million people worldwide. Compared to 28.0 million in Eastern Asia, 17.4 million in South-eastern Asia, and 2.0 million in Oceania, Southern Asia had 412.9 million people who were extremely food-insecure [24]. In the United States, a study in 2015 revealed up to a 12.7% prevalence of food insecurity, affecting almost 16 million households and impacting women, children, and racial minorities more [28,29].

4. The Psychological Impact of Hunger

Hunger refers to a state of stress occasioned by an involuntary absence of food and insufficient calories [30]. Hunger rates are the highest in Sub-Saharan Africa (Figure 1). Conversely, South Asia exhibits markedly higher prevalence rates than the Americas and East Asia [31]. Incidence rates within North America and Europe remain below 2.5%. According to The Global State of Food Security and Nutrition report, over 0.8 billion 820 people worldwide are hungry, with the majority of older people residing in Sub-Saharan Africa [32]. These are dire statistics considering the widespread ramifications of food insecurity and malnutrition on mental health. According to WHO, mental health is "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and can contribute to his or her community" [32].

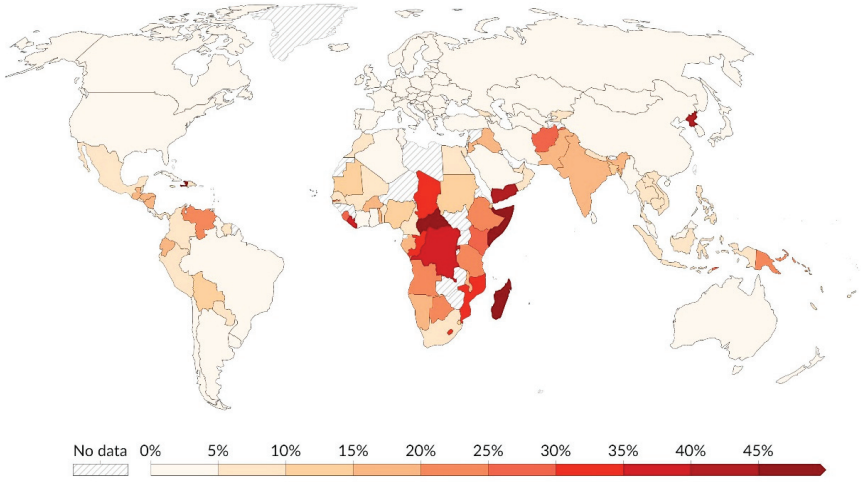

Figure 1. Share of the population that is undernourished (2001–2020) [31].

Even though food insecurity is primarily concerned with nutrition and diet and directly impacts body weight [33], it also has well-noted impacts on human psychological well-being [6]. Conditions of food insecurity encompass issues of psychological acceptability, leading to feelings of deprivation and anxiety over food supply. Consequently, food insecurity can negatively influence psychological health [34]. A global study by Jones analyzing the link between food insecurity and mental health across individuals in 149 countries demonstrated a strong dose–response relationship between poor mental health and food insecurity [26]. According to the study, the increasing severity of food insecurity can be linked with a steady decline in mental health [26]. A similar comprehensive study by Frongillo, which evaluated 138 countries in the 2014 Gallup World Poll for food insecurity and subjective well-being, reported worry, sadness, or stress among individuals living under conditions of food insecurity [35].

A review of twenty-seven qualitative and quantitative studies from developing nations by Weaver and Hadley reported that food insecurity is correlated with anxiety, shame, stress, resignation, and depression [30]. According to a systematic study by Weaver and Hadley in 2009, there is a bidirectional association between mental health and food insecurity in which hunger increases poor emotional health and vice versa [28]. Other psychological symptoms, such as suicidal ideation, anxiety, and sleep disorders, have also been linked to food insecurity and hunger [28].

Numerous studies have demonstrated the long-term effects of nutrition on children's health and development [36]. Adequate nutrition is essential for the correct development of the fetal brain during prenatal and neonatal development, according to research on

mental health and cognitive development [37]. Food insecurity, mainly due to its role in micronutrient deficiency, is correlated with early growth faltering, altered cognitive development, and poorer scores on the mental health indices [38]. Children in food-insecure households are also typically exposed to parental aggression and psychosocial stress, leading to negative child behaviors [14,26,37,39,40].

A large study by Grineski et al. in 2018 showed the impact of food insecurity on children's academic competencies, executive functioning, and social skills [41]. The results highlighted the significant detrimental effects of food insecurity on mathematics, self-control, and working memory. Other diminished parameters in children from food-insecure households include executive function and interpersonal skills. According to the study, a slip into food insecurity was occasioned by lower math and working memory scores [41].

Studies have shown that children in food-insecure households are not only aware of their limited food resources but are physically and psychologically influenced by it [42]. Fram et al. (2011) conducted a study of children aged 9 to 16 years in South Carolina and revealed that children showed cognitive, emotional, and physical awareness of household food insecurity, with emotional awareness characterized by worry, sadness, and anger [43]. In another study conducted in the United Kingdom, children aged 5 to 11 years described the experiences of frequent hunger, hunger when food was unavailable, and hunger at bedtime [44]. A study of Indian teenage girls aged 13–19 by Rani et al. (2018) also found that adolescent girls from food-insecure households were more likely to have high levels of anxiety, depression, loss of behavioral control, and psychological distress compared with those living in food-secure households [45]. Furthermore, research by Fertig (2019) at the University of Kentucky Center for Poverty indicates that mental distress due to food insecurity may linger on even into adulthood [46].

In a United States study on adolescents, insufficient food was closely linked to both depressive disorders and suicidal symptoms based on national data analysis. The study also characterized recovery during refeeding by a slow but gradual elimination of the symptoms [13]. Research has also posited possible biological mechanisms by which food insufficiency is associated with a depressed mood. According to a study by Polivy, chronic dieters or individuals with restricted diets often tend to have heightened emotional responsiveness and increased irritability and distraction [47].

5. Linking Food Security to the Sustainable Development Goals

Food security is directly linked to Sustainable Development Goal 2 (zero hunger), which aims to end hunger by 2030. Achieving this goal requires adequate food availability through sustainable agriculture and ensuring access to food for all individuals. Food security is guaranteed when appropriate measures are implemented to achieve zero hunger. These include food stability and adequate food stock to meet food demand [48]. Having access to healthy food is required for healthy living. This aligns with Sustainable Development Goal Three (SDG 3), which aims at good health and well-being. Parents who cannot afford healthy food could be stressed mentally. This implies that food insecurity impacts the mental health of an individual. Depression, anxiety, and psychological distress are among the reported mental health consequences, underscoring the urgency of addressing this issue [49].

Research demonstrates the detrimental impact of food insecurity on mental health, with the significant prevalence of mental illness resulting from it elevating it to a public health issue demanding immediate intervention [50]. For example, in a recent study on the association of food security with mental health among youths in Canada by Men et al. in 2021, it was reported that severe food insecurity caused poor health among the participants irrespective of their socioeconomic background [50]. The mental health impact of food insecurity could be exacerbated by pandemics, droughts, and natural disasters such as earthquakes and floods [51]. The pandemic affected the food supply chain due to the closure of borders across the globe [52]. Many became worried about how to obtain food as

no one knew how long the pandemic would last, and many individuals could not afford the prices of available food. Students, workers, and families were all impacted.

The World Food Conference in 1974 emphasized the importance of food for physical and mental development, igniting global awareness of food insecurity [53]. In the United States, an estimated 13.7 million people experience this challenge, while a devastating 675.1 million in Africa lack access to sufficient food [7]. Global food insecurity disproportionately affects vulnerable groups [10]. Food security is crucial for a sustainable future amidst global challenges like poverty, injustice, and climate change. Therefore, achieving food security is not an isolated goal but an intertwined stepping stone towards fulfilling the broader vision embodied in the UN Sustainable Development Goals (SDGs).

Aside from the fact that food security is vital towards achieving SDGs 2 and 3, food security is required to achieve other goals. For example, a student who has not eaten might not entirely concentrate in the classroom, thereby affecting the fulfillment of SDG 4, which is access to quality education. While the government or private sector could provide quality education, a hungry student may not be able to achieve it. Often, they may be absent from school, thereby impacting their learning. During the COVID-19 pandemic, the mental health of both domestic and international students in Australia was affected by food insecurity in a study reported in [54].

Farmers affected by drought could not afford quality education for their children [55]. While the drought impacted the mental health of the parents, the children's mental health could also be impacted by not being able to learn like their other classmates. Due to drought affecting the availability and accessibility of food, the following Sustainable Development Goals will be affected in such families: SDG 1 (no poverty—the farmer cannot afford basic needs for their children), SDG 2 (zero hunger—the farmer cannot afford to provide food for their family), SDG 3 (good health and well-being—the farmer's health and the well-being of the children are impacted), and SDG 4 (quality education—the farmer will not be able to send their children to school due to lack of funds).

6. Case Studies and Global Perspectives

Food insecurity, a complex and multifaceted challenge, remains a pressing global challenge, affecting populations across various countries and regions. Food security and mental health are intimately intertwined, with their intersection posing critical challenges and opportunities for sustainable development globally. In this section, we delve into case studies from diverse geographical areas, highlighting the impacts of food insecurity and the responses implemented to address this critical issue. Additionally, we explore success stories and innovative approaches that have shown promise in improving food security and mental well-being. Examining these case studies and global perspectives aims to contribute to a nuanced understanding of the multifaceted nature of food insecurity and inform future strategies for mitigation.

6.1. Impact of Food Insecurity

A critical aspect of understanding the global landscape of food insecurity involves examining its varied impacts on different regions. One striking example is the West and Central Africa region, which has grappled with an unprecedented food security crisis for two consecutive years. The compounded consequences of the 2021 cereal deficit, security challenges, and the COVID-19 pandemic have led to a cereal production deficit of approximately 9.5 million tons, significantly affecting the region's availability and affordability of food [56]. Contrastingly, the European Union (EU) faces distinct challenges in the wake of the Russia–Ukraine conflict. The war has disrupted global supply chains, leading to shortages in critical agricultural inputs, including energy, animal feed, and fertilizers [57]. The impact on the agricultural sector is substantial, with the EU heavily dependent on Russian fertilizer imports [58]. Additionally, the export restrictions imposed by Russia on essential commodities have contributed to food price surges in the EU, affecting both availability and affordability [59]. A comparative analysis of these regions highlights the

diverse nature of food security challenges. While West and Central Africa grapple with the immediate consequences of production deficits and inflation, the EU navigates disruptions in the supply chain and seeks to mitigate the impact of export restrictions. Understanding these distinct challenges is crucial for tailoring effective responses.

Studies have also shown the impact of food insecurity on mental health. A study by Pryor et al. (2016) provides insights from a community sample focusing on young adults [60]. The study underscores the risks posed by food insecurity, including an increased likelihood of suicidal ideation, depression, and substance use. Maynard et al. (2018) explore the link between food insecurity and mental health among females in high-income countries; the study emphasizes the role of toxic stress in intertwining food insecurity and mental health [61].

The study conducted by Elgar et al. (2021) in the United States showed a negative association between relative food insecurity and psychological functioning, even after controlling for food insecurity [5]. This finding suggests that individuals experiencing food insecurity not only struggle with the tangible challenges of accessing sufficient and nutritious food but also battle with the psychological impact of observing others who are less worried about securing their next meal. The study highlights the global patterns observed in the relationship between relative food insecurity and mental health outcomes. The salience of reference groups becomes evident, with associations between food insecurity and poorer mental health intensifying in settings where the problem is less prevalent. This underscores the role of social comparisons in shaping perceptions of well-being and life satisfaction. Interestingly, the study found a diminished association with relative deprivation in high-prevalence contexts, where food insecurity is more commonplace, and individuals may be less likely to experience the same degree of relative deprivation compared to those in low-prevalence settings.

6.2. Responses to Food Insecurity

Understanding the multifaceted response to food insecurity across various regions (Table 1) offers critical insights into the effectiveness of social protection policies and intervention strategies. Governments have implemented over 50 measures to address the food crisis in West and Central Africa. These measures include targeted social safety net programs, tax reductions on food items, the release of existing food stocks, export restrictions, and subsidies on agricultural inputs [56]. However, the effectiveness of these measures is currently questionable, as markets in many countries face high food prices and poor availability of essential commodities.

Table 1. Summary of responses to food insecurity by region.

Region	Key Responses and Interventions
West and Central Africa	Targeted social safety net programs. Tax reductions on food items. Release of existing food stocks. Export restrictions—Subsidies on agricultural inputs.
Somalia, Kenya, Nigeria	Red Cross interventions providing water, food, financial aid, nutrition services, and healthcare. Support for over 500,000 people in Somalia through clinics, mobile health services, and financial aid.
European Union	Engagement with international bodies like FAO, WTO, and G7. Collaborative efforts to promote humanitarian interventions and address supply chain disruptions.
United States	Supplemental Nutrition Assistance Program (SNAP). Means-tested entitlement program providing financial support for purchasing essential foods. Universal Childcare Benefit (UCCB).
Canada	Monthly income supplement for children under 6 years old—reduction in food insecurity by 2.4 percentage points.
High-income countries	Emergence of food banks, limited effectiveness due to nutritional inadequacy and underutilization.
Ghana	Success stories in Ghana with sustainable agriculture and policy interventions.
Asia	Technology-driven solutions like India's e-PDS system.

In countries like Somalia, Kenya, Nigeria, Ethiopia, and the Sahel region, the Red Cross has been actively addressing extreme hunger and food insecurity [62]. Ground teams provide comprehensive support, including water, food, immediate financial aid, nutrition services, and healthcare. The Somali Red Crescent, operating in Somalia, has supported over 500,000 people through clinics, mobile health services, and financial aid for essential items [62]. Similarly, the Kenyan Red Cross and the Nigerian Red Cross have reached over 520,000 and 98,000 people, respectively, providing vital support through food, clean drinking water, health services, and financial assistance [62]. While these interventions alleviate immediate hunger, it is crucial to recognize that long-term solutions must complement emergency relief efforts to build resilience within communities facing climate change and systemic challenges.

In the European Union, responses to food insecurity are characterized by a multi-faceted approach. Recognizing the importance of international cooperation, the EU has regularly met with international and multilateral bodies, such as the FAO, the World Trade Organization (WTO), and the Group of Seven (G7). These collaborations aim to promote humanitarian interventions and address the challenges posed by disruptions in the supply chain [59].

Europe provides a broader perspective on the impact of social protection spending on food insecurity [63]. Social protection expenditures throughout Europe generally encompass the overall support level through initiatives offering financial assistance and non-monetary aid, such as housing allowances [64]. During the Great Recession, countries with higher per capita investment in social protection spending exhibited lower levels of food insecurity [32,63]. Loopstra (2018) considered the cumulative generosity of interventions, encompassing cash benefits and in-kind transfers, including housing subsidies. The buffering effect of spending on housing subsidies on the relationship between rising unemployment and food insecurity underscores the interconnectedness of social protection measures. While income transfers are vital, addressing housing affordability and providing universal healthcare are integral components of a comprehensive strategy to combat food insecurity.

The Supplemental Nutrition Assistance Program (SNAP) is a notable case study addressing food insecurity through social protection policies in the United States. SNAP is a means-tested entitlement program that financially supports eligible households who purchase essential foods [65]. While studies reveal a significant decline in food insecurity among participants [63,66,67], persistently high levels suggest support levels and administration adjustments. The paternalistic nature of SNAP raises questions about its impact on households' ability to maximize utility, prompting a critical examination of social protection programs and the necessity for continuous evaluation and adaptation to address food insecurity effectively.

Canada's Universal Childcare Benefit (UCCB) offers insights into the impact of income transfers on food insecurity. Initiated in 2006, the UCCB provides a monthly income supplement of CAD 100 for each child under 6 years old nationwide [68]. Evaluations from the implementation of the UCCB program showed that using a CAD 1200 UCCB for children under <6 years lowered food insecurity by 2.4 percentage points, highlighting the potential of targeted income transfers to positively influence household food security [69]. Studies by Li et al. (2016) and Loopstra (2018) exploring social assistance programs and poverty reduction interventions in Canada demonstrate significant reductions in food insecurity during increased investment in cash transfer programs, emphasizing the crucial role of income support in comprehensive social protection policies [63,70].

The emergence of food banks has become a prominent intervention in addressing food insecurity, notably in high-income countries [71]. Over recent years, the growing prevalence of food banks in the UK mirrors a broader trend observed in other affluent nations [72]. Food banks, also known as food pantries, serve as charitable institutions where individuals can access groceries free of charge [73]. Common features of food banks include reliance on donated food, either from the community or surpluses donated by the

food industry, and dependence on volunteers for their operation. Despite their prevalence in high-income countries such as Canada, the United States, and Australia, food banks face inherent limitations in effectively addressing food insecurity [63]. Studies suggest that users of food banks often experience high levels of severe food insecurity, and the assistance provided may need to be improved to prevent households from facing hunger [74,75]. The nutritional inadequacy of foods distributed by food banks is a common concern, with reports indicating insufficient amounts of essential nutrients such as fruits, vegetables, calcium, vitamin A, and vitamin C [76].

The impact of food banks on food insecurity is complex, while some research, such as the study by Roncarolo et al. in 2015, claims a reduction in food insecurity attributed to food bank interventions and methodological issues, including the absence of true baseline measures and high attrition rates, which call for cautious interpretation [77]. Additionally, users may experience feelings of shame about resorting to food banks, contributing to the underutilization of these services [78]. Notably, only a fraction of the food-insecure population tends to access food banks, highlighting potential limitations in addressing the widespread issue [8].

In response to the limitations of traditional food banks, organizations have explored alternative approaches, often called community food programs [79]. A summary of responses by region is provided in Table 1. These initiatives aim to provide sustainable alternatives by offering additional services beyond essential food provision [80]. Examples include community food centers, community kitchens, and community shops. In the United Kingdom and Canada, some food banks operate as part of community food centers, where users can access services like benefits counseling, debt counseling, cooking classes, and community kitchens [81]. The effectiveness of community food programs in reducing household food insecurity remains to be determined due to challenges in study design, including the lack of randomized trials and long-term follow-ups.

6.3. Success Stories and Innovative Approaches

While challenges are evident, notable success stories and innovative approaches offer glimpses of hope amid the global food security crisis. One such success story emerges from countries in West Africa that have implemented targeted social safety net programs. These programs aim to provide direct support to vulnerable groups, including children, women, youth, and the elderly, helping them cope with the impact of rising food prices. By focusing on social protection, these countries are addressing the immediate needs of their populations [56].

Innovative approaches to improving food security are evident in the European Union's "Farm to Fork Strategy" [82]. This long-term plan emphasizes innovations such as precision farming, new genomic techniques, improved nutrient management, and integrated pest management to boost agricultural productivity. Additionally, the EU actively pursues trade agreements and policies to reduce dependency on a few countries and tackle global issues like climate change. These strategies reflect a commitment to resilience building and sustainable agricultural practices [59].

Sub-Saharan Africa has faced persistent challenges related to food security, but success stories and innovative approaches have emerged. Ghana, for instance, has made significant strides in improving food security through sustainable agricultural practices and targeted policy interventions. The government's Planting for Food and Jobs program, launched in 2017, has boosted agricultural productivity and enhanced food security [83]. The program has positively impacted the quantity and quality of available food by providing subsidized inputs, technical support, and market linkages to farmers. Such success stories underscore the importance of multifaceted interventions that address immediate food access, sustainable agricultural practices, and livelihood support.

Technology-driven solutions have played a pivotal role in improving food security in Asia, particularly in countries like India and China. Mobile applications and data analytics have been leveraged to enhance the efficiency of food distribution systems, reduce food

wastage, and ensure timely access to nutritional information [84]. For example, India's "e-PDS" (electronic Public Distribution System) integrates technology to streamline the distribution of subsidized food grains to eligible beneficiaries [85]. This improves the effectiveness of food distribution and facilitates better targeting of vulnerable populations. The intersection of technology and food security presents a promising avenue for scalable and sustainable interventions that address the diverse needs of populations across regions.

Some programs have adopted innovative approaches to improving food access in addressing food insecurity. Subsidized fruit and vegetable box programs, such as the Good Food Box program, aim to increase access to fresh produce [86]. Evaluations of such programs have shown mixed results, with enrolled individuals experiencing a lower prevalence of food insecurity, while discontinuation of the program was associated with increased food insecurity. The success of these innovative approaches is contingent on factors like program design, sustained participation, and addressing the diverse needs of vulnerable populations. In emphasizing context-specific interventions, the case studies underscore the need for policies that recognize the diverse sociocultural, economic, and environmental factors.

Additionally, success stories from Sub-Saharan Africa illustrate the effectiveness of holistic approaches that extend beyond immediate food access, incorporating sustainable agricultural practices, livelihood support, and market linkages to foster enduring improvements. Moreover, integrating technology-driven solutions in Asia showcases the potential for achieving scale and efficiency in interventions. The adoption of mobile applications, data analytics, and electronic distribution systems emerges as a strategic avenue to streamline processes, minimize resource wastage, and enhance overall effectiveness in addressing the evolving challenges associated with food security.

7. The Way Forward

The intricate web of challenges posed by food security and mental health intersections has made it imperative to delineate a strategic way forward, incorporating nuanced solutions and robust policy recommendations. Integrating efforts addressing both aspects is vital for fostering sustainable development and achieving the United Nations' SDGs. Scholarly insights underscore the need for comprehensive, integrated strategies that acknowledge the symbiotic relationship between food security and mental health [4,28]. Rather than isolated interventions, a holistic framework encompassing healthcare, nutrition, and social support is essential. This demands collaborative efforts from public health institutions, governmental bodies, and non-governmental organizations.

Robust social protection policies have proven instrumental in mitigating the adverse effects of food insecurity on mental health. Countries with higher per capita investment in social protection spending exhibited lower levels of food insecurity during economic downturns [32,63]. Therefore, policymakers should prioritize investments in social protection programs, ensuring they encompass financial aid, housing allowances, and other non-monetary assistance to address the multifaceted nature of food insecurity [64].

International cooperation is paramount given the global nature of food insecurity and mental health challenges. Collaborative efforts between nations, facilitated by organizations such as the FAO, the WTO, and the G7, can bolster humanitarian interventions and address disruptions in the food supply chain [59]. Shared resources, knowledge exchange, and joint research initiatives can amplify the impact of interventions.

The "Farm to Fork Strategy" employed by the European Union demonstrates the potential of innovative approaches to enhancing food security [82]. Policymakers should prioritize investments in sustainable agriculture practices, leveraging technologies like precision farming and improved nutrient management to bolster agricultural productivity. By ensuring the long-term resilience of food systems, these approaches contribute to food security and the overall well-being of communities.

To break the cycle of the bidirectional association between food insecurity and mental health, interventions should explicitly address mental health concerns. Integrating mental

health support into existing community programs, especially in regions with prevalent food insecurity, can provide a comprehensive approach [28,60]. This requires collaboration between mental health professionals, community leaders, and policymakers.

The dynamic nature of the challenges at the intersection of food security and mental health necessitates ongoing research and evaluation. Policymakers should allocate resources for studies exploring the effectiveness of interventions, identifying gaps, and adapting strategies based on evidence [75]. Continuous evaluation ensures that policies remain responsive to evolving socioeconomic conditions and emerging mental health concerns.

The way forward demands a strategic marriage of social, economic, and healthcare policies that recognize the interconnectedness of food security and mental health. The success of these endeavors relies on a commitment to integrated approaches, global collaboration, and a steadfast dedication to evidence-based policymaking. By adopting such a holistic perspective, we pave the way for a future where communities are food-secure and mentally resilient, laying the foundation for sustainable and equitable development.

8. Conclusions

The intricate examination of food insecurity and its intersection with mental health presented in this study underscores the urgency and complexity of addressing these global challenges. Comprehensive analysis of case studies from diverse regions, responses, and innovative approaches provides a nuanced understanding of the multifaceted nature of food security. Notably, the documented impact on mental health emphasizes the pressing need for integrated strategies encompassing healthcare, nutrition, and social support. The success stories from different parts of the world and innovative approaches offer glimpses of hope amid the crisis. The presented solutions, ranging from targeted social safety net programs to technology-driven interventions, highlight the adaptability required to address the diverse sociocultural, economic, and environmental factors contributing to food insecurity. As this study outlines, the way forward calls for a strategic marriage of social, economic, and healthcare policies committed to global collaboration and evidence-based policymaking. The emphasis on continuous research and evaluation, incorporating mental health support into community programs, and recognizing the interconnectedness of food security and mental health pave the way for a future where communities are not only food-secure but also mentally resilient. Adopting a holistic perspective lays the foundation for sustainable and equitable development, fostering a world where well-being and access to sufficient and nutritious food are prioritized.

The strength of our study lies in its examination of the complex relationship between food insecurity and mental health globally, emphasizing diverse case studies and innovative interventions. It underscores the need for integrated strategies and robust policy recommendations to address these intertwined challenges effectively. Key strengths include its methodology, extensive literature review from 2013 to 2024, and insightful case studies from various regions, highlighting successful approaches and the importance of holistic, evidence-based policymaking. We advocate for continuous research, international cooperation, and integrating mental health support into community programs to achieve sustainable development where nutritional and mental well-being are prioritized.

While this study on food insecurity and mental health presents valuable insights, several limitations exist. The study focuses mainly on case studies, responses from selected regions, and interventions. This may limit the generalizability of findings to other geographical and socioeconomic contexts. There might be inconsistencies or variations in how food insecurity and mental health outcomes are measured across different studies and regions, affecting the comparability and robustness of conclusions. The study may also face challenges in establishing causal relationships between interventions and outcomes due to the complexity of factors influencing food security and mental health. We also did not delve deeper into how these recommendations can be practically implemented and evaluated across diverse policy landscapes. However, this study provides a clear

pathway for future research, including areas where additional data, methodologies, or policy experiments could further advance understanding and interventions to tackle the interconnected challenges of food insecurity and mental health on a global scale.

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References

1. Simon, G.A. *Food Security*; University of Roma Tre: Rome, Italy, 2012.
2. Ejiohuo, O.; Onyeaka, H.; Unegbu, K.C.; Chikezie, O.G.; Odeyemi, O.A.; Lawal, A.; Odeyemi, O.A. Nourishing the Mind: How Food Security Influences Mental Wellbeing. *Nutrients* **2024**, *16*, 501. [CrossRef]
3. United Nations Department of Economic and Social Affairs. *The Sustainable Development Goals Report 2022*; UN: New York, NY, USA, 2022; ISBN 978-92-1-101448-8.
4. Jensen, H.H.; Kreider, B.E.; Pepper, J.V.; Zhylyevskyy, O.; Greder, K.A. Causal Effects of Mental Health on Food Security. *J. Health Econ.* **2023**, *92*, 102804. [CrossRef]
5. Elgar, F.J.; Sen, A.; Gariépy, G.; Pickett, W.; Davison, C.; Georgiades, K.; Hammami, N.; Azevedo Da Silva, M.; Gordon, D.; Melgar-Quiñonez, H.R. Food Insecurity, State Fragility and Youth Mental Health: A Global Perspective. *SSM-Popul. Health* **2021**, *14*, 100764. [CrossRef]
6. Weaver, L.J.; Owens, C.; Tessema, F.; Kebede, A.; Hadley, C. Unpacking the "Black Box" of Global Food Insecurity and Mental Health. *Soc. Sci. Med.* **2021**, *282*, 114042. [CrossRef]
7. Trudell, J.P.; Burnet, M.L.; Ziegler, B.R.; Luginaah, I. The Impact of Food Insecurity on Mental Health in Africa: A Systematic Review. *Soc. Sci. Med.* **2021**, *278*, 113953. [CrossRef]
8. Aguiar, A.; Pinto, M.; Duarte, R. The Bad, the Ugly and the Monster behind the Mirror—Food Insecurity, Mental Health and Socio-Economic Determinants. *J. Psychosom. Res.* **2022**, *154*, 110727. [CrossRef]
9. Julceus, E.F.; Frongillo, E.A.; Mendoza, J.A.; Sauder, K.A.; Malik, F.S.; Jensen, E.T.; Dolan, L.M.; Bellatorre, A.; Dabelea, D.; Reboussin, B.A.; et al. Self-Reported Food Security in Adolescents with Type 1 Diabetes: Association with Hemoglobin A1c and Mental Health Symptoms Independent of Household Food Security. *J. Nutr.* **2024**, *154*, 543–553. [CrossRef]
10. Cain, K.S.; Meyer, S.C.; Cummer, E.; Patel, K.K.; Casacchia, N.J.; Montez, K.; Palakshappa, D.; Brown, C.L. Association of Food Insecurity with Mental Health Outcomes in Parents and Children. *Acad. Pediatr.* **2022**, *22*, 1105–1114. [CrossRef]
11. Nagata, J.M.; Ganson, K.T.; Whittle, H.J.; Chu, J.; Harris, O.O.; Tsai, A.C.; Weiser, S.D. Food Insufficiency and Mental Health in the U.S. During the COVID-19 Pandemic. *Am. J. Prev. Med.* **2021**, *60*, 453–461. [CrossRef]
12. Kamelkova, D.; Strømme, E.M.; Diaz, E. Food Insecurity and Its Association with Mental Health among Syrian Refugees Resettled in Norway: A Cross-Sectional Study. *J. Migr. Health* **2023**, *7*, 100173. [CrossRef]
13. Alaimo, K.; Olson, C.M.; Frongillo, E.A. Family Food Insufficiency, but Not Low Family Income, Is Positively Associated with Dysthymia and Suicide Symptoms in Adolescents. *J. Nutr.* **2002**, *132*, 719–725. [CrossRef] [PubMed]
14. Bernal, J.; Frongillo, E.A.; Herrera, H.A.; Rivera, J.A. Food Insecurity in Children but Not in Their Mothers Is Associated with Altered Activities, School Absenteeism, and Stunting. *J. Nutr.* **2014**, *144*, 1619–1626. [CrossRef] [PubMed]
15. Berry, E.M.; Dernini, S.; Burlingame, B.; Meybeck, A.; Conforti, P. Food Security and Sustainability: Can One Exist without the Other? *Public Health Nutr.* **2015**, *18*, 2293–2302. [CrossRef] [PubMed]
16. Leroy, J.L.; Ruel, M.; Frongillo, E.A.; Harris, J.; Ballard, T.J. Measuring the Food Access Dimension of Food Security: A Critical Review and Mapping of Indicators. *Food Nutr. Bull.* **2015**, *36*, 167–195. [CrossRef] [PubMed]
17. Synthesis of Tecnical Background Documents 9–15. Available online: https://www.fao.org/3/w2537e/w2537e02.htm (accessed on 11 February 2024).
18. Mittal, A.; Krejci, C.; Craven, T. Logistics Best Practices for Regional Food Systems: A Review. *Sustainability* **2018**, *10*, 168. [CrossRef]
19. Ashby, S.; Kleve, S.; McKechnie, R.; Palermo, C. Measurement of the Dimensions of Food Insecurity in Developed Countries: A Systematic Literature Review. *Public Health Nutr.* **2016**, *19*, 2887–2896. [CrossRef] [PubMed]
20. Barrett, C.B. Measuring Food Insecurity. *Science* **2010**, *327*, 825–828. [CrossRef] [PubMed]
21. Farsund, A.A.; Daugbjerg, C.; Langhelle, O. Food Security and Trade: Reconciling Discourses in the Food and Agriculture Organization and the World Trade Organization. *Food Sec.* **2015**, *7*, 383–391. [CrossRef]
22. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2022: Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable*; The State of Food Security and Nutrition in the World (SOFI); FAO; IFAD; UNICEF; WFP; WHO: Rome, Italy, 2022; ISBN 978-92-5-136499-4.

23. FAO (Ed.) *Building Climate Resilience for Food Security and Nutrition*; The State of Food Security and Nutrition in the World; FAO: Rome, Italy, 2018; ISBN 978-92-5-130571-3.
24. FAO; UNICEF; WFP; WHO. *Asia and the Pacific—Regional Overview of Food Security and Nutrition 2022*; Urban Food Security and Nutrition; FAO: Bangkok, Thailand, 2023. [CrossRef]
25. Pawlak, K. Food Security Situation of Selected Highly Developed Countries against Developing Countries. *J. Agribus. Rural. Dev.* **2016**, *40*, 385–398. [CrossRef]
26. Jones, A.D. Food Insecurity and Mental Health Status: A Global Analysis of 149 Countries. *Am. J. Prev. Med.* **2017**, *53*, 264–273. [CrossRef]
27. Global Food Insecurity Is Projected to Decline across All Regions by 2027. Available online: http://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=84364 (accessed on 11 February 2024).
28. Bruening, M.; Dinour, L.M.; Chavez, J.B.R. Food Insecurity and Emotional Health in the USA: A Systematic Narrative Review of Longitudinal Research. *Public Health Nutr.* **2017**, *20*, 3200–3208. [CrossRef] [PubMed]
29. Myers, A.M.; Painter, M.A. Food Insecurity in the United States of America: An Examination of Race/Ethnicity and Nativity. *Food Sec.* **2017**, *9*, 1419–1432. [CrossRef]
30. Weaver, L.J.; Hadley, C. Moving beyond Hunger and Nutrition: A Systematic Review of the Evidence Linking Food Insecurity and Mental Health in Developing Countries. *Ecol. Food Nutr.* **2009**, *48*, 263–284. [CrossRef] [PubMed]
31. Ritchie, H.; Rosado, P.; Roser, M. Hunger and Undernourishment. *Our World in Data*. 2023. Available online: https://ourworldindata.org/hunger-and-undernourishment (accessed on 24 June 2024).
32. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2023: Urbanization, Agrifood Systems Transformation and Healthy Diets across the Rural–Urban Continuum*; Food and Agriculture Organization: Rome, Italy, 2023; Volume 2023. [CrossRef]
33. Morales, M.E.; Berkowitz, S.A. The Relationship Between Food Insecurity, Dietary Patterns, and Obesity. *Curr. Nutr. Rep.* **2016**, *5*, 54–60. [CrossRef]
34. Myers, C.A. Food Insecurity and Psychological Distress: A Review of the Recent Literature. *Curr. Nutr. Rep.* **2020**, *9*, 107–118. [CrossRef]
35. Frongillo, E.A.; Nguyen, H.T.; Smith, M.D.; Coleman-Jensen, A. Food Insecurity Is Associated with Subjective Well-Being among Individuals from 138 Countries in the 2014 Gallup World Poll. *J. Nutr.* **2017**, *147*, 680–687. [CrossRef] [PubMed]
36. Whitaker, R.C.; Phillips, S.M.; Orzol, S.M. Food Insecurity and the Risks of Depression and Anxiety in Mothers and Behavior Problems in Their Preschool-Aged Children. *Pediatrics* **2006**, *118*, e859–e868. [CrossRef] [PubMed]
37. Cook, J.T.; Frank, D.A. Food Security, Poverty, and Human Development in the United States. *Ann. N. Y. Acad. Sci.* **2008**, *1136*, 193–209. [CrossRef] [PubMed]
38. Black, M.M.; Walker, S.P.; Fernald, L.C.H.; Andersen, C.T.; DiGirolamo, A.M.; Lu, C.; McCoy, D.C.; Fink, G.; Shawar, Y.R.; Shiffman, J.; et al. Early Childhood Development Coming of Age: Science through the Life Course. *Lancet* **2017**, *389*, 77–90. [CrossRef]
39. Gee, K.A.; Asim, M. Parenting While Food Insecure: Links Between Adult Food Insecurity, Parenting Aggravation, and Children's Behaviors. *J. Fam. Issues* **2019**, *40*, 1462–1485. [CrossRef]
40. Leung, C.W.; Stewart, A.L.; Portela-Parra, E.T.; Adler, N.E.; Laraia, B.A.; Epel, E.S. Understanding the Psychological Distress of Food Insecurity: A Qualitative Study of Children's Experiences and Related Coping Strategies. *J. Acad. Nutr. Diet.* **2020**, *120*, 395–403. [CrossRef]
41. Grineski, S.E.; Morales, D.X.; Collins, T.W.; Rubio, R. Transitional Dynamics of Household Food Insecurity Impact Children's Developmental Outcomes. *J. Dev. Behav. Pediatr.* **2018**, *39*, 715–725. [CrossRef]
42. Melchior, M.; Chastang, J.-F.; Falissard, B.; Galéra, C.; Tremblay, R.E.; Côté, S.M.; Boivin, M. Food Insecurity and Children's Mental Health: A Prospective Birth Cohort Study. *PLoS ONE* **2012**, *7*, e52615. [CrossRef]
43. Fram, M.S.; Frongillo, E.A.; Jones, S.J.; Williams, R.C.; Burke, M.P.; DeLoach, K.P.; Blake, C.E. Children Are Aware of Food Insecurity and Take Responsibility for Managing Food Resources12. *J. Nutr.* **2011**, *141*, 1114–1119. [CrossRef]
44. Harvey, K. "When I Go to Bed Hungry and Sleep, I'm Not Hungry": Children and Parents' Experiences of Food Insecurity. *Appetite* **2016**, *99*, 235–244. [CrossRef]
45. Rani, D.; Singh, J.; Acharya, D.; Paudel, R.; Lee, K.; Singh, S. Household Food Insecurity and Mental Health Among Teenage Girls Living in Urban Slums in Varanasi, India: A Cross-Sectional Study. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1585. [CrossRef]
46. Fertig, A. *The Long-Term Health Consequences of Childhood Food Insecurity*; University of Kentucky Center for Poverty Research: Lexington, KY, USA, 2019.
47. Polivy, J. Psychological Consequences of Food Restriction. *J. Am. Diet. Assoc.* **1996**, *96*, 589–592. [CrossRef]
48. Chen, X.; Shuai, C.; Wu, Y. Global food stability and its socio-economic determinants towards sustainable development goal 2 (Zero Hunger). *Sustain. Dev.* **2023**, *31*, 1768–1780. [CrossRef]
49. Fang, D.; Thomsen, M.R.; Nayga, R.M. The Association between Food Insecurity and Mental Health during the COVID-19 Pandemic. *BMC Public Health* **2021**, *21*, 607. [CrossRef]
50. Men, F.; Elgar, F.J.; Tarasuk, V. Food Insecurity Is Associated with Mental Health Problems among Canadian Youth. *J. Epidemiol. Community Health* **2021**, *75*, 741–748. [CrossRef]

51. Valladares-Garrido, M.J.; Zapata-Castro, L.E.; García-Vicente, A.; León-Figueroa, D.A.; Huamani-Colquichagua, Y.; Huaman-Garcia, M.; Calle-Preciado, R.E.; Valladares-Garrido, D.; Díaz-Vélez, C.; Failoc-Rojas, V.E.; et al. Food Insecurity in Piura, Peru, in the Context of Post-Earthquake and the COVID-19 Pandemic. *Front. Public Health* **2023**, *11*, 1142550. [CrossRef]
52. Aday, S.; Aday, M.S. Impact of COVID-19 on the Food Supply Chain. *Food Qual. Saf.* **2020**, *4*, 167–180. [CrossRef]
53. FAO (Ed.) *Eradicating World Hunger: Taking Stock Ten Years after the World Food Summit*; The State of Food Insecurity in the World; FAO: Rome, Italy, 2006; ISBN 978-92-5-105580-9.
54. Mihrshahi, S.; Dharmayani, P.N.A.; Amin, J.; Bhatti, A.; Chau, J.Y.; Ronto, R.; Turnip, D.; Taylor, M. Higher Prevalence of Food Insecurity and Psychological Distress among International University Students during the COVID-19 Pandemic: An Australian Perspective. *Int. J. Environ. Res. Public Health* **2022**, *19*, 14101. [CrossRef]
55. Khalili, N.; Arshad, M.; Farajzadeh, Z.; Kächele, H.; Müller, K. Effect of Drought on Smallholder Education Expenditures in Rural Iran: Implications for Policy. *J. Environ. Manag.* **2020**, *260*, 110136. [CrossRef]
56. Food Insecurity and Policy Responses in West Africa: Targeted Measures to Mitigate Impact and Strengthen the Resilience of Vulnerable Groups, January 2023—Burkina Faso | ReliefWeb. Available online: https://reliefweb.int/report/burkina-faso/food-insecurity-and-policy-responses-west-africa-targeted-measures-mitigate-impact-and-strengthen-resilience-vulnerable-groups-january-2023 (accessed on 5 March 2024).
57. Zhang, Z.; Abdullah, M.J.; Xu, G.; Matsubae, K.; Zeng, X. Countries' Vulnerability to Food Supply Disruptions Caused by the Russia–Ukraine War from a Trade Dependency Perspective. *Sci. Rep.* **2023**, *13*, 16591. [CrossRef]
58. Rabbi, M.F.; Ben Hassen, T.; El Bilali, H.; Raheem, D.; Raposo, A. Food Security Challenges in Europe in the Context of the Prolonged Russian–Ukrainian Conflict. *Sustainability* **2023**, *15*, 4745. [CrossRef]
59. Santeramo, F.G.; Kang, M. Food Security Threats and Policy Responses in EU and Africa. *Sustain. Horiz.* **2022**, *4*, 100044. [CrossRef]
60. Pryor, L.; Lioret, S.; Van Der Waerden, J.; Fombonne, É.; Falissard, B.; Melchior, M. Food Insecurity and Mental Health Problems among a Community Sample of Young Adults. *Soc. Psychiatry Psychiatr. Epidemiol.* **2016**, *51*, 1073–1081. [CrossRef]
61. Maynard, M.; Andrade, L.; Packull-McCormick, S.; Perlman, C.; Leos-Toro, C.; Kirkpatrick, S. Food Insecurity and Mental Health among Females in High-Income Countries. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1424. [CrossRef]
62. Africa Hunger Crisis: More than 140 Million Facing Hunger. Available online: https://www.redcross.org.uk/stories/disasters-and-emergencies/world/africa-hunger-crisis-100-million-struggling-to-eat (accessed on 5 March 2024).
63. Loopstra, R. Interventions to Address Household Food Insecurity in High-Income Countries. *Proc. Nutr. Soc.* **2018**, *77*, 270–281. [CrossRef]
64. Garratt, E. Food Insecurity in Europe: Who Is at Risk, and How Successful Are Social Benefits in Protecting against Food Insecurity? *J. Soc. Pol.* **2020**, *49*, 785–809. [CrossRef]
65. Schanzenbach, D.W. Exploring Options to Improve the Supplemental Nutrition Assistance Program (SNAP). *Ann. Am. Acad. Political Soc. Sci.* **2019**, *686*, 204–228. [CrossRef]
66. Bovell-Ammon, A.; Cuba, S.E.D.; Coleman, S.; Ahmad, N.; Black, M.M.; Frank, D.A.; Ochoa, E.; Cutts, D.B. Trends in Food Insecurity and SNAP Participation among Immigrant Families U.S.-Born Young Children. *Children* **2019**, *6*, 55. [CrossRef] [PubMed]
67. Swann, C.A. Household History, SNAP Participation, and Food Insecurity. *Food Policy* **2017**, *73*, 1–9. [CrossRef]
68. Tarasuk, V.; Li, N.; Dachner, N.; Mitchell, A. Household Food Insecurity in Ontario during a Period of Poverty Reduction, 2005–2014. *Can. Public Policy* **2019**, *45*, 93–104. [CrossRef]
69. Ionescu-Ittu, R.; Glymour, M.M.; Kaufman, J.S. A Difference-in-Differences Approach to Estimate the Effect of Income-Supplementation on Food Insecurity. *Prev. Med.* **2015**, *70*, 108–116. [CrossRef] [PubMed]
70. Li, N.; Dachner, N.; Tarasuk, V. The Impact of Changes in Social Policies on Household Food Insecurity in British Columbia, 2005–2012. *Prev. Med.* **2016**, *93*, 151–158. [CrossRef]
71. Pollard, C.M.; Booth, S. Food Insecurity and Hunger in Rich Countries—It Is Time for Action against Inequality. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1804. [CrossRef]
72. Loopstra, R.; Lambie-Mumford, H. Food Banks: Understanding Their Role in the Food Insecure Population in the UK. *Proc. Nutr. Soc.* **2023**, *82*, 253–263. [CrossRef]
73. Hamel, B.T.; Harman, M. Can Government Investment in Food Pantries Decrease Food Insecurity? *Food Policy* **2023**, *121*, 102541. [CrossRef]
74. Sengul Orgut, I.; Brock Iii, L.G.; Davis, L.B.; Ivy, J.S.; Jiang, S.; Morgan, S.D.; Uzsoy, R.; Hale, C.; Middleton, E. Achieving Equity, Effectiveness, and Efficiency in Food Bank Operations: Strategies for Feeding America with Implications for Global Hunger Relief. In *Advances in Managing Humanitarian Operations*; Zobel, C.W., Altay, N., Haselkorn, M.P., Eds.; International Series in Operations Research & Management Science; Springer International Publishing: Cham, Switzerland, 2016; pp. 229–256. ISBN 978-3-319-24416-7.
75. Tarasuk, V.; Fafard St-Germain, A.-A.; Loopstra, R. The Relationship Between Food Banks and Food Insecurity: Insights from Canada. *Voluntas* **2020**, *31*, 841–852. [CrossRef]
76. Oldroyd, L.; Eskandari, F.; Pratt, C.; Lake, A.A. The Nutritional Quality of Food Parcels Provided by Food Banks and the Effectiveness of Food Banks at Reducing Food Insecurity in Developed Countries: A Mixed-method Systematic Review. *J. Hum. Nutr. Diet* **2022**, *35*, 1202–1229. [CrossRef]

77. Roncarolo, F.; Adam, C.; Bisset, S.; Potvin, L. Traditional and Alternative Community Food Security Interventions in Montréal, Québec: Different Practices, Different People. *J. Community Health* **2015**, *40*, 199–207. [CrossRef]
78. El Zein, A.; Vilaro, M.J.; Shelnutt, K.P.; Walsh-Childers, K.; Mathews, A.E. Obstacles to University Food Pantry Use and Student-Suggested Solutions: A Qualitative Study. *PLoS ONE* **2022**, *17*, e0267341. [CrossRef]
79. Phillips, S. Can Community Gardens Improve Food Banks and Food Centers? Lessons from Two Southwestern Ontario Cases. Ph.D. Thesis, The University of Western Ontario, London, ON, Canada, 2020.
80. Kneafsey, M.; Owen, L.; Bos, E.; Broughton, K.; Lennartsson, M. Capacity Building for Food Justice in England: The Contribution of Charity-Led Community Food Initiatives. *Local Environ.* **2017**, *22*, 621–634. [CrossRef]
81. Cloke, P.; May, J.; Williams, A. The Geographies of Food Banks in the Meantime. *Prog. Hum. Geogr.* **2017**, *41*, 703–726. [CrossRef]
82. Baquedano, F.; Jelliffe, J.; Beckman, J.; Ivanic, M.; Zereyesus, Y.; Johnson, M. Food Security Implications for Low- and Middle-income Countries under Agricultural Input Reduction: The Case of the European Union's Farm to Fork and Biodiversity Strategies. *Appl. Econ. Perspect. Policy* **2022**, *44*, 1942–1954. [CrossRef]
83. Fonjong, L.N.; Gyapong, A.Y. Plantations, Women, and Food Security in Africa: Interrogating the Investment Pathway towards Zero Hunger in Cameroon and Ghana. *World Dev.* **2021**, *138*, 105293. [CrossRef]
84. Apostolidis, C.; Brown, D.; Wijetunga, D.; Kathriarachchi, E. Sustainable Value Co-Creation at the Bottom of the Pyramid: Using Mobile Applications to Reduce Food Waste and Improve Food Security. *J. Mark. Manag.* **2021**, *37*, 856–886. [CrossRef]
85. Tanksale, A.; Jha, J.K. An Effective Heuristic for Multi-Period Multi-Foodgrain Inventory Transportation Problem in India. *INFOR Inf. Syst. Oper. Res.* **2016**, *54*, 355–379. [CrossRef]
86. Bradford, V.A.; Quinn, E.L.; Walkinshaw, L.P.; Rocha, A.; Chan, N.L.; Saelens, B.E.; Johnson, D.B. Fruit and Vegetable Access Programs and Consumption in Low-Income Communities. *J. Hunger. Environ. Nutr.* **2019**, *14*, 780–795. [CrossRef]

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Article

Front-of-Package-Label-Style Health Logos on Menus—Do Canadian Consumers Really Care about Menu Health Logos?

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Abstract: Public health policies have been widely utilized to improve population nutrition, such as the newly announced front-of-pack labels (FOPLs) that will be applied to Canadian prepackaged foods to help consumers make healthier selections. However, research on similar health logos in the food service sector has been limited. This study explores the potential application of FOPL-style health logos in the food service sector and its impact on consumer behaviors. A survey was conducted among 1070 Canadians to assess their awareness, perception, and support for health logos on restaurant menus. The results indicate that while participants value healthy food options when dining out, taste, price, and convenience remain the primary factors influencing their choices. Most participants were unaware of existing FOPL policies and demonstrated mixed responses regarding the influence of similar health logos on their restaurant selection. However, a majority expressed a desire to see FOPL-style health logos on menus, and nutrient profile ratings and logos indicating nutrient limitations or encouragements were listed as preferred health logos. Notably, females indicated higher supportiveness for FOPL-style health logos on menus and individuals with food allergies exhibited higher agreement in the likelihood of eating at a restaurant displaying labels. Additionally, findings revealed that FOPL-style health logos alone may not significantly deter consumers from purchasing labelled menu items, especially if price is affected. Overall, this study highlights the need for further understanding consumer perceptions to effectively develop and implement FOPL initiatives in the food service sector.

Keywords: nutritional policy; restaurant foods; consumer research; menu labelling

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1. Introduction

Front-of-package labelling

Dietary risks, as determined by 15 dietary diet quality components (e.g., high in sodium, low in vegetables), were accountable for 8 million global attributable deaths in 2019, according to the Global Burden of Disease Study [1]. To improve population nutrition, many policy frameworks and guidelines have been applied in public health, including individual, organizational, and system-level interventions [2,3]. One of these strategies iss front-of-package labelling (FOPL), which uses symbols that summarize important nutritional characteristics of foods on the display surface of packages, such as a warning label that highlights nutrients which should be limited in the diet [4,5]. The utilization of FOPL has demonstrated efficacy in improving the overall nutritional quality of a population by enhancing consumer nutrition knowledge, facilitating healthier food choices, and encouraging food reformulations [6–10]. Three systematic reviews showed that FOPL has a positive effect on consumer purchasing, such as a lower sugar and sodium content of the purchased foods, although evidence on consumption was limited [7–9]. Song et al. specifically compared different types of labels (e.g., traffic light labels, nutrient warnings) and

showed that warning labels are associated with better overall healthfulness and reduced energy in purchases [9]. Similarly, Ikonen et al. found that although different types of FOPL all have significantly positive impacts on consumers choosing healthier products, warning labels showed the strongest impact [7]. As of 2023, 16 countries had introduced mandatory FOPLs, and 10 of them introduced warning labels [10]. In June 2022, Canada introduced its mandatory FOPL regulations for nutrients of concern, including saturated fat, sodium, and sugar, with implementation slated for completion by 2026 [6].

Labelling in the food service sector

While FOPL has been widely studied on prepackaged foods, research and policies related to labelling in the food services sector have been much scarcer. Menu labelling policies usually focus on displaying the energy content, as several countries (e.g., United States, United Kingdom) have national-level mandatory calorie labelling in large chain restaurants [11]. Several systemic reviews that examined the effects of calorie labelling on foods purchased or consumed in real-world and laboratory settings showed mixed results, concluding that impacts are limited [12–14]. There has been no national policy on health logos on menus worldwide, and New York City and Philadelphia were the first two cities to put sodium warning icons next to restaurant menu items that contain more than 2300 mg of sodium [15].

In Canada, while there are mandatory labelling regulations on prepackaged foods [16], there is currently no federal labelling regulation specific to the food service sector, except for a mandate in Ontario that requires food service establishments with 20 or more outlets to display energy content information on their menus [17]. Considering the significant proportion of Canadians who consume meals at restaurants [18,19] and the poor nutritional quality of Canadian restaurant foods [20], strategies to improve diet quality in the food service sectors become necessary.

Given the significance of understanding consumer perceptions in developing and improving nutrition policy initiatives, this study aims to explore the potential application of comprehensive nutritional information in the food service sector, focusing on three primary research questions: (1) the desire of Canadian consumers to have increased nutritional information presented by health logos on menus and within the food service sector, like the FOPLs designed for prepackaged foods, (2) the demographic groups most likely to be affected by such information, and (3) the potential impact on consumer behaviors within the restaurant sector resulting from enhanced access to nutritional information presented by these health logos.

2. Materials and Methods

This study employed a cross-sectional survey design to assess the potential application of FOPL in the food service sector. A voluntary survey in both English and French was administered to participants across Canada using the online survey platform Qualtrics, in collaboration with Angus Reid, a well-established Canadian field house and a member of the Canadian Marketing Association.

Respondents were recruited through a broad invitation method and a double opt-in screening process for recruitment. Potential participants were engaged through targeted banner advertisements on various websites and partnerships with non-governmental and charitable organizations. This strategy ensures a representative demographic mix that encompasses diversity across all population subgroups. Ethics approval was granted by the Institutional Review Board of Dalhousie University REB No. 2023-6677 (26 May 2023). Participants were required to have lived in Canada for at least 12 months and to be at least 18 years of age. Participants needed to provide informed consent by clicking on a link at the end of the consent form if they agreed to proceed with completing the survey, and the consent could be rescinded by closing their browser.

Data were collected between 1 June and 30 June 2023, and a total of 1070 participants were recruited for the study. Results will show varying totals due to incompletes. Participants were selected from the general population of Canada and were diverse in terms of age, gender, marital status, education level, household income, and dietary restrictions. The demographic characteristics of the participants are summarized in Table 1.

Table 1. Demographics of the study participants (n = 1070).

Age Group	Number	%
The Silent Generation: born 1928–1945	28	3%
Baby Boomers: born 1946–1964	341	32%
Generation X: born 1965–1980	238	22%
Millennials: born 1981–1996	393	37%
Generation Z: born 1997–2012	65	6%
Grand Total	1065	100%
Gender		
Female	536	50.3%
Male	522	49.0%
Other	3	0.3%
Prefer not to answer	4	0.4%
Grand Total	1065	100%
Marital Status		
Married	644	61%
Separated/Divorced	79	7%
Single	290	27%
Widowed	24	2%
Prefer not to answer	27	3%
Grand Total	1064	100%
Education Level		
Did not graduate high school	16	2%
High school graduate certificate or equivalent	137	13%
Community college, technical college, or CEGEP	253	24%
Trades certificate or diploma	87	8%
University (undergraduate degree)	392	37%
Post-graduate degree	180	17%
Grand Total	1065	100%
Household Income		
Under CAD 25,000	53	5%
CAD 25,000 to CAD 49,999	122	11%
CAD 50,000 to CAD 74,999	160	15%
CAD 75,000 to CAD 99,999	146	14%
CAD 100,000 to CAD 124,000	138	13%
CAD 125,000 to CAD 149,999	125	12%
Over CAD 150,000	190	18%
Prefer not to answer	132	12%
Grand Total	1066	100%
Dietary Restrictions		
No dietary restriction	718	67%
Allergies and/or intolerances, and faith-based restrictions (e.g., halal, kosher, etc.)	16	2%
Faith-based restrictions (e.g., halal, kosher, etc.)	18	2%
Food allergies and/or intolerances	271	25%
Others	42	4%
Grand Total	1065	100%

Of the 1070 participants, more than 50% were Millennials (born 1981–1996) and Baby Boomers (born 1946–1964). Of the participants, 50% were female and 49% were male, and 61% of were married. Most participants' education levels were university (37%) and community college, technical college, or CEGEP (24%), followed by post-graduate degree (17%). Sixty-seven percent of participants reported having no dietary restrictions and 25% had food allergies and/or intolerances.

The survey consisted of questions related to participants' perceptions and supportiveness towards health logos on restaurant menus, their restaurant behaviors, and their attitudes towards FOPL-style health logos. The survey included closed-ended questions, rating scales, and multiple-choice questions. Participants were asked whether they had seen health logos on restaurant menus and their perceptions towards them. The types of health logos and their prevalence were assessed. Participants' agreement or disagreement with statements related to the influence of health logos on their restaurant choices was measured.

Participants were asked about their frequency of visiting restaurants, the proportion of their diet composed of foods prepared away from home, and their preferences for different types of restaurants. Participants were presented with the FOPL published by Health Canada (Figure 1) and asked about their awareness and support for applying this FOPL on menus. Participants were also shown triangle warning sign designs and asked about their perceived effectiveness compared to FOPLs for prepackaged foods (Figure 2). Participants' preferences for different types of health logos on menus were assessed. Participants' likelihood of eating at a restaurant with labels displayed on the menu and their willingness to purchase menu items with warning labels were measured.

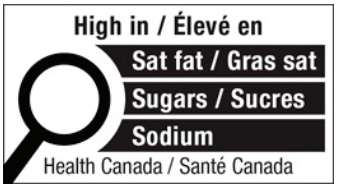

Figure 1. Front-of-pack labelling that will be applied to prepackaged foods.

Figure 2. Proposed design of a FOPL-style health logo for 'high in sodium', 'high in sugar', and 'high in saturated fat'.

Descriptive statistics were used to summarize the demographic characteristics of the participants and the survey responses. Frequencies and percentages were reported for categorical variables. Ordinal logistic regression was used to analyze independent variables including age, gender, marital status, income, education levels, dietary restrictions, and frequency of eating out. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Eating out Behaviors of Participants

The results of this study indicate that participants displayed a regular frequency of visiting restaurants, with all participants reporting at least monthly visits and 45% visiting restaurants on a weekly basis (Figure 3).

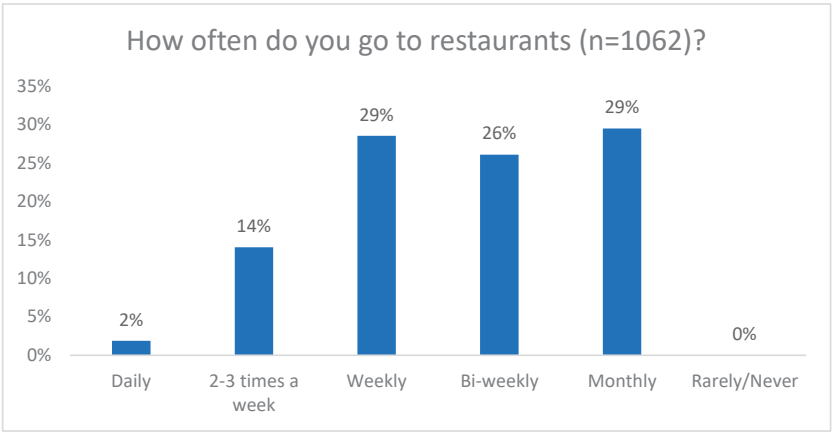

Figure 3. How often do you go to restaurants?

However, most participants (81%) stated that food prepared away from home accounted for only 0–25% of their overall diet, and a mere 4% reported that over half of their diet consisted of food prepared away from home. Among the various types of restaurants, sit-down establishments were the most visited (41%), followed by fast-food restaurants (28%), coffee shops (20%), and bakery/dessert shops (9%). When making choices about dining out, participants prioritized factors such as taste (32%), price (29%), and convenience (16%), with the nutrition profile ranking fourth in importance (12%) (Figure 4).

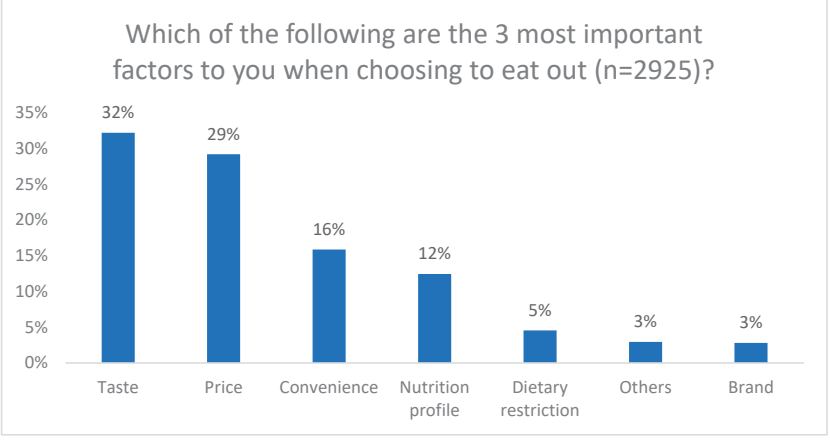

Figure 4. Which of the following are the 3 most important factors to you when choosing to eat out?

Nevertheless, an average of 80% of participants agreed with the notion that having healthy food options when dining out is important. This percentage was significantly higher (84%) among those who attended university or post-graduate degrees compared to those who did not graduate from high school (69%) (Supplementary Table S1, $p < 0.05$). Significantly more female participants (84%) than male participants (75%) agreed with the statement ($p < 0.001$). Baby Boomers (80%) and Millennials (81%) had a higher percentage of agreement compared to the Silent Generation (63%) ($p < 0.05$). Interestingly, people with food allergy/intolerance and faith-based dietary restrictions (53%) had a higher percentage of agreement compared with those without dietary restrictions (79%) ($p < 0.05$). These findings shed light on the participants' restaurant behaviors and preferences, suggesting

that while taste, price, and convenience are primary considerations, there is a prevailing acknowledgment of the significance of healthy food options in the dining out context.

3.2. Perception of Menu Health Logos

Among the respondents, 43% reported observing a health logo on restaurant menus. Within this subset, the most prevalent types of logos were those indicating ratings for the nutrient profile of menu items and logos related to energy content (Figure 5). Conversely, warning labels were the least commonly encountered. Additional responses included logos indicating gluten-related claims and vegan/vegetarian claims. When queried about whether the presence of health logos influences their choice of restaurants, respondents displayed mixed opinions. Approximately 39% of participants neither agreed nor disagreed, while similar percentages of participants indicated disagreement (32%) and agreement (30%). A higher percentage of female participants (33%) and married participants (31%) selected 'agree' compared to male participants (25%) and single participants (23%) ($p = 0.01$ and 0.02, respectively) (Supplementary Table S1). Merely 20% of participants agreed that the individuals they dine with influence their decisions regarding dishes with or without health logos, with the majority either disagreeing (50%) or expressing neutrality (39%). However, a higher percentage of participants who eat out 2–3 times a week (29%) and daily (40%) stated they 'agree' with this statement ($p = 0.02$ and $p = 0.03$, respectively).

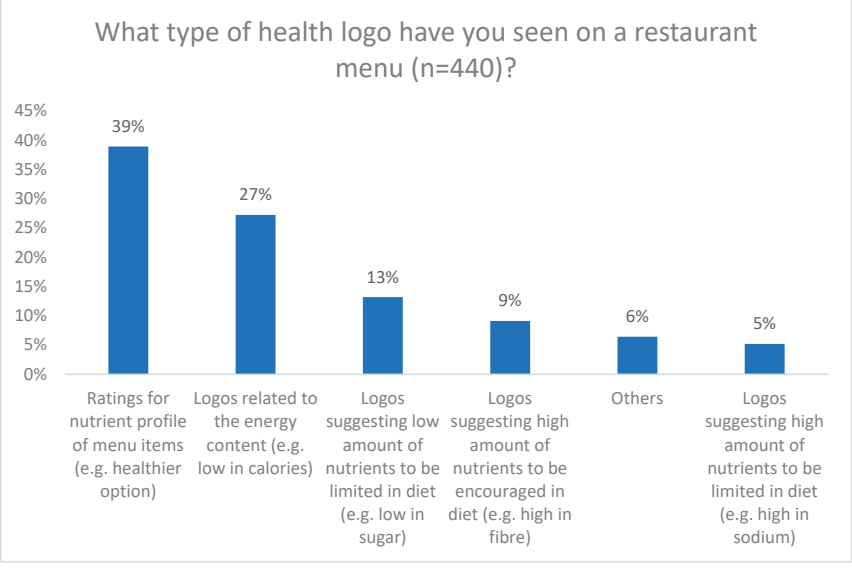

Figure 5. What type of health logo have you seen on a restaurant menu?

When participants were presented with the FOPL logo published by Health Canada, it was found that a significant proportion of participants, specifically 84%, were unaware of this policy. However, 59% of participants expressed their desire to see a similar FOPL-style health logo on menus. When stratifying by gender, 10% more female respondents compared to male respondents selected 'somewhat agree' or 'strongly agree' ($p = 0.01$) (Supplementary Table S1). Moreover, when participants were shown the triangle warning sign design (Figure 2), a considerable 65% agreed that it would be more effective than the current FOPL used for prepackaged foods (Supplementary Table S1).

Regarding the types of health logos participants expressed interest in seeing on menus, the highest responses were observed for ratings indicating the nutrient profile of menu items (27%), followed by logos suggesting a high amount of nutrients to be limited in the

diet (21%), and logos suggesting a high amount of nutrients to be encouraged in the diet (19%) (Figure 6).

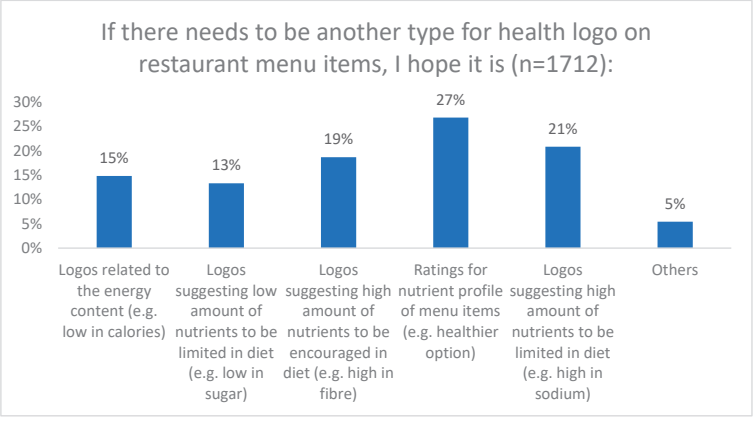

Figure 6. If there needs to be another type for health logo on restaurant menu items, I hope it is.

Despite the majority (64%) of participants agreeing that the use of warning labels on menu items would effectively inform consumers about the nutritional profile of food (Figure 7), questions exploring the potential impact of menu labelling on consumer behaviors revealed contrasting responses. Overall, only 28% of participants agreed that they were more likely to eat at a restaurant displaying labels on the menu. Also, 62% agreed that they would still consider purchasing a menu item or visiting a restaurant even if a warning label was present. When stratified by education level, respondents that did not attend high school had the highest percentage of selecting 'disagree' and the proportion was significantly different from other groups ($p < 0.05$) (Supplementary Table S1). Additionally, a mere 16% of participants agreed that they were willing to pay a higher price for a meal at a restaurant to avoid menu items with warning labels, whereas 32% and 23% of participants expressed strong or moderate disagreement, respectively (Figure 7). However, among participants who eat out daily, 35% agreed that they would pay a higher price, significantly higher than the participants who eat out monthly ($p = 0.02$).

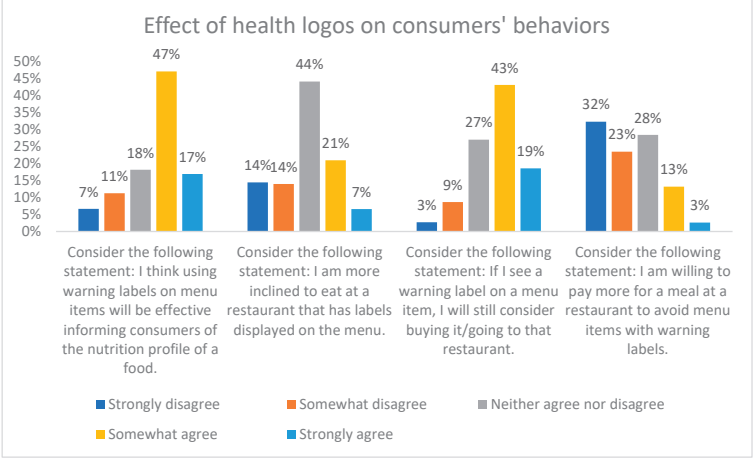

Figure 7. Effect of health logos on consumers' behaviors.

4. Discussion

The findings of this study provide insights into restaurant behaviors and preferences among the participants, shedding light on their dining out habits and the significance of healthy food options. They contribute to the understanding of consumer attitudes towards FOPL and inform the development of initiatives aimed at improving population health through FOPL-style health logos in the food service sector.

Although the eating out frequency reported in this study (45%) was lower than that reported pre-pandemic in 2019 (54%) [18], restaurants still have a role in the participants' overall food consumption patterns, even after the pandemic. However, despite the frequency of restaurant visits, the participants' reliance on food prepared away from home is relatively low, with most people reporting that it accounted for a small proportion of their overall diet. This finding suggests that while dining out is a common practice, it does not dominate their daily food intake. Additionally, only a 4% proportion of participants reported that over half of their diet consisted of food prepared away from home. These results highlight the importance of considering home-cooked meals and other sources of nutrition when evaluating the overall dietary habits of individuals. A multi-faceted approach such as the Health Eating Strategy [21] will be necessary to improve the dietary habits of Canadians at the individual, industrial, and governmental levels.

When analyzing the types of restaurants participants frequented, sit-down establishments emerged as the most visited, followed by fast-food restaurants, coffee shops, and bakery/dessert shops. Previous research has shown that less healthful eating behaviors are mainly associated with eating out at fast food restaurants, rather than at sit-down restaurants [22,23]. Understanding these preferences is crucial for restaurant owners and policymakers to tailor their offerings and interventions accordingly.

Regarding the factors influencing participants' choices when dining out, taste, price, and convenience were identified as the primary considerations. Notably, nutrition profiles ranked fourth in importance. These findings align with previous research, highlighting that taste and cost often outweigh health considerations when making food choices outside the home [24]. However, it is noteworthy that despite the lower ranking of nutrition in the choice factors, the majority of participants expressed agreement with the importance of having healthy food options when dining out. This demonstrates a general awareness and acknowledgement among participants that healthful choices are essential when eating away from home.

This study also explored the awareness and influence of health logos on restaurant menus. While 43% of participants reported observing health logos, ratings for nutrient profiles and energy content were the most prevalent types. Warning labels were less commonly encountered, indicating a potential area for improvement in menu labelling initiatives. Participants' opinions on the influence of health logos on their restaurant choices were mixed, with a notable percentage neither agreeing nor disagreeing. Also, although most participants were unaware of Health Canada's FOPL policy, a considerable percentage expressed a desire to see a similar FOPL-style health logo on restaurant menus. This highlights the potential for menu labelling initiatives to increase consumer awareness of nutritional information and promote healthier choices, but also suggests that the impact of health logos on consumer behavior requires further investigation and possibly a design specifically tailored to menus will be required. This study's results highlighted participants' interest in specific types of health logos on menus, with a focus on nutrient profile ratings and logos suggesting nutrients to be limited or encouraged in the diet. A quasi-experimental trial in France implemented the Nutri-Score system, a summary graded coloured system, in catering and found a significant reduction in the intake of calories, sugars, and saturated fats among participants [25]. Similarly, an Australian study demonstrated the feasibility of applying the Health Star Rating system to restaurant foods [26]. These studies and results provide valuable insights for policymakers and restaurant owners in designing effective menu labelling systems that align with consumers' interests and needs.

Interestingly, the significance of healthy food options and perceptions of health logos varied based on respondents' age, gender, education level, and dietary restrictions. For example, participants with higher education levels (university or post-graduate degree) were more likely to emphasize the importance of healthy food options, indicating a positive association between education and health-conscious choices, which was shown in many previous studies [27,28]. Additionally, female participants displayed a higher agreement with the importance of healthy food options and were more likely to support the implementation of FOPL-style health logos than males, suggesting potential gender differences in health-related preferences in the restaurant setting, echoing those found in previous nutrition behavior research [29]. These differences underscore the importance of targeted interventions and tailored communication strategies for different demographic groups.

Moreover, the potential impact of menu labelling on consumer behavior is complex. While the majority of participants agreed that warning labels would effectively inform consumers about the nutritional profile of food, most participants expressed neutrality in whether they were likely to eat at a restaurant displaying labels on the menu. This suggests that menu labelling alone might not be sufficient to drive significant changes in dining out habits. The U.K. has published sodium guidelines for the eating out, takeaway, and delivery sectors by 2024 [30]. Canada has its sodium target for packaged foods but have not yet extended to the food service sector [31]. Therefore, thorough nutrition guidelines and regulations targeting the restaurant foods will also be necessary so that healthier options are available for consumers.

Furthermore, the willingness to pay a higher price for a meal to avoid menu items with warning labels was very low, indicating that price remains a significant factor in dining out decisions, even in the presence of health-related information. This could be concerning as poor diet quality is particularly evident among Canadians with a lower socioeconomic status [32]. Even if warning labels are presented on unhealthy menu items, lower-income consumers may still purchase them if healthier options are more expensive. Therefore, equity-oriented policies that improve economic security would be more beneficial than information-based nutrition policies in these scenarios.

Overall, these results provide valuable insights into restaurant behaviors and preferences, emphasizing the need for a comprehensive approach to promote healthier dining out choices. While menu labelling initiatives hold promise, they should be complemented with other strategies, such as public awareness campaigns, menu reformulation, and collaborations with the food industry, to achieve meaningful and sustained changes in consumer behavior. Understanding the varying preferences and motivations across demographic groups will be crucial in developing effective and targeted interventions. Policymakers and restaurant owners can utilize these findings to better align their offerings with consumer needs and contribute to a healthier dining out environment. Future research can delve deeper into understanding the barriers to and facilitators of healthy dining out choices and evaluate the long-term impact of menu labelling initiatives on consumer behavior and public health outcomes.

This study has some limitations. Firstly, the sample was drawn from the general population of Canada and was limited to adults who were able to answer questionnaires in English or French, which may limit the generalizability of the findings to children/adolescents and to minority groups who do not communicate in English/French. Secondly, dietary behaviors were collected retrospectively, and self-reported data are subject to recall and response biases. This study examined consumer perceptions and may not represent actual behavioral changes in food purchases and consumptions associated with menu labels.

5. Conclusions

This study assessed the potential application of FOPL-style health logos in the food service sector and the data collected from the survey questionnaire provide insights into participants' perceptions, preferences, and behaviors related to health logos on restaurant menus. Although participants do think it is important to have healthy food options

available when dining out, a much lower number of participants think health logos will affect their choices of restaurants/foods. The two main reasons could be that 1. food away from home is not the major component of their diet and 2. taste, price, and convenience are the most important factors when dining out. This study highlights that FOPL-style health logos in the food services sector may not be sufficient and that more multidisciplinary strategies will be necessary to improve the dietary intake of Canadians.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu16040545/s1, Supplementary Table S1. Participant responses stratified by age group, gender, marital status, education, income, dietary restrictions and eating out frequency.

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References

1. Murray, C.J.L.; Aravkin, A.Y.; Zheng, P.; Abbafati, C.; Abbas, K.M.; Abbasi-Kangevari, M.; Abd-Allah, F.; Abdelalim, A.; Abdollahi, M.; Abdollahpour, I.; et al. Global Burden of 87 Risk Factors in 204 Countries and Territories, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *Lancet* **2020**, *396*, 1223–1249. [CrossRef] [PubMed]
2. Lobczowska, K.; Banik, A.; Romaniuk, P.; Forberger, S.; Kubiak, T.; Meshkovska, B.; Neumann-Podczaska, A.; Kaczmarek, K.; Scheidmeir, M.; Wendt, J.; et al. Frameworks for Implementation of Policies Promoting Healthy Nutrition and Physically Active Lifestyle: Systematic Review. *Int. J. Behav. Nutr. Phys. Act.* **2022**, *19*, 16. [CrossRef] [PubMed]
3. Yi, S.S.; Lee, M.; Russo, R.; Li, Y.; Trinh-Shevrin, C.; Kwon, S.C. Dietary Policies and Programs: Moving Beyond Efficacy and Into "Real-World" Settings. *Health Equity* **2021**, *5*, 194–202. [CrossRef] [PubMed]
4. World Health Organization. Guiding Principles and Framework Manual for Front-of-Pack Labelling for Promoting Healthy Diet. Available online: https://www.who.int/nutrition/publications/policies/guidingprinciples-labelling-promoting-healthydiet/en/ (accessed on 23 July 2023).
5. World Cancer Research Fund International Building Momentum: Lessons on Implementing a Robust Front-of-Pack Food Label. Available online: https://www.wcrf.org/wp-content/uploads/2021/03/PPA-Building-Momentum-2-WEB.pdf (accessed on 22 July 2023).
6. Government of Canada. Canada Gazette, Part II. Volume 156, No. 15. Available online: https://canadagazette.gc.ca/rp-pr/p2/2022/2022-07-20/html/sor-dors168-eng.html (accessed on 17 February 2023).
7. Ikonen, I.; Sotgiu, F.; Aydinli, A.; Verlegh, P.W.J. Consumer Effects of Front-of-Package Nutrition Labeling: An Interdisciplinary Meta-Analysis. *J. Acad. Mark. Sci.* **2020**, *48*, 360–383. [CrossRef]
8. Croker, H.; Packer, J.; Russell, S.J.; Stansfield, C.; Viner, R.M. Front of Pack Nutritional Labelling Schemes: A Systematic Review and Meta-analysis of Recent Evidence Relating to Objectively Measured Consumption and Purchasing. *J. Hum. Nutr. Diet.* **2020**, *33*, 518–537. [CrossRef] [PubMed]
9. Song, J.; Brown, M.K.; Tan, M.; MacGregor, G.A.; Webster, J.; Campbell, N.R.C.; Trieu, K.; Ni Mhurchu, C.; Cobb, L.K.; He, F.J. Impact of Color-Coded and Warning Nutrition Labelling Schemes: A Systematic Review and Network Meta-Analysis. *PLoS Med.* **2021**, *18*, e1003765. [CrossRef] [PubMed]
10. Global Food Research Program Front-of-Package Labeling. Available online: https://www.globalfoodresearchprogram.org/resource/front-of-package-label-maps/ (accessed on 24 July 2023).

11. Rincón-Gallardo Patiño, S.; Zhou, M.; Da Silva Gomes, F.; Lemaire, R.; Hedrick, V.; Serrano, E.; Kraak, V.I. Effects of Menu Labeling Policies on Transnational Restaurant Chains to Promote a Healthy Diet: A Scoping Review to Inform Policy and Research. *Nutrients* **2020**, *12*, 1544. [CrossRef] [PubMed]
12. Kiszko, K.M.; Martinez, O.D.; Abrams, C.; Elbel, B. The Influence of Calorie Labeling on Food Orders and Consumption: A Review of the Literature. *J. Community Health* **2014**, *39*, 1248–1269. [CrossRef] [PubMed]
13. Long, M.W.; Tobias, D.K.; Cradock, A.L.; Batchelder, H.; Gortmaker, S.L. Systematic Review and Meta-Analysis of the Impact of Restaurant Menu Calorie Labeling. *Am. J. Public. Health* **2015**, *105*, e11–e24. [CrossRef] [PubMed]
14. Sinclair, S.E.; Cooper, M.; Mansfield, E.D. The Influence of Menu Labeling on Calories Selected or Consumed: A Systematic Review and Meta-Analysis. *J. Acad. Nutr. Diet.* **2014**, *114*, 1375–1388.e15. [CrossRef] [PubMed]
15. Alexander, E.; Rutkow, L.; Gudzune, K.A.; Cohen, J.E.; McGinty, E.E. Sodium Menu Labelling: Priorities for Research and Policy. *Public. Health Nutr.* **2021**, *24*, 1542–1551. [CrossRef] [PubMed]
16. Government of Canada. Labelling Requirements. Available online: https://www.canada.ca/en/services/business/permits/federallyregulatedbusinessactivities/labellingrequirements.html (accessed on 24 July 2023).
17. Government of Ontario. Healthy Menu Choices Act. Available online: https://www.ontario.ca/page/calories-menus (accessed on 15 April 2023).
18. Statistics Canada. Eating Out—How Often and Why [Stats in Brief: 11-627-M2019003]. Available online: https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2019004-eng.htm (accessed on 15 April 2023).
19. Statistics Canada. Stats Are on the Menu! Canada's Restaurant Industry. Available online: https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021025-eng.pdf (accessed on 15 April 2023).
20. Yang, Y.; Weippert, M.; Ahmed, M.; L'Abbé, M.R. Cross-Sectional Nutritional Information and Quality of Canadian Chain Restaurant Menu Items in 2020. *Am. J. Prev. Med.* **2023**, *64*, 42–50. [CrossRef] [PubMed]
21. Government of Canada Health. Canada's Healthy Eating Strategy. Available online: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating-strategy.html#a1 (accessed on 10 August 2023).
22. Close, M.A.; Lytle, L.A.; Viera, A.J. Is Frequency of Fast Food and Sit-down Restaurant Eating Occasions Differentially Associated with Less Healthful Eating Habits? *Prev. Med. Rep.* **2016**, *4*, 574–577. [CrossRef] [PubMed]
23. Penney, T.L.; Jones, N.R.V.; Adams, J.; Maguire, E.R.; Burgoine, T.; Monsivais, P. Utilization of Away-From-Home Food Establishments, Dietary Approaches to Stop Hypertension Dietary Pattern, and Obesity. *Am. J. Prev. Med.* **2017**, *53*, e155–e163. [CrossRef] [PubMed]
24. Canadian Foundation for Dietetic Research Tracking Nutrition Trends 2015. Available online: https://cfdr.ca/wp-content/uploads/2022/09/Tracking-Nutrition-Trends-IX-2015.pdf (accessed on 9 August 2023).
25. Julia, C.; Arnault, N.; Agaësse, C.; Fialon, M.; Deschasaux-Tanguy, M.; Andreeva, V.A.; Fezeu, L.K.; Kesse-Guyot, E.; Touvier, M.; Galan, P.; et al. Impact of the Front-of-Pack Label Nutri-Score on the Nutritional Quality of Food Choices in a Quasi-Experimental Trial in Catering. *Nutrients* **2021**, *13*, 4530. [CrossRef] [PubMed]
26. Dunford, E.K.; Wu, J.H.Y.; Wellard-Cole, L.; Watson, W.; Crino, M.; Petersen, K.; Neal, B. A Comparison of the Health Star Rating System When Used for Restaurant Fast Foods and Packaged Foods. *Appetite* **2017**, *117*, 1–8. [CrossRef] [PubMed]
27. Azizi Fard, N.; De Francisci Morales, G.; Mejova, Y.; Schifanella, R. On the Interplay between Educational Attainment and Nutrition: A Spatially-Aware Perspective. *EPJ Data Sci.* **2021**, *10*, 18. [CrossRef]
28. Raghupathi, V.; Raghupathi, W. The Influence of Education on Health: An Empirical Assessment of OECD Countries for the Period 1995–2015. *Arch. Public Health* **2020**, *78*, 20. [CrossRef] [PubMed]
29. Wardle, J.; Haase, A.M.; Steptoe, A.; Nillapun, M.; Jonwutiwes, K.; Bellisie, F. Gender Differences in Food Choice: The Contribution of Health Beliefs and Dieting. *Ann. Behav. Med.* **2004**, *27*, 107–116. [CrossRef] [PubMed]
30. Public Health England Salt Reduction Targets for 2024. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/915406/2024_salt_reduction_targets_070920-FINAL-1.pdf (accessed on 10 August 2023).
31. Health Canada. Voluntary Sodium Reduction Targets for Processed Foods 2020–2025. 2020. Available online: https://www.canada.ca/en/health-canada/services/publications/food-nutrition/sodium-reduced-targets-2020-2025.html (accessed on 15 April 2023).
32. Olstad, D.L.; Campbell, N.R.C.; Raine, K.D. Diet Quality in Canada: Policy Solutions for Equity. *CMAJ* **2019**, *191*, E100–E102. [CrossRef] [PubMed]

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Differences in the Values and Related Factors of Eating a Balanced Meal among the Younger Generation in Japan

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Abstract: This study examined young Japanese adults' values regarding the consumption of balanced meals consisting of staples, main dishes, and side dishes and how these values relate to demographics, socioeconomic status, nutrition knowledge, attitudes, skills, behaviors, and diet-related quality of life. Data were obtained from the "Survey on Dietary Habits of the Younger Generation" (2000 responses, ages 18–39), of which 1888 valid responses were analyzed. The principal component analysis identified three value patterns: PC1—valuable yet burdensome; PC2—environment-reliant, weak initiative; and PC3—low value due to hassle. Both PC1 and PC3 were associated with prioritizing prices in food choices and knowledge of a balanced meal. However, PC1 participants valued balanced meals and possessed meal preparation skills, whereas PC3 participants valued balanced meals less and had negative attitudes toward eating them. PC1 was positively associated with the frequency of eating balanced meals while PC3 was negatively associated. PC2 individuals had positive attitudes toward eating balanced meals but were less concerned about nutritional balance when choosing foods themselves. This study highlights the importance of adopting an approach that aligns with the value patterns of the target population.

Keywords: values; motivations; dietary behaviors; healthy eating; young adults; Japan

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1. Introduction

Healthy eating is vital in preventing non-communicable diseases. Poor diet, overweight, and obesity are major risk factors for diabetes, cardiovascular disease, and cancer [1]. Adherence to healthy eating patterns, such as the Mediterranean Diet, Healthy Eating Index, or Dietary Approaches to Stop Hypertension, is associated with lower mortality risks among adults [2,3]. Adherence to the Japanese Food Guide Spinning Top, which recommends having a balanced meal consisting of staples, main dishes, and side dishes, is also known to lower the total and cerebrovascular mortality risks [4] and frailty risks [5] among middle-aged and older Japanese adults.

Research has identified that young adults globally have poor diet quality compared to other adults [6–9], with high consumption of ultra-processed foods [6] and low intake of fruits and vegetables [7] and whole grains [8]. Furthermore, early adulthood is a period associated with poor eating habits and rapid weight gain. This is because early adulthood is a transitional period that includes environmental, social, and lifestyle changes that may affect dietary changes [10]. Leaving home and education are associated with negative dietary changes. Therefore, further research is needed to identify and understand specific segments within the young adult age group, which is particularly prone to dietary changes, to develop tailored strategies for promoting balanced diets. Encouraging a healthy diet from an early age is essential for overall well-being [11]. Individual lifestyle patterns that develop during this transition often persist later in life. Although this age group is prone to dietary changes due to life events such as marriage and parenting, which may have health implications [12], young people's health has often been neglected in global public health because this age group is perceived as healthy and is difficult to reach.

To improve dietary intake, it is necessary to explore the determinants of dietary behavior and their influence on diet quality. Diet changes over time, and food preparation behaviors persist. Involvement in food preparation during the early stages of adulthood has been linked to healthier dietary intake in the mid-to-late twenties [13]. However, individuals' dietary behaviors are influenced by various factors, including intrapersonal factors (e.g., age, sex, education, lifestyle, motivation, knowledge, skills, and appetite), interpersonal factors (e.g., family support, social occasion, culture or traditions, and dietary patterns of friends or family), and environmental factors (e.g., food cost, food accessibility and availability, and media) [14–16]. Financial concerns are frequently reported as barriers to healthy eating [14]. Specifically, for youths, social media use is an important determinant of dietary behavior. A systematic review indicated that young adults seemed receptive to healthy eating and recipe tips through social media [17]. Encouraging consumer demand for healthy foods and diets through nutrition education and developing healthy food environments, including social media, are important.

Eating meals consisting of staples, main dishes, and side dishes at least twice a day is associated with better nutrient and food group intake and a higher likelihood of meeting the Dietary Reference Intakes for the Japanese [18]. In Japan, as part of the national health promotion initiatives, consuming such meals twice or more daily, almost daily, is an important objective. However, <40% of the adult population is engaged in this practice, and the figure is even lower among the younger population aged 20–39 years, falling below 30% [19]. To achieve this goal, it is crucial to understand the factors hindering desirable dietary behaviors and consider specific measures accordingly. While many previous studies have reported on dietary behaviors, attitudes, and socioeconomic factors related to the frequency of consuming meals with staples, main dishes, and side dishes [20–33], these studies have mostly focused only on behavioral aspects. Therefore, evidence of the differences underlying people's values behind such behaviors is limited.

Factors reported to be related to the frequency of eating a combination of staples, main dishes, and side dishes include demographics [30,33], financial resources [20,25,28], education [28], health awareness [23,31,32], knowledge [27,32], cooking frequency [22,31] preference [27], dietary behaviors including skipping meals [30,33], and eating out [24,30]. However, no studies have evaluated the values toward eating a balanced meal and how such values are associated with individual factors. Therefore, clarifying the core components of the specific patterns of the younger generation's values toward eating a balanced meal and its related factors could be a valuable resource for considering an approach that matches the value patterns of the target population. Therefore, this study aimed to elucidate the core components and patterns of the younger generation's perceived value of eating a balanced meal. In addition, this study examined the factors associated with the identified value patterns, such as sociodemographic factors, food knowledge, attitudes, skills, behaviors, and diet-related quality of life.

2. Materials and Methods

2.1. Survey Methodology and Participants

We reanalyzed the data from the "Survey on Dietary Habits of Younger Generations" conducted by the Ministry of Agriculture, Forestry, and Fisheries [34]. This cross-sectional survey included 2000 responses from individuals aged 18–39 years living nationwide. The survey was conducted online in November 2019 using monitors from Cross Marketing Inc. (Tokyo, Japan). Cross Marketing Inc., a professional marketing research company, has one of the largest active registered panels in Japan, with over 5 million people, including panels registered with partner companies [35]. The survey had a target sample size of 2000 individuals (1000 males and 1000 females). Allocation by sex, age, and area of residence was determined according to the results of national census data [34]. Students were excluded because of their different lifestyles. In addition, those who had received special nutrition and culinary arts training were excluded to avoid response bias.

Before analysis, permission for data use was obtained from the government. After excluding incomplete responses, 1888 responses were analyzed.

2.2. Measures

We used data on sociodemographic and anthropometric variables, perceived values of eating a balanced meal, dietary knowledge, attitudes, skills, behaviors, and diet-related quality of life.

2.2.1. Sociodemographic and Anthropometric Variables

The sociodemographic variables collected included demographics (age, sex, living status, marital status, and living with children) and socioeconomic characteristics (occupation, education, and household economic status). Anthropometric characteristics included body mass index (BMI), calculated based on the self-reported height and weight of the participants.

2.2.2. Perceived Values Regarding Eating a Balanced Meal

A 12-item questionnaire was used to examine the participants' perceived values regarding eating a balanced meal (a combination of staples, main dishes, and side dishes), as shown in Table 1. The participants rated the items on a 7-point Likert scale (1, not applicable at all; 7, very applicable). Participants were asked, "Please indicate the extent to which the following statements apply to your opinion of eating a combination of staples, main dishes, and side dishes, using a rating of 1 to 7 points". Cronbach's alpha for the 12 items was 0.900.

Table 1. Characteristics of participants.

		n	%
Sociodemographic and anthropometric variables			
Age		29.7 ± 6.2	
Sex	male	960	50.8
	female	928	49.2
Living status	living alone	516	27.3
	living with others	1372	72.7
Marital status	single	1230	65.1
	married	658	34.9
Living with children	no	1417	75.1
	yes	471	24.9
Occupation	full-time employee/civil servant	999	52.9
	part-time job	350	18.5
	freelance/self-employed	71	3.8
	housewives/unemployed	217	11.5
	others (not specified)	251	13.3
Education	junior or senior high school	732	38.8
	junior college or vocational school	342	18.1
	college, university, graduate school	814	43.1
Household economic status	Financially constrained, causing significant distress	303	16.0
	Financial constrained, accompanied by some concern	621	32.9
	Financially constrained, yet little worrisome	781	41.4
	Financially secure, living worry-free	183	9.7
Body Mass Index (kg/m^2)		21.5 ± 3.5	
BMI categories	underweight (BMI < 18.5)	365	19.3
	normal (BMI 18.5–24.9)	1266	67.1
	obese (25.0 ≤ BMI)	257	13.6

Mean ± standard deviation.

2.2.3. Dietary Knowledge, Attitudes, Motivations for Food Choices, and Skills

Dietary knowledge regarding the consumption of a combination of staples, main dishes, and side dishes was assessed using a single item. Participants were asked, "Do you know what a "meal consisting of a combination of staples, main dishes and side dishes" is?". Subsequently, they selected one of three answers (1: I know both the term and its meaning; 2: I do not know the meaning, but I have heard the term; and 3: I do not know the term or its meaning).

Regarding dietary attitudes, we assessed two items. First, we assessed the participants' attitudes toward practicing healthy eating habits. Participants were asked, "Are you committed to practicing a healthy diet regularly?". They rated their commitment on a 4-point Likert scale (1, not at all; 4, always). Second, participants were asked about eating a combination of staples, main dishes, and side dishes daily: "Please indicate how much of the following applies to your daily dietary habits by rating them from 1 to 7". They rated the items on a 7-point Likert scale (1, not applicable at all; 7, very applicable). The following 10 items were used to assess participants' motivations for food choices: nutritional balance, energy (calories), taste, price, seasonality, safety, appearance, word-of-mouth, popularity, and image of the manufacturer or store. Participants were asked ahead of each item, "Please indicate how much of the following applies to what you consider important when cooking or choosing meals in your daily life". They rated the items on a 7-point Likert scale (1, not applicable at all; 7, very applicable).

Dietary skills were determined based on the following five items: considering the balance of nutrition and taste when planning a menu; knowing what ingredients and utensils are needed for preparing meals; reading nutrition labels and making food selections; ability to prepare most dishes; and ability to prepare meals in a short time, even when busy. Participants were asked ahead of each item, "Please rate the extent to which the following applies to your meal preparation knowledge and skills". They rated the items on a 7-point Likert scale (1, not applicable at all; 7, very applicable).

2.2.4. Dietary Behavior and Diet-Related Quality of Life

Regarding the dietary behavior of eating a combination of staples, main dishes, and side dishes, participants were asked, "In your daily life, how many days of the week do you eat a combination of staples, main dishes, and side dishes at least twice a day?". They then selected one of the following four answers: (1) almost never, (2) 2 or 3 days a week, (3) 4 to 5 days a week, or (4) almost every day.

Diet-related quality of life was assessed using the subjective diet-related quality of life (SDQOL) measure, a validated four-item scale [36]. The SDQOL is composed of four items ("I enjoy mealtimes", "I am eager for mealtimes to come", "My meals are eaten in a positive atmosphere", and "I am satisfied with my daily diet"). Responses were provided on a 5-point Likert scale (1, disagree; 5, agree). Cronbach's alpha for the 12 items was 0.829.

2.3. Ethics Approval

The survey was administered online by Cross Marketing Inc. (Tokyo, Japan). All participants were informed that the questionnaire was given for research purposes and that their participation was completely voluntary. Because the data were collected anonymously using an online questionnaire without including personal data, written informed consent was not required. The study protocol was approved by the Ethics Committee of Kagawa Nutrition University (Saitama, Japan; approval number: 291; approval date: 17 May 2023).

2.4. Statistical Analysis

Using principal component analysis, we identified the value patterns of consuming a balanced meal from the 12 surveyed items. Multiple regression analysis was used to explore independent factors associated with these patterns.

The patterns of the participants' perceptions regarding the consumption of staples, main dishes, and side dishes were analyzed as follows. Principal component analysis (PCA)

with varimax rotation, including 12 items, was conducted to facilitate the interpretation of each component. The varimax rotation technique is a type of orthogonal rotation technique that results in uncorrelated components to ease the interpretation underlying the phenomenon being captured by each component [37]. Therefore, in our analyses, we used varimax rotation. Three principal components with eigenvalues > 1 were identified, and the cumulative contribution ratio was 75.1%. To identify a component as meaningful, the cumulative variance-extracted components must encompass at least 70% of the dataset's variance [38]. Considering up to the third principal component, the principal component scores were calculated to have a mean of 0 and a variance of 1. The higher the principal component score, the higher the loadings of each of the items that make up the pattern; thus, it is an indicator of the characteristics of the composition of the pattern [38]. Following this, items displaying factor loadings beyond ± 0.4 were scrutinized as having significant interpretive loadings [38]. Based on their characteristics, type names were assigned to each component. Sample validity was verified using the Kaiser–Meyer–Olkin measure of sampling adequacy (KMO measure), yielding a KMO measure of 0.879, confirming its validity.

Simple and multiple linear regression models with stepwise methods were used to describe the characteristics of each principal component pattern. The component scores were used as the dependent variables. The independent variables were sociodemographic characteristics, dietary knowledge, attitudes, motivations for food choices, skills, behaviors, and diet-related quality of life.

All analyses were performed using the IBM SPSS Statistics software version 27.0 (IBM Corp, Armonk, NY, USA).

3. Results

3.1. Participant Profile

Table 1 displays the means and standard deviations of the participants' demographic and anthropometric variables. Among the 1888 participants, 50.8% were male, with an average age of 29.7 years (SD = 6.2). Regarding living status, 27.3% of the participants lived alone. Approximately two of three participants were single (65.1%) and did not have children (75.1%). According to educational attainment, the predominant form of education was higher education, encompassing degrees beyond the college or university level. Most participants experienced varying degrees of financial constraint, with only 9.7% reporting financial security and worry-free lifestyles. Most participants were within the normal range (BMI, 18.5–24.9); however, 19.3% were underweight (BMI < 18.5) and 13.6% were obese ($25.0 \leq$ BMI).

Table 2 shows participants' profiles regarding dietary knowledge, attitudes, skills, behaviors, and diet-related quality of life. At the level of knowledge regarding eating a combination of staples, main dishes, and side dishes, nearly half of the participants (46.3%) demonstrated an understanding of both the terminology and its meaning; however, more than half of the participants lacked an understanding of the meaning (53.6%). Among the food choice motives, "taste" scored the highest (4.9 ± 1.5), followed by "price" (4.8 ± 1.5). However, a very small proportion of participants (7.5%) always prioritized the practice of healthy eating habits. Regarding eating behaviors, approximately one of four participants (24.8%) reported consuming a combination of staples, main dishes, and side dishes twice or more daily, almost every day. Alternatively, a similar percentage of respondents (26.3%) indicated that they rarely do so.

Table 2. Dietary knowledge, attitudes, skills, and behaviors and diet-related quality of life.

		n	%
Knowledge	Regarding eating a combination of staples, main dishes and side dishes		
	I do not know the term or its meaning	289	15.3
	I do not know the meaning, but I have heard the term	724	38.3
	I know both the term and its meaning	875	46.3
Attitude	Toward practicing healthy eating habits		
	not at all	199	10.5
	not so much	794	42.1
	sometimes	753	39.9
	always	142	7.5
	Toward eating a combination of staples, main dishes and side dishes on daily basis (1: not applicable at all, to 7: very applicable)	4.1 ± 1.5	
Motivations for food choices (1: not applicable at all, to 7: very applicable)			
	nutritional balance	4.2 ± 1.6	
	energy (calories)	4.0 ± 1.5	
	taste	4.9 ± 1.5	
	price	4.8 ± 1.5	
	seasonality	4.0 ± 1.5	
	safety	4.4 ± 1.5	
	appearance	4.1 ± 1.5	
	word-of-mouth	3.5 ± 1.6	
	popularity	3.4 ± 1.6	
	good manufacturer or store brand image	3.5 ± 1.5	
Skills (1: not applicable at all, to 7: very applicable)			
	considering the balance of nutrition and taste when planning a menu	3.8 ± 1.6	
	knowing what ingredients and utensils are needed for preparing meals	4.1 ± 1.6	
	reading nutrition labels and making food selections	3.8 ± 1.6	
	ability to prepare most dishes	4.0 ± 1.8	
	ability to prepare meals in a short time, even when busy	3.8 ± 1.6	
Behaviors	Eating a combination of meals at least twice a day		
	almost never	497	26.3
	two to three days a week	494	26.2
	four to five days a week	428	22.7
	almost everyday	469	24.8
Diet-related QOL	SDQOL (4~20 points)	13.7 ± 3.5	

Mean ± standard deviation. QOL: quality of life, SDQOL: subjective diet-related quality of life.

3.2. Principal Component Analysis of Perceptions Regarding Eating a Balanced Meal

We analyzed 12 measures of the participants' perceptions regarding eating a combination of staples, main dishes, and side dishes using principal component analysis with varimax rotation. The three components had eigenvalues > 1.0, accounting for 75.1% of the total item variance. The Kaiser–Meyer–Olkin measure of sampling adequacy was high (KMO = 0.879).

As shown in Table 3, the first component was labeled "Valuable yet burdensome" (PC1: Eigenvalue = 5.85, 48.7% item variance). PC1 had high positive loadings (0.828–0.878) for three components that considered a balanced meal healthy, nutritious, and fulfilling for participants. In addition, it had moderately positive loadings (0.429–0.733) regarding positive attitudes toward eating if meals were prepared or if someone was eating them. However, it also had moderately positive loadings (0.483–0.544) for feeling the burden of preparation and adoption. The second component was labeled 'environment-reliant, weak initiative' (PC2: Eigenvalue = 1.90, 15.8% item variance). This component showed moderate to high positive loadings (0.662–0.872) on items such as meals participants would use if they were available or easily purchased. The third component was labeled "Low value due to hassle" (PC3: Eigenvalue = 1.26, 10.5% item variance). PC3 had high positive loadings (0.687–0.791) for three components regarding burden: preparing a balanced meal wastes time, is troublesome, and is costly. Although the factor loadings were small, there

were negative loadings for eating a balanced meal to build relationships with others or eating when others eat.

Table 3. Factor loadings of the 12 components regarding participants' perceived values of eating a combination of staples, main dishes, and side dishes through principal component analysis with varimax rotation.

	PC1	PC2	PC3
I think it is good for our health.	**0.878**	0.090	0.285
I think that it improves nutritional balance.	**0.877**	0.068	0.299
It helps to feel that I am living a fulfilling life.	**0.828**	0.241	0.127
If such meal is prepared, I would like to proactively adopt it.	**0.733**	0.301	0.289
It helps to facilitate communication with family members.	**0.572**	**0.488**	−0.182
If there are places where such meals can be purchased or eaten near my home or commute route, I would like to incorporate them.	0.109	**0.872**	0.185
If there is a service that delivers such meals at a reasonable price, I would be willing to adopt it.	0.059	**0.819**	0.243
If such meals are offered at a lower price at workplace, I would be willing to select it.	0.183	**0.803**	0.259
If I have someone to eat with, I'm willing to eat such meals.	**0.429**	**0.662**	−0.138
I feel that preparing such meals is a waste of time.	0.040	0.265	**0.791**
I feel that preparing such meals is troublesome.	**0.483**	0.088	**0.757**
I think that adopting such meals cost a lot money.	**0.544**	0.107	**0.687**
Eigenvalue	5.85	1.90	1.26
Explained variance (%)	48.73	15.85	10.52
Cumulative variance explained (%)	48.73	64.58	75.10

Kaiser–Meyer–Olkin (KMO): 0.879. PC1: Valuable yet burdensome, PC2: Environment-reliant, weak initiative, and PC3: Low value due to hassle. Factor loadings exceeding +0.40 or falling below −0.40 are highlighted in bold.

3.3. Factors Associated with Participants' Perception Patterns Regarding Eating a Balanced Meal

Table 4 shows the linear regression coefficients from simple and multiple analyses, examining factors associated with participants' perception patterns regarding eating a balanced meal. The multiple linear regression analysis reveals that factors associated with the PC1 pattern include being female ($\beta = 0.040$, $p < 0.05$), being married ($\beta = 0.052$, $p < 0.01$), having sufficient knowledge ($\beta = 0.091$, $p < 0.001$), having a positive attitude ($\beta = 0.090$, $p < 0.001$), and possessing skills for preparing meals ($\beta = 0.114$, $p < 0.001$). Additionally, food choice motives such as taste ($\beta = 0.259$, $p < 0.001$) and price ($\beta = 0.199$, $p < 0.001$) were positively associated with this pattern, while participants were less likely to consider popularity ($\beta = -0.110$, $p < 0.001$) and word-of-mouth ($\beta = -0.079$, $p < 0.001$) when choosing foods. The adjusted R^2 was 0.411 in the multiple model.

Analysis of the PC2 pattern revealed negative associations with sociodemographic variables and food-choice motives. Individuals who had higher component scores for this pattern were more likely to be young ($\beta = -0.060$, $p < 0.01$), male ($\beta = -0.070$, $p < 0.001$), living alone ($\beta = -0.077$, $p < 0.001$), and have lower motives for nutritional balance ($\beta = -0.116$, $p < 0.001$) and taste ($\beta = -0.056$, $p < 0.05$) when selecting foods. On the other hand, individuals in this pattern showed higher scores for attitudes toward eating a balanced meal ($\beta = 0.105$, $p < 0.001$) and higher concerns for selecting foods with good manufacturer or store brand image ($\beta = 0.240$, $p < 0.001$) or popularity ($\beta = 0.142$, $p < 0.001$). The adjusted R^2 was 0.268 for the multiple models.

Lastly, the linear regression analysis for the PC3 pattern demonstrated a positive association with age ($\beta = 0.052$, $p < 0.05$) and knowledge ($\beta = 0.095$, $p < 0.001$) but a negative association with household economic status ($\beta = -0.065$, $p < 0.01$) and attitudes toward eating a balanced meal ($\beta = -0.142$, $p < 0.001$). In terms of food choice motives, this pattern was more likely to be concerned with price ($\beta = 0.298$, $p < 0.001$) and taste ($\beta = 0.103$, $p < 0.001$) but less concerned with seasonality ($\beta = -0.168$, $p < 0.001$). The adjusted R^2 was 0.195 for multiple models.

Table 4. Linear regression coefficients (β) from simple and multiple analyses examining perception patterns in relation to participants' sociodemographics and anthropometric variables, knowledge, attitudes, skills, behaviors, and diet-related QOL among young Japanese adults.

	PC1: Valuable Yet Burdensome		PC2: Environment-Reliant, Weak Initiative		PC3: Low Value due to Hassle	
	Simple	Multiple	Simple	Multiple	Simple	Multiple
Sociodemographic and anthropometric variables						
Age	0.053 *	-	−0.052 *	−0.060 **	0.009	0.052 *
Sex (1: Male, 2: Female)	0.150 ***	0.040 *	−0.062 **	−0.070 ***	−0.018	-
Living status (1: living alone, 2: living with others)	0.118 ***	-	−0.036	−0.077 ***	−0.089 ***	-
Marital status (1: single, 2: married)	0.149 ***	0.052 **	0.043	0.056 *	−0.121 ***	−0.083 ***
Living with children (1: no, 2: yes)	0.105 ***	-	0.027	-	−0.062 **	-
Occupation 1 (1: full-time employee/civil servant, 0: all other)	−0.048 *	-	0.084 ***	-	−0.020	-
Occupation 2 (1: part-time job, 0: all other)	0.016	-	−0.034	-	0.009	-
Occupation 3 (1: freelance/self-employed, 0: all other)	−0.009	-	0.011	-	0.016	-
Occupation 4 (1: housewives/unemployed, 0: all other)	0.134 ***	-	−0.013	-	−0.052 *	-
Education (1: junior or senior high school, 2: junior college or vocational school, 3: college, university or graduate school)	0.030	-	0.040	-	−0.076 ***	-
Household economic status (1: Financially constrained, causing significant distress~4: Financially secure, living worry-free)	0.045	-	0.044	-	−0.160 ***	−0.065 **
Body Mass Index	−0.047 *	-	0.045	0.048 *	0.006	-
Knowledge (1: I don't know the term or its meaning, to 3: I know both the term and its meaning)						
Regarding eating a combination of staple food, main dishes, and side dishes	0.297 ***	0.091 ***	0.050 *	-	0.045	0.095 ***
Attitudes						
Toward practicing healthy eating habits (1: not at all, to 4: always)	0.197 ***	-	0.105 ***	-	−0.132 ***	−0.054 *
Toward eating a combination of staple food, main dish and side dishes on daily basis (1: not applicable at all, to 7: very applicable)	0.360 ***	0.090 ***	0.294 ***	0.105 ***	−0.175 ***	−0.142 ***
Motivations for food choices (1: not applicable at all, to 7: very applicable)						
nutritional balance	0.363 ***	-	0.255 ***	−0.116 **	−0.098 ***	-
energy (calories)	0.248 ***	-	0.314 ***	0.075 *	−0.062 **	-
taste	0.538 ***	0.259 ***	0.088 ***	−0.056 *	0.110 ***	0.103 ***
price	0.479 ***	0.199 ***	0.091 ***	-	0.228 ***	0.298 ***
seasonality	0.322 ***	0.053 *	0.344 ***	0.104 ***	−0.141 ***	−0.168 ***
safety	0.383 ***	-	0.238 ***	-	−0.025	-
appearance	0.316 ***	-	0.295 ***	-	−0.059 *	-
word-of-mouth	0.074 **	−0.079 **	0.440 ***	-	−0.071 **	-
popularity	0.025	−0.110 ***	0.463 ***	0.142 ***	−0.079 ***	-
good manufacturer or store brand image	0.058 *	-	0.408 ***	0.240 ***	−0.066 **	0.061 *
Skills (1: not applicable at all, to 7: very applicable)						
considering the balance of nutrition and taste when planning a menu	0.287 ***	-	0.274 ***	-	−0.117 ***	-
knowing what ingredients and utensils are needed for preparing meals	0.365 ***	0.114 ***	0.190 ***	-	−0.035	-
reading nutrition labels and making food selections	0.229 ***	-	0.304 ***	0.097 ***	−0.056 *	-
ability to prepare most dishes	0.313 ***	-	0.219 ***	-	−0.058 *	-
ability to prepare meals in a short time, even when busy	0.263 ***	-	0.262 ***	-	−0.096 ***	-
Behaviors (1: almost never, to 4: almost every day)						
Eating a combination of staple foods, main dishes, and side dishes at least twice a day	0.212 ***	0.043 *	0.067 **	-	−0.203 ***	−0.122 ***
Diet-related QOL						
SDQOL (4~20 points)	0.343 ***	0.138 ***	0.092 ***	-	−0.144 ***	−0.129 ***
Adjusted R^2		0.411		0.268		0.195

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Stepwise model. standardized regression coefficient (β). QOL: quality of life, SDQOL: subjective diet-related quality of life.

In terms of behavior, a higher frequency of eating a balanced meal was observed in the PC1 pattern ($\beta = 0.043$, $p < 0.05$), while a lower frequency was observed in the PC3 pattern ($\beta = -0.122$, $p < 0.001$). Furthermore, a higher SDQOL score was associated with PC1, while a lower score was observed in PC3. No significant association was observed with the PC2 pattern.

4. Discussion

4.1. Value Patterns and Related Factors

This study identified three patterns and components of perceived value among young adults regarding the consumption of a balanced meal consisting of staples, main dishes, and side dishes more than twice daily. Furthermore, we identified the independent factors associated with each pattern. Different characteristics were observed for each pattern. Individuals with high component scores in the PC1 pattern believed that eating a balanced meal was important for their health and wanted to incorporate it; however, they also felt a sense of burden. Despite facing time and financial constraints, individuals with high PC1 scores had a higher frequency of consuming a balanced meal in practice because they possessed the necessary knowledge, skills, and attitudes for meal planning. Those with higher PC2 component scores were more motivated to eat a balanced meal. However, nutritional balance and taste were not prioritized in their actual food choices, and there was no significant association with meal preparation skills. Consequently, there was no association with the frequency of eating balanced meals. Finally, individuals with higher PC3 scores who were less likely to value a balanced meal because of the hassle of cost, effort, and time investment were negatively associated with the practice of a balanced meal. In addition, those who scored higher in this pattern were found to lack financial comfort and to be more concerned with taste, price, and brand image when making food choices. To our knowledge, this is the first study to identify the core components and patterns of individuals' values regarding eating a balanced meal and how they relate to sociodemographic factors, dietary knowledge, attitudes, skills, behaviors, and SDQOL.

Positive values for eating a combination of staples, main dishes, and side dishes were predominantly observed in participants who followed the PC1 pattern. The participants were more likely to be female or married. They were also more concerned about eating a balanced meal daily and perceive such a lifestyle as more applicable. Generally, healthier food behaviors are associated with older age, higher education, and female sex [39]. Additionally, the participants who followed PC1 and PC2 perceived several benefits of eating a balanced meal in a social context. For example, it facilitates communication with family members and increases their willingness to eat if others are eating. However, participants in PC2 were more environmentally dependent and did not value eating a balanced meal as much as those in PC1, and food-choice motives were negatively associated with nutritional balance. Therefore, no significant association was observed between PC2 and eating balanced meals. Furthermore, for PC3, the value of a balanced meal within the social context found in PC1 and PC2 was negative, indicating a negative association. Our findings suggest that different value patterns may influence actual behavior. Therefore, we explore the potential factors associated with these value differences and consider their implications for promotion strategies.

Price was an independent predictor for both PC1 and PC3 and was positively associated with both patterns. For PC3, price showed the largest regression coefficient among the independent predictors. One possible reason for the differences in actual eating behavior is the existence of economic constraints. Among the three patterns, household economic status was an independent predictor only for PC3, indicating that it was associated with greater constraints. A previous study targeting younger adults aged 20–39 years reported that, regardless of educational attainment, a poor subjective financial status increases the risk of unhealthy dietary habits, including low frequency of eating a balanced meal [28]. The tendency to prioritize price as a motivation for food selection was demonstrated in PC1 and PC3, but it was more strongly associated with PC3. It has been reported that individu-

als with lower household incomes tend to prioritize price over factors such as nutritional value when making food choices, compared to those with higher incomes [20]. Therefore, the presence of economic constraints suggests that individuals might be hindered from maintaining nutritionally balanced meals.

Regarding paying attention to nutritional balance when making food choices, univariate analysis showed significant associations between PC1 and PC3. However, multivariate analysis did not reveal any significant associations. In the simple regression model, a positive association was observed with PC1, while a negative association was observed with PC3. However, for PC2, a positive association was indicated in the simple regression model, but it turned into a negative association in the multivariate analysis. One possible interpretation is the effect of adjusting for demographic characteristics. The demographic characteristics of PC2 included younger age and male sex. Additionally, individuals with higher BMI scores were more prevalent in this group. Females generally tend to make healthier food choices than men and are more concerned about healthy eating behaviors to maintain their physique [39]. Since those who had higher PC2 scores had a predominance of younger males and higher BMI scores, they may have been less concerned with nutritional balance.

Taste was positively associated with both PC1 and PC3. It is crucial in food selection, with innate preferences for basic tastes such as sweet and bitter. These tastes are present in both healthy and unhealthy foods. Although taste often guides food choices, its link to specific dietary patterns remains unclear. Research suggests that prioritizing taste over health can lead to unhealthy food choices [40]. PC1 individuals prioritized taste, aimed for a balanced meal, and consumed it more frequently. Belief about the taste of unhealthy foods affects responses to health messages [41]. Taste is a key factor in food choice across cultures. Therefore, promoting healthy eating should focus on taste rather than health messages.

Food literacy encompasses the knowledge, attitudes, and skills required for informed dietary decisions and health impacts [42], significantly enhancing overall well-being [43]. Vidgen and Gallegos defined food literacy as a collection of interrelated knowledge, skills, and behaviors required to plan, manage, select, prepare, and eat food to meet needs and determine intake [43]. Multivariate regression analysis confirmed positive associations of attitudes and skills with PC1 and PC2 but a negative association between attitudes and PC3. College students with better meal preparation skills prepared more meals, including staples, main dishes, and side dishes [21]. Cooking for oneself is correlated with higher diet quality, whereas consuming commercial meals is associated with poorer quality [9]. Pregnant females with meal knowledge also had greater confidence in their meal preparation skills and were more likely to eat meals with staples, main dishes, and side dishes every day [27]. Although knowledge was associated with PC3, it may also be related to age. However, as food literacy suggests, knowledge alone does not guarantee behavioral change. PC1's adoption of a favorable diet may stem from understanding balanced meals and maintaining positive attitudes. Therefore, fostering improved attitudes, skills, and confidence is crucial for behavioral changes.

Participants characterized by the PC3 pattern were less likely to consume a balanced meal consisting of staples, main dishes, and side dishes and exhibited lower SDQOL scores. A study involving adults aged 20 years and older found that those who adhered to a balanced meal reported a better subjective health status, regardless of demographic characteristics, time availability, or financial resources [29]. In our study, PC3 was negatively associated with SDQOL, even after adjusting for demographic variables and other factors. Conversely, PC1 exhibited a positive association, indicating a high frequency of balanced meal consumption. While causal relationships cannot be inferred due to the cross-sectional nature of this study, the findings suggest that individuals who felt burdened by adhering to a balanced meal did not practice such dietary habits, resulting in lower SDQOL scores.

4.2. Limitations

This study had some limitations that should be considered when interpreting the results. First, it was a secondary analysis of a cross-sectional survey of 2000 males and females aged 18–39 living nationwide, which was not conducted for the purpose of this study. Therefore, the items measuring food literacy, such as food knowledge and attitude, are limited and may be lacking. For example, meal preparation behaviors such as the frequency of cooking and preference for cooking have also been reported to be associated with meals that include staples, main dishes, and side dishes [22,27]. The ability to prepare good-tasting meals is an essential life skill and a major aspect of food literacy [43]. In addition, the frequency of eating out and using prepared meals have been reported to be associated with the practice of balanced meals [9,30]. Therefore, further studies are warranted. Second, the participants were recruited from a panel of an internet research company, and the survey was conducted online; web-based questionnaires with volunteer panels may feature recruitment and response biases [44]. However, the sample size was allocated by sex, age group, and region of residence according to the census results; students and individuals who had received professional education in nutrition or culinary arts were excluded from the study population. Respondents' answers are subject to response bias. This study used the Likert method to assess participants' views on eating a balanced meal, which may be affected by midpoint and extreme responses, as well as social desirability bias. However, to control for these biases, strategies such as avoiding ambiguous questions, mixing negative and positive items, and ensuring anonymity are recommended [45,46]. While this study incorporated several of these measures, it did not address noncontingent respondents who may not read the questionnaire carefully. Although trap questions can detect and exclude such respondents, they were not used in this web survey. Future research should implement these methods to improve data reliability and validity. Despite these limitations, this is the first study to measure the core components and patterns of values and related factors among young Japanese individuals toward eating a balanced meal to achieve the goal of a national health promotion program. This study revealed the need to consider socioeconomic conditions and other factors, emphasizing the importance of improving the eating environment, especially for those unwilling to actively adopt a balanced meal or who have a negative impression of such a diet, to achieve national health promotion goals.

Future studies should explore the impact of external factors, such as socioeconomic conditions and global events, such as the COVID-19 pandemic, on dietary behaviors. Additionally, longitudinal and intervention studies are recommended to examine changes in dietary values over time and to test strategies for promoting balanced meals. These approaches will provide a more comprehensive understanding of the factors influencing dietary behaviors.

4.3. Implications for Future Practices

This study revealed three core patterns in valuing the consumption of a complete set of staples, main dishes, and side dishes. It is essential to adopt an approach that matches the value patterns of the target population to promote desirable eating behaviors among young people. Individuals with higher PC1 scores tended to have a more balanced diet owing to their knowledge, skills, and attitudes toward meal planning. However, they also felt burdened. Therefore, nutrition professionals should provide recipes and skills training to encourage positive attitudes and improve meal preparation skills. Additionally, considering previous research findings [47] on convenience cooking products, such as meal bases and ready-made sauces, incorporating these into dietary interventions could offer time-saving solutions and alleviate the burden felt by individuals with higher PC1 scores. These products often include vegetable-rich recipes, addressing barriers of cooking skills, confidence, and creativity. Encouraging their use alongside skills training could be a practical approach to promoting healthier dietary habits among individuals with varying cooking skills and knowledge. Alternatively, for PC2, which was not associated with

the intake of a balanced meal, and PC3, which was negatively associated, the following approach was considered: First, PC2, consisting mostly of young, single men living alone, was willing to use meals if available. However, they were not inclined to make food choices based on nutritional concerns. Therefore, strategies such as making vegetable dishes default side dishes at restaurants and delicatessens were considered effective. A previous study reported that creating a default healthy menu increased the selection rate of healthy menu items [48].

Given that PC3, who had a strong sense of burden related to consuming a combination of staple, main, and side dishes, also had limited financial resources, a strategy that leverages incentives, such as discounting set menus, may be a viable option. An intervention study that offered JPY 50 cashback to customers who ordered dishes with more vegetables reported an increase in their usage, especially among those with limited food budgets [49]. Although monetary incentives are relatively modest, this study indicates that incentives may be beneficial in reducing disparities in healthy food choices. Therefore, it is proposed that educational approaches and environmental improvements, such as modifying defaults and using economic incentives, are crucial. Policymakers, nutrition educators, and public health officials can implement these findings in real-world settings to improve dietary behaviors among young adults. Targeted interventions based on identified value patterns will vary depending on the situation and context of the target population, but considering target-specific strategies can help create an environment that supports healthier food choices.

5. Conclusions

This study identified three patterns of values among the younger generation regarding the consumption of a balanced meal consisting of staples, main dishes, and side dishes more than twice a day, as well as the core components of each pattern. In addition, the results revealed that sociodemographic factors, as well as nutritional knowledge, attitudes, skills, behaviors, and SDQOL, were related to each pattern. It is vital to adopt an approach that matches the value patterns of the target population to promote desirable eating behaviors among young people. Therefore, these findings could be a valuable resource for promoting nutrition education among younger generations. This study underscores the significance of reinforcing the values associated with practicing balanced meals to enhance their adoption among young Japanese adults. Furthermore, the use of defaults and incentives may be a valuable strategy for engaging a population less inclined to adhere to balanced meals. For future practice, such an integrated approach could serve as a pivotal instrument in promoting healthier dietary practices, thereby improving diet-related quality of life.

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Informed Consent Statement: Because the data were collected anonymously using an online questionnaire without including personal data, written informed consent was not required.

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References

1. World Health Organization. Healthy Diet. Available online: https://www.who.int/news-room/fact-sheets/detail/healthy-diet. (accessed on 17 December 2023).
2. Schwingshackl, L.; Schwedhelm, C.; Galbete, C.; Hoffmann, G. Adherence to Mediterranean Diet and Risk of Cancer: An Updated Systematic Review and Meta-Analysis. *Nutrients* **2017**, *9*, 1063. [CrossRef] [PubMed]
3. Schwingshackl, L.; Bogensberger, B.; Hoffmann, G. Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: An Updated Systematic Review and Meta-Analysis of Cohort Studies. *J. Acad. Nutr. Diet.* **2018**, *118*, 74–100. [CrossRef] [PubMed]
4. Kurotani, K.; Akter, S.; Kashino, I.; Goto, A.; Mizoue, T.; Noda, M.; Sasazuki, S.; Sawada, N.; Tsugane, S.; Japan Public Health Center based Prospective Study Group. Japan Public Health Center-Based Prospective Study Group. Quality of Diet and Mortality among Japanese Men and Women: Japan Public Health Center based Prospective Study. *BMJ* **2016**, *352*, i1209. [CrossRef] [PubMed]
5. Watanabe, D.; Kurotani, K.; Yoshida, T.; Nanri, H.; Watanabe, Y.; Date, H.; Itoi, A.; Goto, C.; Ishikawa-Takata, K.; Kimura, M.; et al. Diet Quality and Physical or Comprehensive Frailty among Older Adults. *Eur. J. Nutr.* **2022**, *61*, 2451–2462. [CrossRef] [PubMed]
6. Marino, M.; Puppo, F.; Del Bo', C.; Vinelli, V.; Riso, P.; Porrini, M.; Martini, D. A Systematic Review of Worldwide Consumption of Ultra-Processed Foods: Findings and Criticisms. *Nutrients* **2021**, *13*, 2778. [CrossRef] [PubMed]
7. Bezerra, I.N.; de Carvalho Gurgel, A.O.; Barbosa, R.B.; da Silva, G.B., Jr. Dietary Behaviors among Young and Older Adults in Brazil. *J. Nutr. Health Aging* **2018**, *22*, 575–580. [CrossRef] [PubMed]
8. GBD 2017 Diet Collaborators. Health Effects of Dietary Risks in 195 Countries, 1990-2017: A Systematic Analysis for the Global Burden of Disease Study 2017. *Lancet* **2019**, *393*, 1958–1972. [CrossRef] [PubMed]
9. Thorpe, M.G.; Kestin, M.; Riddell, L.J.; Keast, R.S.J.; McNaughton, S.A. Diet Quality in Young Adults and Its Association with Food-Related Behaviours. *Public Health Nutr.* **2014**, *17*, 1767–1775. [CrossRef]
10. Winpenny, E.M.; van Sluijs, E.M.F.; White, M.; Klepp, K.I.; Wold, B.; Lien, N. Changes in Diet Through Adolescence and Early Adulthood: Longitudinal Trajectories and Association with Key Life Transitions. *Int. J. Behav. Nutr. Phys. Act.* **2018**, *15*, 86. [CrossRef]
11. World Health Organization Europe. How Healthy Are Children's Eating Habits?–WHO/Europe Surveillance Results. Available online: https://www.who.int/europe/news/item/03-03-2021-how-healthy-are-children-s-eating-habits-who-europe-surveillance-results (accessed on 17 December 2023).
12. Mazurek-Kusiak, A.K.; Kobylka, A.; Korcz, N.; Sosnowska, M. Analysis of Eating Habits and Body Composition of Young Adult Poles. *Nutrients* **2021**, *13*, 4083. [CrossRef]
13. Neumark-Sztainer, D.; Wall, M.; Larson, N.I.; Eisenberg, M.E.; Loth, K. Dieting and Disordered Eating Behaviors from Adolescence to Young Adulthood: Findings from a 10-year Longitudinal Study. *J. Am. Diet. Assoc.* **2011**, *111*, 1004–1011. [CrossRef] [PubMed]
14. Tsofliou, F.; Vlachos, D.; Hughes, C.; Appleton, K.M. Barriers and Facilitators Associated with the Adoption of and Adherence to a Mediterranean Style Diet in Adults: A Systematic Review of Published Observational and Qualitative Studies. *Nutrients* **2022**, *14*, 4314. [CrossRef] [PubMed]
15. Kebbe, M.; Damanhoury, S.; Browne, N.; Dyson, M.P.; McHugh, T.L.F.; Ball, G.D.C. Barriers to and Enablers of Healthy Lifestyle Behaviours in Adolescents with Obesity: A Scoping Review and Stakeholder Consultation. *Obes. Rev.* **2017**, *18*, 1439–1453. [CrossRef] [PubMed]
16. Munt, A.E.; Partridge, S.R.; Allman-Farinelli, M. The Barriers and Enablers of Healthy Eating among Young Adults: A Missing Piece of the Obesity Puzzle: A Scoping Review. *Obes. Rev.* **2017**, *18*, 1–17. [CrossRef] [PubMed]
17. Chau, M.M.; Burgermaster, M.; Mamykina, L. The Use of Social Media in Nutrition Interventions for Adolescents and Young Adults-A Systematic Review. *Int. J. Med. Inform.* **2018**, *120*, 77–91. [CrossRef] [PubMed]
18. Ishikawa-Takata, K.; Kurotani, K.; Adachi, M.; Takimoto, H. Frequency of Meals that Includes Staple, Main and Side Dishes and Nutrient Intake: Findings from the 2012 National Health and Nutrition Survey, Japan. *Public Health Nutr.* **2020**, *24*, 2618–2628. [CrossRef] [PubMed]
19. Ministry of Agriculture Forestry and Fisheries. Survey on Attitudes Towards Shokuiku 2022. Available online: https://www.maff.go.jp/j/syokuiku/ishiki/r05/index.html (accessed on 17 December 2023).
20. Hayashi, F.; Takemi, Y.; Murayama, N. The Association between Economic Status and Diet-related Attitudes and Behaviors, as Well as Diet-related Quality of Life in Adults. *Jpn. J. Nutr. Diet.* **2015**, *73*, 51–61. [CrossRef]
21. Oshino, K.; Komaba, C.; Konishi, F. The Relationship between Healthy Meals, Dietary Habits, and Matters related to Meal Preparation among University Students. *J. Home Econo. Jpn.* **2024**, *75*, 108–118.
22. Nakayasu, M.; Akamatsu, R.; Kojima, Y.; Shimpo, M. Relationship between the Frequency of Both Cooking and Intake of a Japanese Well-Balanced Diet among Those Living Alone. *Jpn. J. Nutr. Diet.* **2023**, *81*, 53–60. [CrossRef]
23. Hamashita, K.; Akamatsu, R. Relationship between Eating Slowly and Frequency of Consuming a Balanced Diet including Staple Foods, Main Dishes, and Side Dishes among Japanese Adults. *Jpn. J. Health Edu. Promot.* **2023**, *31*, 110–116.

24. Nakade, M.; Kibayashi, E.; Morooka, A. The Relationship between Eating Behavior and a Japanese Well-Balanced Diet among Young Adults aged 20–39 years. *J. Jpn. Soc. Nutr. Food Sci.* **2021**, *74*, 265–271. [CrossRef]
25. Eda, M.; Kawasaki, Y.; Akamatsu, R.; Fujiwara, Y. Relationship between Attitudes toward Food Costs and Frequency of Meals Combining Staple Food, Main Dish, and Side Dish among Female University Students. *Jpn. J. Nutr. Diet.* **2021**, *79*, 134–141. [CrossRef]
26. Takaizumi, K. Influence of Healthy Eating Literacy on Awareness of the Food Environment and Consumption of Meals Consisting of Grain Dishes, Fish and Meat Dishes, and Vegetable Dishes: Path Analysis in Men and Women in Their Thirties. *Jpn. J. Nutr. Diet.* **2021**, *79*, 113–125. [CrossRef]
27. Hayashi, F.; Noguchi, M.; Uno, K.; Takemi, Y. Factors Related to the Frequency of Consuming a "Japanese Healthy Meal" by Pregnant Women. *Jpn. J. Nutr. Diet.* **2020**, *78*, 24–36. [CrossRef]
28. Nishinakagawa, M.; Sakurai, R.; Nemoto, Y.; Matsunaga, H.; Takebayashi, T.; Fujiwara, Y. Influence of Education and Subjective Financial Status on Dietary Habits among Young, Middle-Aged, and Older Adults in Japan: A Cross-Sectional Study. *BMC Public Health* **2023**, *23*, 1230. [CrossRef] [PubMed]
29. Sakamoto, T.; Inamura, Y.; Hayashi, N. Association between Frequency of Meal Consumption consisting of Grain, Fish and Meat, and Vegetable dishes and Self-Rated Health in Japanese Adults: Data from "The Survey of Attitude toward Shokuiku". *Jpn. J. Health Edu. Promot.* **2021**, *29*, 348–354.
30. Nakade, M.; Nakamura, K.; Fukui, R.; Matsushita, M.; Fujishiro, M. Association of a Well-Balanced Diet with Diet-Related Factors in Childhood among Female University Students. *Jpn. J. Health Edu. Promot.* **2022**, *30*, 207–217.
31. Nakade, M.; Iwaki, N.; Nakamura, Y.; Kurotani, K. Association of a Well-Balanced Diet with Lifestyle, Knowledge, Health Consciousness, and Health Status among Female University Students. *Jpn. J. Health Edu. Promot.* **2021**, *29*, 51–60.
32. Kibayashi, E.; Nakade, M.; Morooka, A. Dietary Habits and Health Awareness in Regular Eaters of Well-balanced Breakfasts (Consisting of Shushoku, Shusai, and Fukusai). *Jpn. J. Nutr. Diet.* **2000**, *78*, 243–253. [CrossRef]
33. Ueda, M.; Mochida, K.; Simpo, M.; Akamatsu, R. "Japanese Well-Balanced Diet" and Other Eating Behaviors among Japanese Male Workers. *Jpn. J. Health Edu. Promot.* **2018**, *26*, 238–247.
34. Ministry of Agriculture, Forestry, and Fisheries. A Survey on the Dietary Habits of Younger Generations. 2019. Available online: https://www.maff.go.jp/j/syokuiku/websurvey/websurvey.html (accessed on 22 March 2024).
35. Cross Marketing Inc. Available online: https://www.cross-m.co.jp/marketing_research/ (accessed on 22 March 2024).
36. Ainuki, T.; Akamatsu, R.; Hayashi, F.; Takmi, Y. The Reliability and Validity of the Subjective Diet-Related Quality of Life (SDQOL) scale among Japanese adults. *Jpn. J. Nutr. Diet.* **2012**, *70*, 181–187. [CrossRef]
37. Yu, T.; Oguma, Y.; Asakura, K.; Takayama, M.; Abe, Y.; Arai, Y. Identification of Dietary Patterns and Their Relationship with Physical Performance in Adults of 85 years of Age and Older—A cross Sectional Study from the Tokyo Oldest Old Survey on Total Health Study. *Geriatr. Gerontol. Int.* **2022**, *59*, 507–517. [CrossRef] [PubMed]
38. O'Rourke, N.; Hatcher, L.A. *Step-by-Step Approach to Using SAS for Factor Analysis and Structural Equation Modeling*, 2nd ed.; SAS Institute: Cary, NC, USA, 2013.
39. Arganini, C.; Saba, A.; Comitato, R.; Virgili, F.; Turrini, A. Gender Differences in Food Choice and Dietary Intake in Modern Western Societies. *Public Health-Soc. Behav. Health Prof.* **2012**, *4*, 83–102. [CrossRef]
40. Liem, D.G.; Russell, C.G. The Influence of Taste Liking on the Consumption of Nutrient Rich and Nutrient Poor Foods. *Front. Nutr.* **2019**, *6*, 174. [CrossRef] [PubMed]
41. Paakki, M.; Kantola, M.; Junkkari, T.; Arjanne, L.; Luomala, H.; Hopia, A. "Unhealthy = Tasty": How Does It Affect Consumers' (Un)Healthy Food Expectations? *Foods* **2022**, *11*, 3139. [CrossRef] [PubMed]
42. Silva, P.; Araújo, R.; Lopes, F.; Ray, S. Nutrition and Food Literacy: Framing the Challenges to Health Communication. *Nutrients* **2023**, *15*, 4708. [CrossRef] [PubMed]
43. Vidgen, H.A.; Gallegos, D. Defining Food Literacy and Its Components. *Appetite* **2014**, *76*, 50–59. [CrossRef] [PubMed]
44. Ekman, A.; Litton, J.E. New Times, New Needs; E-Epidemiology. *Eur. J. Epidemiol.* **2007**, *22*, 285–292. [CrossRef]
45. Baumgartner, H.; Steenkamp, J. Response Styles in Marketing Research: A Cross-National Investigation. *J. Mark. Res.* **2001**, *38*, 143–156. [CrossRef]
46. Taniguchi, M.; Ohmori, S. Voter Turnout Bias in Social Research. *NIRA Work. Pap.* **2022**, *5*, 1–17.
47. Brasington, N.; Jones, P.; Bucher, T.; Beckett, E.L. Correlations between Self-Reported Cooking Confidence and Creativity and Use of Convenience Cooking Products in an Australian Cohort. *Nutrients* **2021**, *13*, 1724. [CrossRef] [PubMed]
48. Anzman-Frasca, S.; Mueller, M.P.; Sliwa, S.; Dolan, P.R.; Harelick, L.; Roberts, S.B.; Washburn, K.; Economos, C.D. Changes in Children's Meal Orders Following Healthy Menu Modifications at a Regional U.S. Restaurant Chain. *Obesity* **2015**, *23*, 1055–1062. [CrossRef] [PubMed]
49. Nagatomo, W.; Saito, J.; Kondo, N. Effectiveness of a Low-Value Financial-Incentive Program for Increasing Vegetable-Rich Restaurant Meal Selection and Reducing Socioeconomic Inequality: A Cluster Crossover Trial. *Int. J. Behav. Nutr. Phys. Act.* **2019**, *16*, 81. [CrossRef] [PubMed]

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Article

Using the Theory of Perceived Value to Determine the Willingness to Consume Foods from a Healthy Brand: The Role of Health Consciousness

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Abstract: Eating low amounts of healthy foods leads to high rates of diet-related diseases. How can we control and reduce the increase in these diseases? One of the recommendations is to improve nutritional competence, which means greater health consciousness. The objective of the present study is to determine the influence of health consciousness on the dimensions of perceived value and their impact on the willingness to consume foods from a healthy brand. Through a non-experimental, cross-sectional, and explanatory study, the responses of 518 participants (men and women) who confirmed being consumers of the healthy brands of food were analyzed. The study included adults aged from 18 to 58 years recruited using non-probability sampling. Data was collected using a self-report form and statistically analyzed using Smart PLS. The findings support that health awareness positively and significantly influences perceived quality value, perceived financial value, perceived social value, and perceived emotional value; contrary to this, it was detected that the perceived financial value does not influence the willingness to consume foods from healthy brands. This study contributes significantly to health science by showing how the theory of perceived value predicts the intention to consume healthy brands, with health consciousness intervening in this prediction. Therefore, it is concluded that the study population that consumes healthy foods has experienced the positive impact of perceived value and reports that the factors that comprise it influence their intention to consume healthy foods.

Keywords: healthy foods; diet; healthy brand; health consciousness; perceived value

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1. Introduction

Eating healthy foods is essential to maintain good health and achieve a long quality of life [1–3]. The benefits go beyond disease prevention, as they also influence aspects such as energy, mental well-being, and overall quality of life [4,5]. Adopting healthy eating habits is an investment in personal well-being and a key component to a whole and healthy life [6]. Nowadays, people are more aware that a healthy and balanced diet and lifestyle could influence purchasing decisions [7,8]. This is where brands that offer healthy options can appeal to this growing group of health-conscious consumers [1,5,7].

Companies, governments, and international organizations have been joining social efforts to improve people's lives and health. A clear example of effort is revealed in the formulation of international policies by the United Nations' (UN) 2030 Sustainable Development Agenda. This is a normative agenda on sustainable development, covering

17 Sustainable Development Goals (SDGs) and 169 goals for achieving them. The OSD—Zero Hunger (SDG 2) and Health and Well-being (SDG 3)—are strongly allied under the mission of achieving a healthy diet for all people. By addressing malnutrition and guaranteeing access to nutritious food, we contribute significantly to improving the health of a population and moving towards sustainable development [9].

There is a strong social trend of great interest in sustainability and conscious eating. Previous studies confirm that this can affect people's willingness to consume foods from brands that support these trends [9,10]. This topic is a complex phenomenon that involves a combination of individual and contextual factors [11], the same ones that contribute to the formation of a healthier society [5], where consumers can make informed decisions contributing to individual and community well-being. Following this same direction, continuous education on healthy eating is vital to address the public health challenges that each country faces, and consumers with high levels of education will have a healthier consumption philosophy [12].

Health is one of the main drivers of healthy food consumption [13]. Considering this, health consciousness is the tendency to care for one's health [6]. Although most people's level of health consciousness is related to eating behavior [14], health-conscious people tend to be willing to do something for themselves and take action for their health. Many studies show a correlation between health consciousness and consuming organic and healthy foods [15]. Most people believe that healthy brand products are good for people's health because they contain healthier nutritional values than conventional products and are safer. That is, the consumer leans toward foods that help them be healthier without harming the environment [16]. Therefore, people with low health consciousness are often less motivated to engage in behaviors that help them stay healthy [15].

One of the theories applied to these health and nutrition contexts is the theory of perceived value. This theory was initially proposed by Zeithaml and is currently applied in research on perceived value and purchase intention in various contexts [17]. Many studies show that perceived value predicts consumer purchase intention better than satisfaction or quality [17,18]. Perceived value is defined as the general psychological evaluation [17] and subjective nature of a product or service by consumers, measured by their perceptions, generally influenced by benefits and costs [19,20]. Perceived value has been widely used in behavioral research and is closely related to customer loyalty, satisfaction, and continuance intention [21]. In this sense, research shows that perceived value is a key factor influencing consumer attitudes toward purchases [18], which is based, among other things, on past experiences [8].

After carefully reviewing the background, there is evidence of growing interest among academics, business, and health professionals in continuing to research these topics. It can be validated that scientific dissemination has been increasing since 2006, and the interest in continuing research is evident. The preceding studies have been applied to various areas, sectors, and populations, such as management and business, social sciences, medicine, environmental sciences, decision sciences, and psychology. Bibliometric indicators reveal that the ten countries that publish the most scientific results are the USA, China, Taiwan, South Korea, Great Britain, Indonesia, Spain, Malaysia, Australia, and India. When evaluating scientific dissemination by country, it has been found that the research carried out in the Peruvian population needs to be expanded; more scientific literature can support and guide future research in these areas.

Despite the importance that has been given to the present topic, within the scientific literature available, no studies have been found that develop or explain health awareness and its influence on the dimensions of perceived value and, in turn, its influence on the purchase intention of healthy products. Thus, this research aims to fill this knowledge gap by focusing on a Peruvian context and proposing future research that addresses other population scenarios. Furthermore, given the prevalence of malnutrition, diet, and health-related diseases, this study could provide valuable contributions to professionals in academia and related fields.

Considering what was referred to in the previous paragraphs, the objective of the present study is to determine the influence of health consciousness on the dimensions of perceived value and their impact on the willingness to consume foods from a healthy brand. Furthermore, specific objectives are set to identify if (a) health consciousness influences the perceived quality value of a healthy product, (b) health consciousness influences the perceived social value of a healthy product, (c) health consciousness influences the perceived emotional value of a healthy product, (d) health consciousness influences the perceived financial value of a healthy product, (e) perceived quality value influences willingness to consume healthy brand foods, (f) perceived social value influences willingness to consume healthy brand foods, (g) perceived emotional value influences willingness to consume healthy brand foods, and (h) perceived financial value willingness to consume healthy brand foods. Next, this study is divided into the following sections (having already covered the first section): Section 2 contains the theoretical framework and hypothesis development. Section 3 provides materials and methods. Section 4 focuses on the results. Section 5 refers to the discussion, and Section 6 to the conclusions.

2. Theoretical Framework and Hypotheses Development

Health consciousness has increased over time, gaining a notable boost since the COVID-19 pandemic. Given this circumstance, research has emerged that examines customer perception of a brand or product, even more so when it comes to rating key aspects of perceived value, such as quality [8,22]. According to background research, it has been shown that although health consciousness is part of a consumer's philosophy regarding conscious eating, this philosophy can vary depending on the context of the country and culture. Despite these differences, the consumer tends to evaluate a product and, among other characteristics, its quality [23]. Although the food industry sector is considered unbalanced due to the presence of unsustainable practices, it has been detected that within the framework of satisfying human needs, individuals who intend to maintain a healthy diet maintain practices of health consciousness, thus seeking the quality of the products received [24]. With this, the following hypothesis is proposed:

H1. *Health consciousness influences the perceived quality of a healthy product.*

Some studies establish that health-conscious consumers, independently of thinking about their well-being, also think about the well-being of others, which is why they evaluate the impact of the brand on society. This attitude is known as social value [25,26]. Likewise, scientific records establish that behaviors that benefit sustainability are part of the perceived social value since multiple positive impacts have been recognized. Here, the consumer is aware of caring for himself and the environment and adopting other behaviors that impact the environment [27]. In this way, the health-conscious consumer limits him/herself to marketing efforts and focuses on choosing a healthy product that cares for his/her environment since he/she recognizes its function as a catalyst for social change [28]. What was previously mentioned leads to the following hypothesis:

H2. *Health consciousness influences the perceived social value of a healthy product.*

Taking into account that consumer segmentation revolves around specific criteria, it is established that one of these is the preference for food [29,30]. In this way, the literature establishes that some consumer behaviors are closely linked to health consciousness [31]. This is a public health approach that impacts consumer experiences. On the other hand [32–34], it describes that consumers who are health conscious are more demanding in their criteria when evaluating certain products since they are also characterized by having a particular interest in knowing it more after choosing it, buying it again and again, and feeling the experience of the benefits the product creates, establishing a deep and sustainable emotional bond and connection over time, which is called emotional value. With this, the following hypothesis is proposed:

H3. *Health consciousness influences the perceived emotional value of a healthy product.*

In the same way, it has been identified that when consumers are aware of their health, they also look for environmentally friendly products, and when it comes to purchasing them, they are willing to pay as long as it does not exceed the projected budget [35,36]. This means the health-conscious consumer plans ahead and allocates a budget according to consumer preferences regarding healthy products. With this, the following hypothesis is proposed:

H4. *Health consciousness influences the perceived financial value of a healthy product.*

Perceived quality involves a multidimensional assessment of the attributes of healthy foods from the consumer's perspective, including beliefs about nutritional value, naturalness, and positive health impacts [15,24,30,37]. Regarding purchase intention, it expresses the subjective probability that consumers will choose to obtain healthy food shortly, determined by confidence in the benefits of the product, personal adherence to sustainability, and perceived social norms [14,16,36,38]. In this way, various studies support that functional and organic foods with high dietary quality increase the probability of future purchases, both in Western and Asian consumers [12,39–41]. What was reviewed raises the following hypothesis:

H5. *Perceived quality influences the purchase intention of healthy products.*

Perceived social value involves the subjective assessment of improvements in status and image within the social circle, which current consumers can obtain by adopting positively validated behaviors in their community [3,22,38,42]. This involves perceptions about optimizing interpersonal relationships, reputation, and self-concept by manifestly adhering to prevailing trends or norms [2,4,43,44]. Some studies indicate that this perceived social value can increase the estimated subjective probability that millennials and centennials will choose food options promoted as healthy by their reference groups, thus increasing adherence to those socially validated consumption behaviors [39,42,43]. With the mentioned above, the following hypothesis is proposed:

H6. *Perceived social value influences the purchase intention of healthy products.*

Perceived emotional value involves the subjective assessment of feelings of connection and well-being that current consumers in regions of exceptional longevity associate with organic foods [2,21,45–47]. Here, the emotional usefulness and symbolic expressiveness of cultural and environmental preservation options are incorporated [48–50]. Evidence indicates that the high emotional value perceived in organic products increases the estimated probability of healthy purchasing the following year, increasing conscious eating behaviors [50,51]. Therefore, this hypothesis is proposed:

H7. *Perceived emotional value influences the purchase intention of healthy products.*

The perceived financial value implies the integrative evaluation of the economic benefits and costs of obtaining a product for the consumer [52–54]. In addition, it ranges from quality to price to comfort to perceived savings to satisfying the buyer's needs [49,55,56]. Therefore, the evidence indicates that this financial value positively impacts the purchase intentions of ecological products in different age groups [38,50,57], promoting conscious consumption behaviors. With this, the following hypothesis is proposed:

H8. *Perceived financial value influences the purchase intention of healthy products.*

Considering the hypotheses mentioned above, the ensuing conceptual model of the study can be visualized, as depicted in Figure 1.

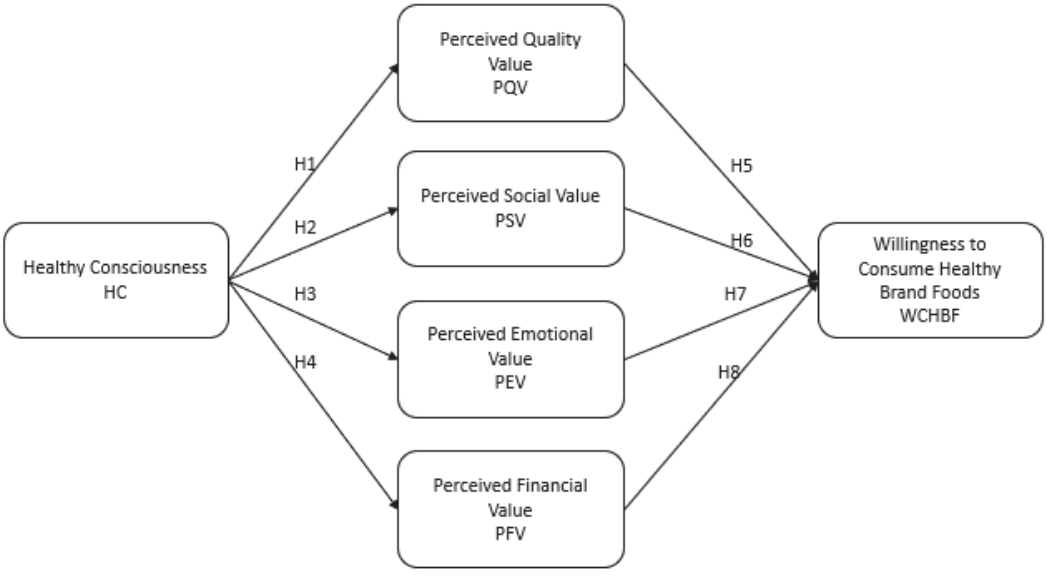

Figure 1. Proposed model.

3. Materials and Methods

This article aimed to build an explanatory model through an empirical study to examine healthy consciousness (HC), perceived quality value (PQV), perceived social value (PSV), perceived emotional value (PEV), perceived financial value (PFV), and the willingness to consume healthy brand foods (WCHBF) that takes place in the Peruvian market. The study used a self-administered questionnaire using a quantitative, non-experimental, and cross-sectional design approach [58].

3.1. Sample and Procedure

It is important to note that the study population is more representative of young people since they are the ones who maintain a high tendency to consume healthy products [59,60]. For this study, Peruvian residents who stated that they consumed foods from a healthy brand (Union brand) were summoned. The brand in question has been in the Peruvian market for more than 90 years and, since its founding (1929), has sought products with a high nutritional value index that provides, to a certain extent, the prevention of diseases. In addition, being characterized by making healthy products available to the market, allowing a healthy experience for the consumer, this brand is socially responsible by contributing to the educational development of young university students by allowing them to finance their studies through the sale of their products.

One solid condition for participants to take part in this study is that they had to be of legal age and had to have consumed the Union brand. In addition, all participants were informed about the research objectives and the use of the information collected. Before proceeding with filling out the survey, they signed informed consent. Approval was obtained from the school's ethics committee of Postgraduate Studies of the Universidad Peruana Unión, according to document 2023-CE-EPG-00041. The questionnaire was self-administered and anonymous, thus increasing the probability of obtaining honest answers. The survey was hosted in the Google Forms application and shared through social networks, official academic WhatsApp groups, and official groups of the Union brand. Thus, the participation of 518 individuals selected through non-probabilistic convenience sampling was achieved [61], whose characteristics are detailed in Table 1.

Table 1. Sociodemographic characteristics (n = 518).

Category	Frequency	Percentage
Age		
18–25	451	87.0
26–33	41	7.9
34–42	14	2.7
43–50	6	1.2
51–58	6	1.2
Gender		
Male	183	35.3
Female	335	64.7
Marital status		
Married	30	5.8
Divorced	2	0.4
Single	486	93.8
Religion		
Adventist	444	85.7
Catholic	57	11
Evangelical	7	1.4
Other	10	1.9
Academic formation		
Secondary completed	19	3.7
Advanced technician	4	0.8
University (undergraduate)	462	89.2
University (postgraduate)	33	6.3
Family economic income		
Up to 2 minimum salaries	266	51.4
From 3 to 4 minimum salaries	131	25.3
From 5 to 10 minimum salaries	92	17.8
From 11 to 20 minimum salaries	19	3.6
Greater than 20 minimum salaries	10	1.9

3.2. Measurement Scales

The digital questionnaire was structured in 3 sections: The first section presented the instructions for filling out the questionnaire and the informed consent through the statement "I agree to participate". The second section contained the measurement scales regarding healthy products, specifically the "Union brand". And the third section was composed of questions related to sociodemographic data such as age, sex, marital status, religion, educational level, and family economic income. The constructs reached a high level of reliability, with Cronbach's alpha values of 0.951 for health awareness, 0.947 for emotional value, 0.929 for perceived financial value, 0.954 for perceived quality value, and 0.929 for willingness to consume healthy brand foods. Willingness to consume healthy brand foods (WCHBF) was measured in 7 items for each variable [62]. Using the proposal of Köse and Kırcova [13], health consciousness (HC) was assessed using 7 items; however, to measure perceived quality value (PQV), perceived social value (PSV), perceived emotional value (PEV), and perceived financial value (PFV), 3 items were used for each construct (Appendix A). All items were evaluated using a 5-point Likert-type scale, where 1 means "Strongly disagree" and 5 means "Strongly agree".

3.3. Statistical Analysis

The statistical analysis of this research was performed using a two-step approach: first, the evaluation of the measurement model, and second, the evaluation of the structural model [58]. For this purpose, the statistical software Smart-PLS version 4.0 was used to perform the reliability test of the measurement model, such as discriminant validity and convergent validity [58], and also to test the hypotheses of the structural model. In addition, this study also used IBM SPSS version 25 software to analyze the demographic data of the respondents, which are shown in Table 1.

To determine the influence of health consciousness on the dimensions of perceived value and the influence of these on the willingness to consume foods from a healthy brand (see Figure 1), the partial least squares structural equation model (PLS-SEM) was used [63] since it is a comprehensive approach to multivariate statistical analysis, it involves

several variables equal to or greater than three variables, and it includes structural and measurement components to examine the relationships between each of the variables in a conceptual model simultaneously [58].

The measurement instrument evaluation process examined three indicators. (1) Internal consistency and reliability, in which Cronbach's alpha and the composite reliability (CR) indices were sought to be above 0.70. (2) Convergent validity is met when all items of the construct have loadings greater than 0.70, and the average variance extracted from the construct is greater than 0.50. Moreover, (3) the construct's discriminant validity is met when the coefficients of the Heterotrait–Monotrait (HTMT) indicator are below 0.85 [64].

To evaluate the structural model, it was first verified whether the relationships established in the model were significant; for this, the *p*-value had to be less than 0.05. Next, two indicators, R2, were examined to test the model's predictive power. The adjusted R2 values of 0.19, 0.33, and 0.67 are considered weak, moderate, and substantial, respectively [65]. Likewise, in behavioral studies, a value of 0.2 for R2 is acceptable [63].

4. Results

The results are presented in two stages: (1) measurement model evaluation, which evaluates the validity and reliability of the measurement model, and (2) structural model evaluation, which evaluates the structural model and addresses the relationships between the constructs [63].

4.1. Evaluation of the Measurement Model

Regarding the convergent evaluation, Table 2 shows that all the items of the six constructs comply with this validation since all the factor loadings were less than 0.70 [58]. Furthermore, it is confirmed that Cronbach's Alpha and composite reliability are greater than 0.70. Likewise, it is confirmed that all constructs' average variance extracted is greater than 0.50. Therefore, the convergent validity of the measurement model was excellent.

Table 2. Scale elements.

Predictor	Code	Outer Loadings	α	Composite Reliability (rho_a)	Composite Reliability (rho_c)	AVE
Healthy consciousness (HC)	HC1	0.833	0.951	0.951	0.960	0.773
	HC2	0.893				
	HC3	0.896				
	HC4	0.907				
	HC5	0.897				
	HC6	0.870				
	HC7	0.781				
Perceived emotional value (PEV)	PEV1	0.943	0.947	0.949	0.966	0.904
	PEV2	0.953				
	PEV3	0.925				
Perceived financial value (PFV)	PFV1	0.891	0.929	0.930	0.955	0.875
	PFV2	0.929				
	PFV3	0.907				
Perceived quality value (PQV)	PQV1	0.945	0.954	0.954	0.971	0.917
	PQV2	0.920				
	PQV3	0.943				
Perceived social value (PSV)	PSV1	0.963	0.952	0.953	0.969	0.912
	PSV2	0.953				
	PSV3	0.941				
Willingness to consume healthy brand food (WCHBF)	WCHB1	0.800	0.929	0.931	0.943	0.701
	WCHB2	0.778				
	WCHB3	0.779				
	WCHB4	0.778				
	WCHB5	0.826				
	WCHB6	0.809				
	WCHB7	0.785				

To evaluate this study's discriminant validity, the Heterotrait–Monotrait criterion was used. This criterion is met if the HTMT value is less than 0.95 [64]. Table 3 shows that this criterion is met since the highest value is 0.781, well below the required limit. Therefore, discriminant validity was established between the six constructs of the model.

Table 3. Herotrait–Monotrait (HTMT) matrix.

	HC	PEV	PFV	PQV	PSV	WCHB
HC						
PEV	0.538					
PFV	0.534	0.781				
PQV	0.578	0.742	0.754			
PSV	0.359	0.646	0.612	0.455		
WCHB	0.561	0.721	0.673	0.724	0.535	

4.2. Structural Model Evaluation

Table 4 and Figure 2 show the results of the structural model with path coefficients between −1 and +1 [58]. The R2 coefficients of the present work for PQV, PSV, PEV, PFV, and WCHBF were 0.333, 0.129, 0.290, 0.285, and 0.615, respectively. That is, the R2 values had values from acceptable to substantial, except for PSV, which is weak. Therefore, the values show that the variables of the present study explain an acceptable percentage of the variance of the WCHB. The overall model fit was measured using the root mean square residual (SRMR), resulting in a value of 0.035 for this indicator, below the recommended threshold value of 0.080 [63].

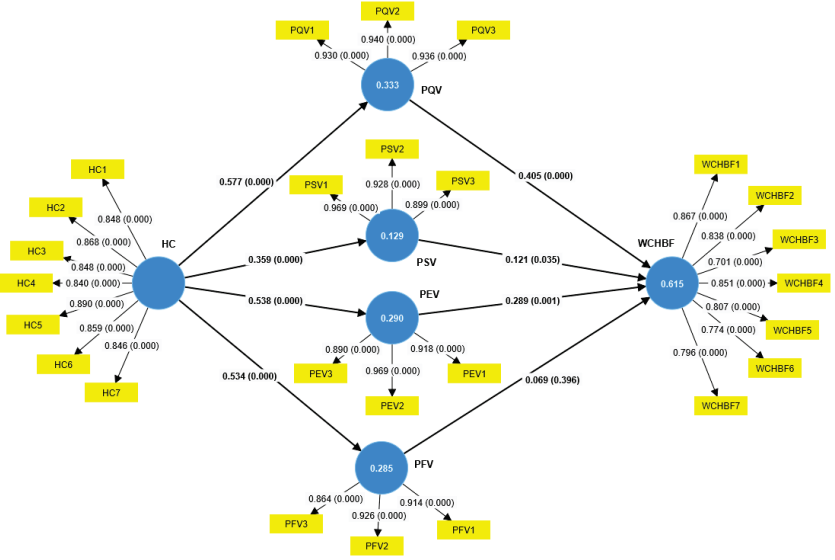

Figure 2. Structural model.

Hypothesis tests and evaluation of path coefficients can be seen in Table 4. The results show that HC positively and significantly influences PQV, PSV, PEV, and PFV, supporting hypotheses H1, H2, H3, and H4. The results also show that PQV, PSV, and PEV positively and significantly influence WCHBF, which supports hypotheses H5, H6, and H7. This model indicates that PFV does not influence WCHBF, so H8 is not accepted.

Table 4. Estimates of the proposed hypotheses.

H	Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values	Decision
H1	HC -> PQV	0.577	0.577	0.039	14.829	0.000	Accepted
H2	HC -> PSV	0.359	0.360	0.049	7.312	0.000	Accepted
H3	HC -> PEV	0.538	0.539	0.044	12.284	0.000	Accepted
H4	HC -> PFV	0.534	0.534	0.042	12.673	0.000	Accepted
H5	PQV -> WCHB	0.405	0.407	0.071	5.693	0.000	Accepted
H6	PSV -> WCHB	0.121	0.122	0.057	2.114	0.035	Accepted
H7	PEV -> WCHB	0.289	0.288	0.086	3.375	0.001	Accepted
H8	PFV -> WCHB	0.069	0.068	0.082	0.848	0.396	Rejected

5. Discussion

The results of this study have shown that health awareness influences the perceived quality of a healthy product. To support this finding, research has been identified that indicates that the greater the health awareness, the higher the evaluation of the product's quality; this means that the health-conscious consumer usually seeks more information about the quality of the product to be purchased [66,67]. Other studies that support the results shown establish that nutritional knowledge allows consumers to reflect and make the appropriate and informed decision regarding their diet, thus increasing health awareness, a decision that is based on the evaluation of the quality of the food product [67,68] and is that in a scenario where healthy products have attributes associated with higher quality standards, they are recognized and valued with greater emphasis in consumers who maintain health awareness [37,69].

According to the results, it has been shown that health awareness influences the perceived social value of a healthy product. This finding is also reported by Sánchez-Feijoo et al. [70], who establish that products from a brand with a social value that also seeks common well-being have a better perspective from the perspective of a health-conscious consumer [44]; these consumers are also the ones who have the greatest susceptibility to opt for those products whose mechanism maintains and promotes social value [71]. In addition, other research that supports the results of this study shows that health-conscious consumers have a high tendency to know the social behavior of the company or brand in the face of various environmental problems; therefore, their behavior tends to validate their commitment to products and/or brands that, independently of meeting quality standards, are aligned with social impact practices [72]; this means that health-conscious consumers, beyond seeking benefits regarding their physical health, also seek a special contribution to society [8].

Another factor that influences health awareness is the perceived emotional value of the healthy product, as demonstrated in this study. In this regard, Zahid et al. [73] demonstrate that affective emotions emerge with greater emphasis when a consumer identifies that the consumption of a specific product generates well-being. That is, when he/she becomes aware of his/her health, then repurchase behavior comes from this, which refers to a scenario where the consumer reduces his/her susceptibility to consider alternative products due to the attachment that has been created [74]. Under this same context and to support the findings of this study, a recent study has been identified that refers to the health-conscious consumer as that character who associates a healthy product with emotional value, and that is that when a consumer believes in a product, and it meets their expectations of health and well-being, an emotional relationship is generated, the same one that derives from a pleasant experience [75,76].

Likewise, it has been found that health awareness influences the perceived financial value. This result is completely consistent with the studies of Vieria [77], who established that when a consumer chooses a healthy food, they also evaluate the price [78]. For example, a low price could be a reason for consumer distrust [79]. In this sense, there is research

that supports that healthy products must guarantee equity between quality and price since health-conscious consumers seek to obtain nutritional benefits that ensure health care in exchange for a financial value that the product or brand merits [80,81]. In this case, health awareness influences the financial value when evaluating the nutritional benefit against a justified and balanced price.

Another finding establishes that the perception of quality exerts a positive influence on the intention to purchase healthy products. Research that has addressed this topic strongly supports this behavior; according to Ordoñez et al. [27], perceived quality significantly affects purchase intentions. Recent studies [38,39] have shown that quality is a relevant aspect that can affect the purchasing decision when choosing a product or selecting a brand [40]. Under this context, it is necessary that companies develop strategies to communicate quality attributes in order to achieve a true purchase intention for their products. Likewise, there is other research that supports the results of this study by indicating that one of the criteria that drives purchase intention is quality and that this criterion is part of the consumer's decision when purchasing a product [82,83].

Likewise, it has been shown that perceived emotional value influences the purchase intention of healthy products; this finding is supported by researchers Sánchez et al. [84] and Bonisoli and Micolta [85] who place special emphasis on specifying that emotional value is part of a set of evaluative aspects that have a positive influence on the consumer's purchase intention; furthermore, another recent study has shown that the interaction between emotional value and purchase intention of healthy products is explained by consumer perception; that is, when they feel an important attachment between themselves and the brand and/or product, they will not hesitate to choose it [86]. In this way, emotional value assumes a leading role where the connection between the consumer and the product is lasting, thus generating greater willingness to purchase when choosing a product, which generates an important advantage for the brand over the competition since the barrier of the purchase modality is not a limitation when the emotional value exists [87,88].

Another result, in the applied context, indicates that financial value does not influence the purchase intention of healthy products; this result contradicts some previous research that determines that price influences purchase decisions [89]. However, recent studies have shown that when it comes to healthy products, quality plays a more important role in purchase intention [90,91]. This means that financial value is not necessarily a determinant of purchase intention. Furthermore, other research reveals that nowadays, consumers prioritize their health and are willing to pay a high price if required [92,93]. With this recent background, the results found in this study are supported, taking into account that the financial value can be a decisive element depending on the context where it is applied, being in the context of healthy foods a secondary factor that does not determine the purchase intention.

In general terms, evidence has been found that health awareness influences three dimensions of perceived value (perceived quality, social value, emotional value). This means that every health-conscious consumer has a high tendency to value the quality of health products more, granting greater social value to products due to the recognition they have in the social environment, which means they experience a positive emotional value. These multiple influences highlight how important it is for consumers to become health conscious, thus avoiding negative outcomes regarding their health [94,95]. With this, companies could establish clear policies that lead to capturing and achieving loyalty in a segmented manner with customers that are health-conscious consumers while having support from governments and health authorities, who maintain an important participation in the improvement of public health conditions [96,97].

5.1. Theoretical and Practical Implications

Despite recognition that a healthy diet is economically fair, affordable, nutritionally adequate, and safe, few countries have adopted healthy eating principles in government dietary recommendations. Based on this study's findings, marketing strategies can be

developed to increase consumer preference for healthy branded products. To this effect, it is necessary to promote consumer education so that they can have the ability to assertively decide which healthy products to consume. Under this circumstance, companies are called to use attractive packaging that draws the attention of the consumer by seeking the collaboration of influencers to promote healthy eating.

Given the critical role that consumers' health consciousness plays in healthy food choices, marketers and government policymakers should focus on conducting educational campaigns through various media channels to promote awareness about health topics among consumers. In educational programs presented on various media and social media channels, recognition of opinions from important leaders can effectively change consumer attitudes and dietary choices. In addition to providing knowledge about healthy foods, marketers can emphasize the psychological benefits of nutritious foods during the consumption experience. Since food consumption is experiential and primarily related to consumers' emotions, the psychological benefits associated with the consumption experience will increase consumers' willingness to purchase foods from healthy brands.

Alternatively, once this research is conducted, companies could source food products tailored to the preferences and values of health-conscious consumers. If they offer health benefits, they could also innovate by creating new ingredients and recipes low in sodium, saturated fat, and added sugars.

Through market segmentation, food industries can easily find a market segment that consists of health-conscious consumers willing to consume products from a healthy food brand. Therefore, they can easily change production and marketing according to consumer interests and preferences. They may even have a different product for health-focused consumers. Likewise, they can collaborate with the health industry, nutritionists, or wellness experts to be the recommended brand. Thus, brand credibility will increase. It is also believed that restaurant companies can consider these options and offer healthier alternatives to attract consumers from this segment. In this way, they can improve their brand's reputation by demonstrating a complete and genuine commitment to the health and well-being of consumers.

Finally, this study can provide valuable information for companies to adapt their strategies, policies, products, and operations to meet market demands aimed at population health. Adapting to the desires of health-conscious consumers improves brand image, reputation, and perceived value and contributes to the general well-being of society.

5.2. Limitations and Future Research

Although this study provides an in-depth understanding of how perceived value theory predicts willingness to consume foods from a healthy brand and how health consciousness may play a role in this prediction, there are limitations to the research. For example, although we have information on the economic income of the study participants, an analysis of the association of this income with the purchase of healthy products has not yet been carried out. The reason for this is that homogeneous samples were not obtained that would allow comparison. Under this context, it is proposed that future research investigate whether the economic condition of individuals could be associated with the willingness to consume foods from a healthy brand.

Another limitation of this study corresponds to the sample that was selected. It is a non-probabilistic sampling that was used at the convenience of the researcher. As a result of this, a high representation of women was obtained in the surveys, with a high number of participants whose ages range between 18 and 25 years and a significant percentage of participants who declared themselves to be Adventists (a group characterized by having a differentiated lifestyle with respect to their diet, customs, and beliefs), which means this could be a bias regarding the results obtained. The lack of balance between the number of men and women could reduce the possibility of generalizing the results. Considering this, it is proposed that future studies segment the sample in order to include a greater

diversity of participants and carry out comparative studies between sociodemographic characteristics such as religious belief, age, gender, and marital status.

On the other hand, the concept and knowledge of each study participant about healthy brands have not been recorded; this could represent research bias because the lack of this detail could vary respondents' perceptions. Thus, it is proposed that future investigations carry out a quasi-experimental investigation where, in the first instance, the study population is made aware of the consumption of healthy foods, thus ensuring that the participants have prior information regarding healthy foods.

Furthermore, other research could focus on qualitative studies that explore motivations or barriers that influence an individual's consumption decision when choosing healthy foods. The results found would be key information to promote the choice of healthy foods and increase awareness of health.

6. Conclusions

This study shows how the theory of perceived value can predict the willingness to consume foods from a healthy brand, with health consciousness intervening in this prediction. Thus, it is concluded that the population under study that consumes healthy foods has experienced the positive impact of perceived value and reports that the factors that comprise it influence their intention to consume nutritious foods. In this case, it is important that healthy brand companies can consolidate and strengthen quality and social, emotional, and financial value. This fact constitutes the option of activating two agents of change that can contribute to the willingness to consume food. First, educational institutions could be part of the change in consumer behavior since educational programs can promote health consciousness, encouraging students to choose healthy foods in their daily diet. On the other hand, there are also companies dedicated to producing healthy foods; these assume a fundamental role by having the capacity to directly impact the intention to consume healthy foods by consolidating the value of perceived components. Focusing on the components of perceived value is part of a social initiative that aims to influence the Peruvian population's habits positively.

Likewise, the need to disseminate healthy food consumption patterns is conclusive. For this purpose, actions must be taken to transform consumers' attitudes and behaviors so that they are willing to integrate alternatives that lead to healthy eating. This fact is noted in a health-conscious approach.

Finally, considering that this research's findings indicate that health consciousness can influence perceived value, the need to establish strategies that place high relevance on health consciousness is highlighted, extending from individual to collective decisions. For this reason, it is necessary to integrate educational programs and health lectures that allow the population to make better decisions regarding their diet.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available on request from the authors.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Constructs and Items.

Construct	Items	Loadings
Healthy consciousness (HC)		Personally...
	HC1	I reflect a lot on my health.
	HC2	I am very conscious of my health.
	HC3	I am alert to changes in my health.
	HC4	I take responsibility for the state of my health.
	HC5	I am aware of the state of my health throughout the day.
	HC6	I look to choose foods that are good for my health.
	HC7	I prefer food products without additives.
Perceived quality value (PQV)		Union brand products...
	PQV1	They are always of good quality.
	PQV2	They have a good presentation.
	PQV3	They have an adequate useful life.
Perceived social value (PSV)		Consume Union brand products...
	PSV1	It helps me feel accepted by others.
	PSV2	Improves the way I am perceived.
	PSV3	They give me social approval.
Perceived emotional value (PEV)		Consume Union brand products...
	PEV1	It gives me satisfaction.
	PEV2	It makes me feel good.
	PEV3	It gives me peace of mind.
Perceived financial value (PFV)		Buy Union brand products...
	PFV1	It offers good value for money.
	PFV2	Worth the price.
	PFV3	They have a reasonable price.
Willingness to consume healthy brand food (WCHBF)		I am willing to buy the following Union brand products...
	WCHBF1	Bread (multiseed, special whole wheat flour fortified with iron and B vitamins, bromate-free).
	WCHBF2	Cookies (special whole wheat flour fortified with iron and B complex vitamins, free of artificial coloring).
	WCHBF3	Beverages (0% alcohol wine, sugar-free fruit juices, free of artificial colors and flavorings).
	WCHBF4	Granolas (mix of nuts, seeds, and cereals).
	WCHBF5	Snacks (sticks with sesame, chia, kion, garlic, flaxseed, and omega 9, 6, and 3).
	WCHBF6	Spreads (grape jam, peanut butter, and omega 6 and 9).
	WCHBF7	Panettone (fortified with iron, contains source of fiber and source of protein, contains omega 6 and 9).

References

1. Fastame, M.C. Well-Being, Food Habits, and Lifestyle for Longevity. Preliminary Evidence from the Sardinian Centenarians and Long-Lived People of the Blue Zone. *Psychol. Health Med.* **2022**, *27*, 728–733. [CrossRef] [PubMed]
2. Poulain, M.; Herm, A.; Errigo, A.; Chrysohoou, C.; Legrand, R.; Passarino, G.; Stazi, M.A.; Voutekatis, K.G.; Gonos, E.S.; Franceschi, C.; et al. Specific Features of the Oldest Old from the Longevity Blue Zones in Ikaria and Sardinia. *Mech. Ageing Dev.* **2021**, *198*, 1–9. [CrossRef]
3. Legrand, R.; Nuemi, G.; Poulain, M.; Manckoundia, P. Description of Lifestyle, Including Social Life, Diet and Physical Activity, of People = 90 Years Living in Ikaria, a Longevity Blue Zone. *Int. J. Environ. Res. Public. Health* **2021**, *18*, 6602. [CrossRef] [PubMed]
4. Pes, G.M.; Dore, M.P.; Tsofliou, F.; Poulain, M. Diet and Longevity in the Blue Zones: A Set-and-Forget Issue? *Maturitas* **2022**, *164*, 31–37. [CrossRef] [PubMed]
5. Hitchcott, P.K.; Fastame, M.C.; Penna, M.P. More to Blue Zones than Long Life: Positive Psychological Characteristics. *Health Risk Soc.* **2018**, *20*, 163–181. [CrossRef]

6. Khayyam, M.; Chuanmin, S.; Qasim, H.; Ihtisham, M.; Anjum, R.; Jiaxin, L.; Tikhomirova, A.; Khan, N. Food Consumption Behavior of Pakistani Students Living in China: The Role of Food Safety and Health Consciousness in the Wake of Coronavirus Disease 2019 Pandemic. *Front. Psychol.* **2021**, *12*, 673771. [CrossRef] [PubMed]
7. Foxall, G.; Bhate, S. Cognitive Style and Personal Involvement as Explicators of Innovative Purchasing of "Healthy" Food Brands. *Eur. J. Mark.* **1993**, *27*, 5–16. [CrossRef]
8. García-Salirrosas, E.E.; Millones-Liza, D.Y.; Esponda-Pérez, J.A.; Acevedo-Duque, Á.; Müller-Pérez, J.; Sánchez Díaz, L.C. Factors Influencing Loyalty to Health Food Brands: An Analysis from the Value Perceived by the Peruvian Consumer. *Sustainability* **2022**, *14*, 10529. [CrossRef]
9. Vargas, A.M.; de Moura, A.P.; Deliza, R.; Cunha, L.M. The Role of Local Seasonal Foods in Enhancing Sustainable Food Consumption: A Systematic Literature Review. *Foods* **2021**, *10*, 2206. [CrossRef]
10. Schubert, E.; Bode, S. Positive Emotions and Their Upregulation Increase Willingness to Consume Healthy Foods. *Appetite* **2023**, *181*, 106420. [CrossRef]
11. Byaruhanga, R.; Isgren, E. Rethinking the Alternatives: Food Sovereignty as a Prerequisite for Sustainable Food Security. *Food Ethics* **2023**, *8*, 16. [CrossRef]
12. Wang, J.; Xue, Y.; Liu, T. Consumer Motivation for Organic Food Consumption: Health Consciousness or Herd Mentality. *Front. Public. Health* **2023**, *10*, 1042535. [CrossRef]
13. Köse, Ş.G.; Kırcova, I. Using Theory of Consumption Values to Predict Organic Food Purchase Intention: Role of Health Consciousness and Eco-Friendly LOHAS Tendency. *Span. J. Agric. Res.* **2021**, *19*, e0109. [CrossRef]
14. Siegrist, M.; Bearth, A.; Hartmann, C. The Impacts of Diet-Related Health Consciousness, Food Disgust, Nutrition Knowledge, and the Big Five Personality Traits on Perceived Risks in the Food Domain. *Food Qual. Prefer.* **2022**, *96*, 104441. [CrossRef]
15. Huang, Z.; Zhu, Y.D.; Deng, J.; Wang, C.L. Marketing Healthy Diets: The Impact of Health Consciousness on Chinese Consumers' Food Choices. *Sustainability* **2022**, *14*, 2059. [CrossRef]
16. Nguyen, P.H.; Nguyen, D.N.; Nguyen, L.A.T. Quantitative Insights into Green Purchase Intentions: The Interplay of Health Consciousness, Altruism, and Sustainability. *Cogent Bus. Manag.* **2023**, *10*, 2253616. [CrossRef]
17. Song, H.; Yin, G.; Wan, X.; Guo, M.; Xie, Z.; Gu, J. Increasing Bike-Sharing Users' Willingness to Pay—A Study of China Based on Perceived Value Theory and Structural Equation Model. *Front. Psychol.* **2022**, *12*, 747462. [CrossRef] [PubMed]
18. Lin, C.-C.; Dong, C.-M. Exploring Consumers' Purchase Intention on Energy-Efficient Home Appliances: Integrating the Theory of Planned Behavior, Perceived Value Theory, and Environmental Awareness. *Energies* **2023**, *16*, 2669. [CrossRef]
19. Jiang, L.; Probst, T.M. The Rich Get Richer and the Poor Get Poorer: Country- and State-Level Income Inequality Moderates the Job Insecurity-Burnout Relationship. *J. Appl. Psychol.* **2017**, *102*, 672–681. [CrossRef]
20. Singh, S.; Singh, N.; Kalinić, Z.; Liébana-Cabanillas, F.J. Assessing Determinants Influencing Continued Use of Live Streaming Services: An Extended Perceived Value Theory of Streaming Addiction. *Expert. Syst. Appl.* **2021**, *168*, 114241. [CrossRef]
21. Wang, X.; Wang, L. Investment Intention towards Online Peer-to-Peer Platform: A Data Mining Approach Based on Perceived Value Theory. *Commun. Comput. Inf. Sci.* **2019**, *931*, 90–99. [CrossRef]
22. Li, Z.; Zhao, A.; Li, J.; Ke, Y.; Huo, S.; Ma, Y. Food and Nutrition Related Concerns Post Lockdown during Covid-19 Pandemic and Their Association with Dietary Behaviors. *Foods* **2021**, *10*, 2858. [CrossRef] [PubMed]
23. Bauerné Gáthy, A.; Kovácsné Soltész, A.; Szűcs, I. Sustainable Consumption-Examining the Environmental and Health Awareness of Students at the University of Debrecen. *Cogent Bus. Manag.* **2022**, *9*, 2105572. [CrossRef]
24. Gazdecki, M.; Goryńska-Goldmann, E.; Kiss, M.; Szakály, Z. Segmentation of Food Consumers Based on Their Sustainable Attitude. *Energies* **2021**, *14*, 3179. [CrossRef]
25. Zailani, S.; Iranmanesh, M.; Sean Hyun, S.; Ali, M. Applying the Theory of Consumption Values to Explain Drivers' Willingness to Pay for Biofuels. *Sustainability* **2019**, *11*, 668. [CrossRef]
26. Sheth, J.; Newman, B.; Gross, B.L. Why We Buy What We Buy: A Theory of Consumption Values. *J. Bus. Res.* **1991**, *22*, 159–170. [CrossRef]
27. Ordoñez Abril, D.Y.; Calderón Sotero, J.H.; Padilla Delgado, L.M. Revisión de Literatura de La Teoría Del Comportamiento Planificado En La Decisión de Compra de Productos Orgánicos. *Rev. Nac. Adm.* **2021**, *12*, e3178. [CrossRef]
28. Wang, R.; Strong, D. Beyond Accuracy: What Data Quality Means to Data Consumers. *J. Manag. Inf. Syst.* **1996**, *12*, 5–33. [CrossRef]
29. Nie, C.; Zepeda, L. Lifestyle Segmentation of US Food Shoppers to Examine Organic and Local Food Consumption. *Appetite* **2011**, *57*, 28–37. [CrossRef]
30. Gerini, F.; Alfnes, F.; Schjøll, A. Organic- and Animal Welfare-labelled Eggs: Competing for the Same Consumers? *J. Agric. Econ.* **2016**, *67*, 471–490. [CrossRef]
31. Andervazh, L.; Jalili, S.; Zanjani, S. Studying the Factors Affecting the Attitude and Intention of Buying Organic Food Consumers: Structural Equation Model. *Iran. J. Health Educ. Health Promot.* **2020**, *8*, 35–44. [CrossRef]
32. Wu, H.; Cheng, C.-C.; Ai, C.-H. What Drives Green Experiential Loyalty towards Green Restaurants? *Tour. Rev.* **2021**, *76*, 1084–1103. [CrossRef]
33. Yoshihiro, Y.; Kuo, H.M.; Shieh, C.J. The Impact of Seniors' Health Food Product Knowledge on the Perceived Value and Purchase Intention. *Rev. Cercet. Interv. Soc.* **2019**, *64*, 199–212. [CrossRef]

34. Yuen, K.F.; Chua, J.Y.; Li, X.; Wang, X. The Determinants of Users' Intention to Adopt Telehealth: Health Belief, Perceived Value and Self-Determination Perspectives. *J. Retail. Consum. Serv.* **2023**, *73*, 103346. [CrossRef]
35. Antošová, I.; Stávková, J. Changes in the Intensity and Impact of Factors Influencing Consumer Behaviour in the Food Market over Time. *Agric. Econ.* **2023**, *69*, 358–365. [CrossRef]
36. Moser, A. Consumers' Purchasing Decisions Regarding Environmentally Friendly Products: An Empirical Analysis of German Consumers. *J. Retail. Consum. Serv.* **2016**, *31*, 389–397. [CrossRef]
37. Javeed, A.; Aljuaid, M.; Khan, Z.; Mahmood, Z.; Shahid, D. Role of Extrinsic Cues in the Formation of Quality Perceptions. *Front. Psychol.* **2022**, *13*, 913836. [CrossRef]
38. Tian, Z.; Sun, X.; Wang, J.; Su, W.; Li, G. Factors Affecting Green Purchase Intention: A Perspective of Ethical Decision Making. *Int. J. Environ. Res. Public. Health* **2022**, *19*, 11151. [CrossRef]
39. Bursan, R.; Wiryawan, D.; Jimad, H.; Listiana, I.; Riantini, M.; Yanfika, H.; Widyastuti, R.; Mutolib, A.; Adipathy, D. Effect of Consumer Skepticism on Consumer Intention in Purchasing Green Product. *IOP Conf. Ser. Earth Environ. Sci.* **2022**, *1027*, 012037. [CrossRef]
40. Chen, H.; Eyoun, K. Do Mindfulness and Perceived Organizational Support Work? Fear of COVID-19 on Restaurant Frontline Employees' Job Insecurity and Emotional Exhaustion. *Int. J. Hosp. Manag.* **2021**, *94*, 102850. [CrossRef]
41. Japutra, A.; Vidal-Branco, M.; Higueras-Castillo, E.; Molinillo, S. Unraveling the Mechanism to Develop Health Consciousness from Organic Food: A Cross-Comparison of Brazilian and Spanish Millennials. *Br. Food J.* **2022**, *124*, 197–220. [CrossRef]
42. Chen, C.-C.; Chen, C.-W.; Tung, Y.-C. Exploring the Consumer Behavior of Intention to Purchase Green Products in Belt and Road Countries: An Empirical Analysis. *Sustainability* **2018**, *10*, 854. [CrossRef]
43. De Moraes, M.; Ruiz, M.; Puiggròs, C. "How Long Is Its Life?": Qualitative Analysis of the Knowledge, Perceptions and Uses of Fermented Foods among Young Adults Living in the City of Barcelona. *Rev. Esp. Nutr. Humana Y Diet.* **2021**, *25*, 365–375. [CrossRef]
44. Pu, B.; Zhang, L.; Tang, Z.; Qiu, Y. The Relationship between Health Consciousness and Home-Based Exercise in China during the Covid-19 Pandemic. *Int. J. Environ. Res. Public. Health* **2020**, *17*, 5693. [CrossRef]
45. Choi, M.; Law, R.; Heo, C. An Investigation of the Perceived Value of Shopping Tourism. *J. Travel. Res.* **2018**, *57*, 962–980. [CrossRef]
46. Loor-Noboa, A.; Paez-Salguero, K.; Moreno-Gavilanes, K. Compras Impulsivas de Nuevos Productos: Un Análisis Empírico Del Sector Comercial de La Provincia de Tungurahua. *593 Digit. Publ. CEIT* **2022**, *7*, 221–232. [CrossRef]
47. Wu, J.; Zhang, L.; Lu, C.; Zhang, L.; Zhang, Y.; Cai, Q. Exploring Tourists' Intentions to Purchase Homogenous Souvenirs. *Sustainability* **2022**, *14*, 1440. [CrossRef]
48. Gadeikiene, A.; Svarcaite, A. Impact of Consumer Environmental Consciousness on Consumer Perceived Value from Sharing Economy. *Eng. Econ.* **2021**, *32*, 350–361. [CrossRef]
49. Jamrozy, U.; Lawonk, K. The Multiple Dimensions of Consumption Values in Ecotourism. *Int. J. Cult. Tour. Hosp. Res.* **2017**, *11*, 18–34. [CrossRef]
50. Wibowo, S.F.; Ahmad, G.N. Perceived Value of Green Residence: The Role of Perceived Newness and Perceived Relative Advantage. *Int. J. Econ. Bus. Adm.* **2020**, *8*, 443–456. [CrossRef]
51. Zhou, Y.; Lyu, Y.; Zhao, R.; Shi, H.; Ye, W.; Wen, Z.; Li, R.; Xu, Y. Development and Validation of Nutrition Literacy Assessment Instrument for Chinese Pregnant Women. *Nutrients* **2022**, *14*, 2863. [CrossRef] [PubMed]
52. Fusva, A.; Dean, D.; Suhartanto, D.; Syarief, M.E.; Arifin, A.; Suhaeni, T.; Rafdinal, W. Loyalty Formation and Its Impact on Financial Performance of Islamic Banks—Evidence from Indonesia. *J. Islam. Mark.* **2020**, *12*, 1872–1886. [CrossRef]
53. Hermantoro, M. E-Servicescape Analysis and Its Effect on Perceived Value and Loyalty on e-Commerce Online Shopping Sites in Yogyakarta. *Int. J. Bus. Ecosyst. Strategy (2687–2293)* **2022**, *4*, 39–49. [CrossRef]
54. Kim, L.; Pongsakornrungsilp, S.; Pongsakornrungsilp, P.; Jindabot, T.; Kumar, V. Why Do Customers Want to Buy COVID-19 Medicines? Evidence from Thai Citizens. *Int. J. Environ. Res. Public. Health* **2023**, *20*, 5027. [CrossRef] [PubMed]
55. Ceyhan, A. The Impact of Perception Related Social Media Marketing Applications on Consumers' Brand Loyalty and Purchase Intention. *EMAJ Emerg. Mark. J.* **2019**, *9*, 88–100. [CrossRef]
56. Hernández-Nava, L.; Egnell, M.; Aguilar-Salinas, C.; Córdova-Villalobos, J.; Barriguete-Meléndez, J.; Pettigrew, S.; Hercberg, S.; Julia, C.; Galán, P. Impacto de Diferentes Etiquetados Frontales de Alimentos Según Su Calidad Nutricional: Estudio Comparativo En México. *Salud Publica Mex.* **2019**, *61*, 609. [CrossRef] [PubMed]
57. Abu-Elsamen, A.A.; Akroush, M.N.; Asfour, N.A.; Al Jabali, H. Understanding Contextual Factors Affecting the Adoption of Energy-Efficient Household Products in Jordan. *Sustain. Account. Manag. Policy J.* **2019**, *10*, 314–332. [CrossRef]
58. Hair, J.F., Jr.; Sarstedt, M.; Ringle, C.M.; Gudergan, S.P.; Castillo Apraiz, J.; Cepeda Carrión, G.A.; Roldán, J.L. *Manual Avanzado de Partial Least Squares Structural Equation Modeling (PLS-SEM)*; OmniaScience Scholar: Terrassa, Barcelona, 2019; ISBN 9788494799624.
59. Orea-Giner, A.; Fusté-Forné, F. The Way We Live, the Way We Travel: Generation Z and Sustainable Consumption in Food Tourism Experiences. *Br. Food J.* **2023**, *125*, 330–351. [CrossRef]
60. Predanócyová, K.; Árvay, J.; Šnirc, M. Exploring Consumer Behavior and Preferences towards Edible Mushrooms in Slovakia. *Foods* **2023**, *12*, 657. [CrossRef]
61. Otzen, T.; Manterola, C. Sampling Techniques on a Population Study. *Int. J. Morphol.* **2017**, *35*, 227–232. [CrossRef]

62. Kumar, A.; Prakash, G.; Kumar, G. Does Environmentally Responsible Purchase Intention Matter for Consumers? A Predictive Sustainable Model Developed through an Empirical Study. *J. Retail. Consum. Serv.* **2021**, *58*, 102270. [CrossRef]
63. Hair, J.; Sarstedt, M.; Hopkins, L.; Kuppelwieser, V. Partial Least Squares Structural Equation Modeling (PLS-SEM): An Emerging Tool in Business Research. *Eur. Bus. Rev.* **2014**, *26*, 106–121. [CrossRef]
64. Henseler, J.; Ringle, C.M.; Sarstedt, M. A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling. *J. Acad. Mark. Sci.* **2015**, *43*, 115–135. [CrossRef]
65. Chin, M.G. The Partial Least Squares Approach to Structural Formula Modeling. *Adv. Hosp. Leis.* **1998**, *8*, 295–336.
66. Hansen, T.; Thomsen, T.U. The Influence of Consumers' Interest in Healthy Eating, Definitions of Healthy Eating, and Personal Values on Perceived Dietary Quality. *Food Policy* **2018**, *80*, 55–67. [CrossRef]
67. Xu, J.; Wang, J.; Li, C. Impact of Consumer Health Awareness on Dairy Product Purchase Behavior during the COVID-19 Pandemic. *Sustainability* **2021**, *14*, 314. [CrossRef]
68. Carrasco-Solís, M.E.; Fernández-Alcántara, M.; Fernández-Ávalos, M.I.; Gómez-Vida, J.M.; Pérez-Iáñez, R.; Laynez-Rubio, C. Percepción Parental de Los Factores Relacionados Con La Obesidad y El Sobrepeso En Hijos/as Adolescentes: Un Estudio Cualitativo. *Rev. Española Nutr. Humana Y Dietética* **2022**, *26*, 178–188. [CrossRef]
69. Sutanto, I.S.; Wulandari, R. The Effect of Price Perception and Product Quality on Consumer Purchase Interest with Attitude and Perceived Behavior Control as an Intervention Study on Environmentally Friendly Food Packaging (Foopak). *Int. J. Sci. Manag. Stud. (IJSMS)* **2023**, *6*, 85–99. [CrossRef]
70. Sánchez-Feijoo, M.; Bonisoli, L. Conocer Para Actuar: El Conocimiento y La Preocupación Como Antecedentes de La Intención de Compra de Productos Orgánicos. *593 Digit. Publ. CEIT* **2022**, *7*, 92–100. [CrossRef]
71. Wang, C.; Guo, J.; Huang, W.; Tang, Y.; Man Li, R.Y.; Yue, X. Health-Driven Mechanism of Organic Food Consumption: A Structural Equation Modelling Approach. *Heliyon* **2024**, *10*, e27144. [CrossRef]
72. Sadiq, M.; Adil, M.; Paul, J. Does Social Influence Turn Pessimistic Consumers Green? *Bus. Strategy Environ.* **2021**, *30*, 2937–2950. [CrossRef]
73. Zahid, H.; Ali, S.; Danish, M.; Sulaiman, M. Factors Affecting Consumers Intentions to Purchase Dairy Products in Pakistan: A Cognitive Affective-Attitude Approach. *J. Int. Food Agribus. Mark.* **2022**, 1–26. [CrossRef]
74. Pu, Y.; Luo, R. How Promotes Consumers' Green Consumption of Eco-Friendly Packaged Food: Based on Value System. In Proceedings of the Sixteenth International Conference on Management Science and Engineering Management; Springer: Cham, Switzerland, 2022; pp. 313–326.
75. Wells, J.; Tan, C. Examining the Influence of Functional Value, Social Value and Emotional Value on Purchase Intention for Tires in Japan. *J. Asia Bus. Stud.* **2024**, *18*, 593–608. [CrossRef]
76. Chae, M.; Kim, Y.; Roh, T. Consumers' Attention, Experience, and Action to Organic Consumption: The Moderating Role of Anticipated Pride and Moral Obligation. *J. Retail. Consum. Serv.* **2024**, *79*, 103824. [CrossRef]
77. Vieria, A.; Raj, A.; De Almeida, M.; Lopes, E. How Cashback Strategies Yield Financial Benefits for Retailers: The Mediating Role of Consumers' Program Loyalty. *J. Bus. Res.* **2022**, *141*, 200–212. [CrossRef]
78. Calzolari, G.; Denicolò, V. Loyalty Discounts and Price-Cost Tests. *Int. J. Ind. Organ.* **2020**, *73*, 102589. [CrossRef]
79. Ahmed, S.; Al Asheq, A.; Ahmed, E.; Chowdhury, U.; Sufi, T.; Mostofa, M. The Intricate Relationships of Consumers' Loyalty and Their Perceptions of Service Quality, Price and Satisfaction in Restaurant Service. *TQM J.* **2023**, *35*, 519–539. [CrossRef]
80. Sharma, R.; Kaur, B. E-Mail Viral Marketing: Modeling the Determinants of Creation of "Viral Infection.". *Manag. Decis.* **2020**, *58*, 112–128. [CrossRef]
81. Mookherjee, S.; Lee, J.; Sung, B. Multichannel Presence, Boon or Curse?: A Comparison in Price, Loyalty, Regret, and Disappointment. *J. Bus. Res.* **2021**, *132*, 429–440. [CrossRef]
82. Pradana, M.; Elisa, H.; Syarifuddin, S. The Growing Trend of Islamic Fashion: A Bibliometric Analysis. *Cogent Soc. Sci.* **2023**, *9*, 2184557. [CrossRef]
83. Pradana, M.; Rubiyanti, N.; Marimon, F. Measuring Indonesian Young Consumers' Halal Purchase Intention of Foreign-Branded Food Products. *Humanit. Soc. Sci. Commun.* **2024**, *11*, 150. [CrossRef]
84. Sánchez González, I.; Benítez Luzuriaga, F.; Moscoso Parra, A.; Muñoz Suarez, M. Desarrollo Sostenible En Las Mipymes de Ecuador y Su Impacto En El Consumidor. *Cumbres* **2020**, *6*, 33–42. [CrossRef]
85. Bonisoli, L.; Micolta Bagui, P.E. Teoría de Valores de Consumo: Granjas Sostenibles En Ecuador. *Rev. Erud.* **2022**, *3*, 65–83. [CrossRef]
86. Corboș, R.; Bunea, O.; Triculescu, M.; Mișu, S. Which Values Matter Most to Romanian Consumers? Exploring the Impact of Green Attitudes and Communication on Buying Behavior. *Sustainability* **2024**, *16*, 3866. [CrossRef]
87. Ballco, P.; de-Magistris, T.; Caputo, V. Consumer Preferences for Nutritional Claims: An Exploration of Attention and Choice Based on an Eye-Tracking Choice Experiment. *Food Res. Int.* **2019**, *116*, 37–48. [CrossRef]
88. Peschel, A.O.; Kazemi, S.; Liebichová, M.; Sarraf, S.C.M.; Aschemann-Witzel, J. Consumers' Associative Networks of Plant-Based Food Product Communications. *Food Qual. Prefer.* **2019**, *75*, 145–156. [CrossRef]
89. Rödiger, M.; Hamm, U. How Are Organic Food Prices Affecting Consumer Behaviour? A Review. *Food Qual. Prefer.* **2015**, *43*, 10–20. [CrossRef]
90. Rana, J.; Paul, J. Consumer Behavior and Purchase Intention for Organic Food: A Review and Research Agenda. *J. Retail. Consum. Serv.* **2017**, *38*, 157–165. [CrossRef]

91. Pham, T.H.; Nguyen, T.N.; Phan, T.T.H.; Nguyen, N.T. Evaluating the Purchase Behaviour of Organic Food by Young Consumers in an Emerging Market Economy. *J. Strateg. Mark.* **2019**, *27*, 540–556. [CrossRef]
92. Ong, A.; German, J.; Almario, A.; Vistan, J.; Galang, J.; Dantis, J.; Balboa, E. Consumer Behavior Analysis and Open Innovation on Actual Purchase from Online Live Selling: A Case Study in the Philippines. *J. Open Innov. Technol. Mark. Complex.* **2024**, *10*, 100283. [CrossRef]
93. Liu, L.; Zhao, H. Research on Consumers' Purchase Intention of Cultural and Creative Products—Metaphor Design Based on Traditional Cultural Symbols. *PLoS ONE* **2024**, *19*, e0301678. [CrossRef] [PubMed]
94. McAdams, E.; Tingey, B.; Ose, D. Train the Trainer: Improving Health Education for Children and Adolescents in Eswatini. *Afr. Health Sci.* **2022**, *22*, 657–663. [CrossRef] [PubMed]
95. Sajeev, M.; Joshy, C. Exploring Perceptions and Health Awareness in Fish Consumption Across Coastal and Inland Kerala. *Indian. J. Ext. Educ.* **2024**, *60*, 100–104. [CrossRef]
96. Shoji, A.; Kudo, K.; Murashita, K.; Nakaji, S.; Igarashi, A. Reduction in All-Cause Medical and Caregiving Costs through Innovative Health Awareness Projects in a Rural Area in Japan: A Retrospective Cohort Study. *BMC Health Serv. Res.* **2024**, *24*, 370. [CrossRef] [PubMed]
97. Alhazmi, A. The Impact of COVID-19 Pandemic Linguistic Landscapes on Lifestyle, Health Awareness and Behavior. *World J. Engl. Lang.* **2024**, *14*, 359–375. [CrossRef]

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US Adults' Perceptions, Beliefs, and Behaviors towards Plant-Rich Dietary Patterns and Practices: International Food Information Council Food and Health Survey Insights, 2012–2022

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Abstract: Expert groups recommend that populations adopt dietary patterns higher in whole, plant-based foods and lower in red and processed meat as a high-impact climate action. Yet, there is limited understanding of populations' willingness to adopt plant-rich dietary patterns. This study examined United States (US) adults' perceptions, beliefs, and behaviors towards plant-rich dietary patterns and practices over a decade. Fifteen questions from the International Food Information Council's Food and Health Surveys (2012–2022) were analyzed across four sustainability domains (i.e., human health, environmental, social, and economic domains). Most respondents had favorable perceptions of environmentally sustainable food and beverages, but sustainability influenced less than half of consumers' purchase decisions. Plant-rich dietary pattern adherence increased across survey years (12.1% [2019] to 25.8% [2022], $p < 0.001$). One-quarter (28.1%) of Americans reported reducing their red meat intake over 12 months (2020–2022). Yet, another 15.5% reported greater red meat intake, and 18.8% reported greater plant-based meat alternative (PBMA) intake over 12 months. The percentage of respondents who reported greater red meat and PBMA consumption in the previous 12 months significantly increased across the years surveyed (2020–2022, $p < 0.05$). IFIC Survey findings highlight growing US consumer awareness of health, environmental, and social sustainability but low adoption of plant-rich dietary patterns and practices. Government leadership and coordinated actions by health professionals, civil society, and businesses are needed to educate and incentivize Americans to adopt plant-rich dietary behaviors, and greater industry transparency is needed to show how food and beverage products support human and planetary health.

Keywords: sustainable diets; sustainability; eating behavior; red meat; plant-based meat alternatives; planetary health

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1. Introduction

The United States' (US) food system and the average American dietary pattern are not sustainable for supporting long-term human and planetary health and societal well-being [1,2]. There is growing consensus that sustainable diets support nutrition security and human health, environmental and ecological health, social equity, and economic prosperity [3–5]. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) emphasize that sustainable diets "promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe, and equitable; and are culturally acceptable" to support current and future generations [6].

Reducing human consumption of red and processed meats (RPM) and shifting people toward dietary patterns higher in minimally processed, whole-plant-based foods (i.e., pulses, legumes, whole grains, nuts, seeds, fruits, and vegetables) is a high-impact action that can mitigate the food system's impact on climate change [1,7–9]. This strategy has been recommended by US and international expert bodies to promote human and planetary health [6,10–13].

The current Western diet followed by many Americans is characterized by excessive intake of sugary beverages, meat, refined grains, and highly processed foods rich in added sugars and sodium, as well as low intake of fruits, vegetables, nuts and seeds, whole grains, and seafood [8,14,15]. The high US consumer demand for and overconsumption of red meat (i.e., beef, pork, and lamb) and processed meats is of particular concern, as diets rich in these products are linked to an increased risk of type 2 diabetes, heart disease, stroke, and colorectal cancer in individuals and populations [16–18]. The large-scale industrialized agricultural production of beef in the US contributes to environmental degradation, as it requires significant water and land use compared to plant-based foods, and produces substantial greenhouse gas emissions, especially methane, that negatively impact the climate [8,19,20]. Many US dietary patterns align with the broader definition of a sustainable diet devised by the FAO and WHO (Figure 1). These patterns can collectively be described as plant-rich dietary patterns and are associated with lower NCD risks and lower environmental impacts (or equivalent, in the case of the Healthy US-Style) compared to the Western diet followed by most Americans [8,9,11,20,21].

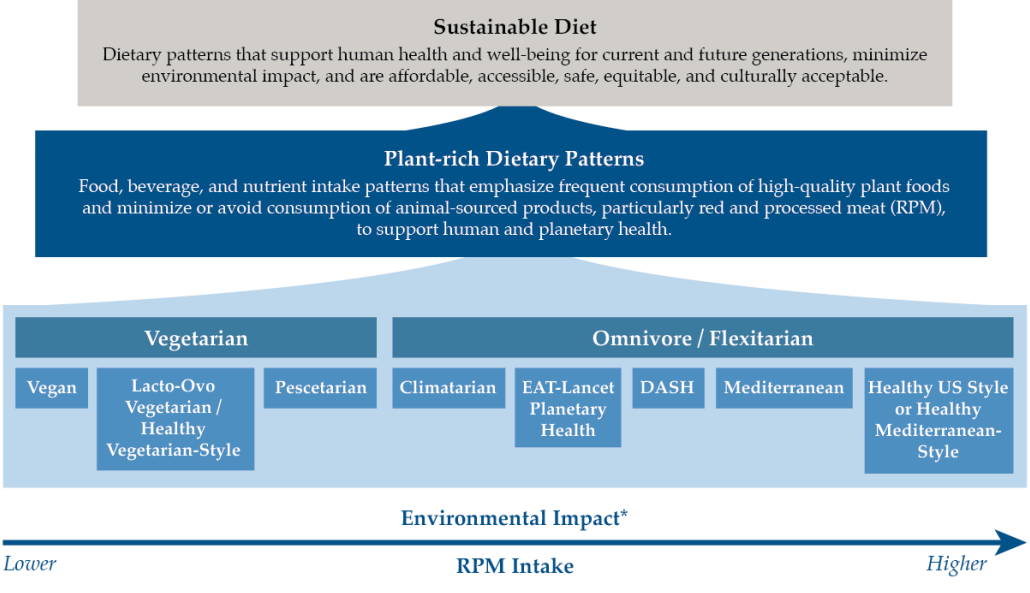


Figure 1. Plant-rich dietary patterns that support sustainable dietary transitions for US adults [6–8,10,12,20]. * The environmental impact estimate is based on the level of animal-sourced protein intake, particularly RPM intake, as there is substantial evidence to suggest that dietary patterns high in plant-based foods and low in or free from animal-sourced foods have lower greenhouse gas emissions and land use. These patterns may also have lower water and energy use, although this depends on the types of plant-based foods consumed.

The emphasis on plant-rich dietary patterns has contributed to a steep rise in the quantity of plant-based food products available in the US marketplace, particularly plant-based meat alternative (PBMA) products, which aim to mimic the sensory attributes of traditional meat products and undergo substantial industry processing [22,23]. PBMA

products may offer environmental and animal welfare benefits compared to traditional meat products [24,25]. However, there is limited evidence that these products will support human health [22,26]. Many PBMA products lack the daily requirements of certain nutrients of which animal-sourced foods are key sources (e.g., vitamin B12 and iron), raising concerns about their use as direct replacements for red meat and other animal-sourced proteins [22,26].

The published literature provides limited insights on American adults' perceptions, beliefs, and behaviors regarding adopting plant-rich dietary patterns and practices, which could inform community- and population-level strategies to drive greater sustainability action. A 2023 scoping review on sustainable diet-related consumer attitudes and behaviors found only three published US-based studies and four multi-country studies that included US consumers [27]. Research into consumer perceptions and behaviors has mainly focused on the health and environmental aspects of sustainability rather than the use of a multi-dimensional approach that considers all four sustainability domains (i.e., human health, environmental, social, and economic domains) [27,28]. Encouraging the adoption of plant-rich dietary patterns requires greater understanding of Americans' beliefs, motivations, and behaviors for selecting food and beverage products that align with such patterns.

The National Health and Nutrition Examination Surveys (NHANES) are the US Government's primary method for assessing trends in American adults' health and nutritional status [29], but these surveys do not currently include sustainable diet metrics. Since 2006, the International Food Information Council (IFIC) has independently conducted annual Food and Health Surveys that assess Americans' perceptions, beliefs, and behaviors related to food and beverage purchases and consumption, including sustainability components. Several publications have described diet and health trends based on the IFIC Food and Health surveys [30–32]. However, no published analysis has comprehensively examined the sustainable diet metrics included in these surveys over the past decade (2012–2022).

The purpose of this study is to conduct a secondary data analysis of the annual IFIC Food and Health Surveys carried out over the past decade (2012–2022). We sought to analyze US adults' perceptions, beliefs, and behaviors regarding plant-rich dietary patterns and practices (e.g., reducing RPM intake and purchasing sustainable food and beverage products) across four sustainability domains (i.e., human health, environmental, social, and economic domains). Differences in perceptions, beliefs, and behaviors based on the respondent's age, gender, and household income level were assessed to identify how different US adult sub-populations may contribute to sustainable dietary transitions.

2. Materials and Methods

2.1. IFIC Survey Participants and Data Collection Procedures

The 2012–2022 IFIC Food and Health Surveys were based on a representative sample of the US adult population (aged 18 to 80 years old) and ranged from 62 to 84 survey items each year. Weighting was used to ensure that the distribution of the sample reflected that of the US adult population, guided by the latest annual Current Population Survey available at the time of survey administration [33]. The samples were specifically weighted by age, education, race/ethnicity, region, and gender. The surveys were collected online by Greenwald and Associates using Dynata's (formerly ResearchNow) consumer panel [34]. The IFIC Food and Health Surveys (2012 to 2022) were completed in an average of 24.2 min. The survey sample size ranged from a high of 1058 respondents in 2012 to a low of 1002 respondents in 2017, with an average sample size of 1012 adult participants per survey year. While select questions remained consistent across the survey years, the IFIC changed some survey questions or response options each year. The full survey results by year are available on the IFIC's website.

2.2. Procedures

For this secondary retrospective study, Food and Health Survey data were obtained through a formal request to the IFIC, after which the researchers independently analyzed the data. Eleven Food and Health Surveys (2012–2022) were reviewed to identify and

analyze questions relevant to at least one of the four sustainable diet domains (i.e., human health, environmental, social, and economic domains) [4,5]. Relevant questions were those that were asked in at least two Food and Health Surveys. Open-ended questions, as well as responses that were not offered in at least two survey years, were excluded. Questions about food access, food safety, food waste, and access to nutrition information were beyond the scope of these surveys and, therefore, not analyzed in this study.

2.3. Analysis

A cross-tabulation analysis [35] using Statistical Package for the Social Sciences (SPSS) version 29.0 [36] was conducted for 15 IFIC Food and Health Survey questions, as shown in Supplementary Table S1. One question related solely to the health domain, five to the environmental domain, seven to the health and environmental domains, one to the social and environmental domains, and one to all four sustainability domains. Responses to the 15 survey questions were analyzed by household income group to indirectly capture components of the economic sustainability domain. All 15 questions were analyzed by respondents' age (categorized by generation, based on Pew Research Center definitions [37]), gender, and household income level (Table 1). Questions were analyzed as single items rather than summed or indexed. Survey responses were provided as means and ranges or percentages. Chi-square analyses were conducted on selected questions to assess the significance of trends across survey years. Given the changes in the annual IFIC survey questions and response options over time, more detailed statistical analyses were not feasible for some of the questions.

Table 1. Demographic characteristics of respondents used for the International Food Information Council Food and Health Survey analysis (2012–2022).

Demographic Characteristic	Groups Used for Analysis	Source
Gender	Male, female	2012–2018 Food and Health Surveys: "male" and "female" were the only gender options that respondents could choose. 2019–2022 Food and Health Surveys: "prefer not to say" and "other" response options were added. [1]
Generation (years)	Silent Generation (born 1928–1945) Baby Boomers (born 1946–1964) Generation X (born 1965–1980) Millennials (born 1981–1996) Generation Z (born 1997–2012)	2012–2022 Food and Health Surveys: age was collected as a continuous variable (18–80 years old). Generational age based on Pew Research Center definitions [37].
Household income	Lower income ($0 to <$75,000 USD) Higher income ($75,000 to $150,000+ USD)	The 2012–2022 Food and Health Surveys included six income groups that were divided into two groups (i.e., lower income and higher income) for this analysis. [2]

USD = US dollars. [1] Only "male" and "female" options were analyzed for consistency across survey years, and they are referred to as "men" and "women", respectively, in this paper. [2] Individuals who responded "not sure" or "prefer not to answer" for household income level were excluded from the income-related analyses.

3. Results

This section presents selected results from the cross-tabulation analysis of the 15 IFIC Food and Health survey questions relevant to plant-rich dietary patterns and principles. One question related to the adoption of or adherence to plant-rich dietary patterns. The other 14 relevant IFIC questions related to consumer perceptions, beliefs, and behaviors regarding plant-rich dietary principles. These questions fell into four main categories: red meat and plant protein consumption, sustainable food and beverage considerations, sustainable food and beverage purchases, and access to sustainable food and beverage information.

3.1. Plant-Rich Dietary Pattern Adherence

From 2019 to 2022, the percentage of respondents who reported following any plant-rich dietary pattern (i.e., vegetarian, vegan, Mediterranean, plant-based, flexitarian, or Dietary Approaches to Stop Hypertension [DASH]) in the past year more than doubled (12.1% [2019] to 25.8% [2022], $X^2[1, N = 2060] = 62.788$, $p < 0.001$). Younger consumers (i.e., Generation Z [born 1997–2012] and Millennials [born 1981–1996]) were more likely to follow a plant-rich pattern than older consumers (i.e., Generation X [born 1965–1980], Baby Boomers [born 1946–1964], and the Silent Generation [born 1928–1945] [37]) across all four years surveyed. In 2022, nearly twice as many young consumers reported following plant-rich dietary patterns compared to 2019 (19.3% vs. 37.1%, $X^2[1, N = 748] = 26.894$, $p < 0.001$), while more than three times as many older consumers followed these dietary patterns (9.0% vs. 17.3%, $X^2[1, N = 1312] = 20.307$, $p < 0.001$).

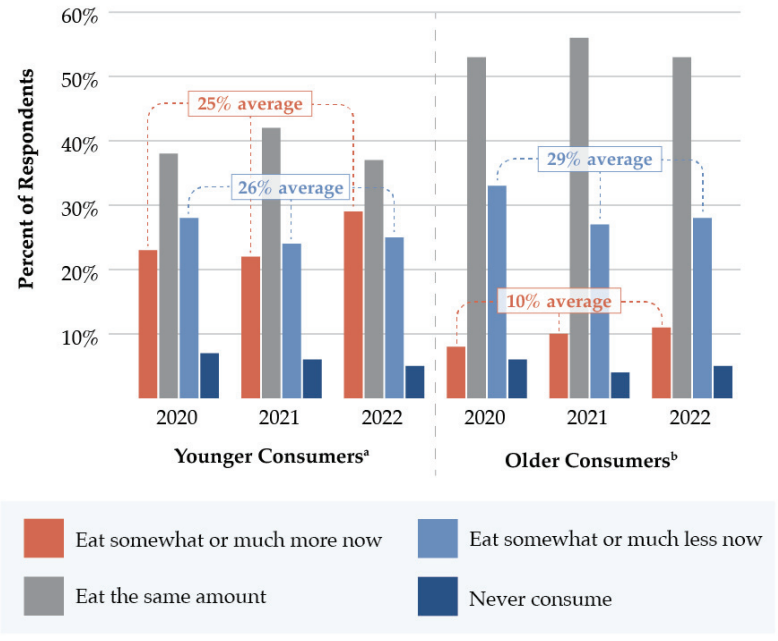
Over this time period, vegetarian or vegan dietary pattern adherence varied between 3.1% (2021) and 6.1% (2022), with an average of 4.6% of respondents following vegetarian or vegan dietary patterns. Mediterranean dietary pattern adherence ranged from 4.3% (2021) to 5.8% (2020), with an average of 5.2% of respondents following this dietary pattern, while DASH adherence was steady from 2019 to 2021 (1.9% average), before increasing to 5.5% in 2022. Adherence to a flexitarian dietary pattern significantly increased across the survey years from 2.1% to 7.4% (2019–2022, $X^2[1, N = 2060] = 32.424$, $p < 0.001$), while plant-based dietary adherence increased from 4.0% to 11.8% ($X^2[1, N = 2060] = 43.624$, $p < 0.001$) in the same time period. Younger respondents were more likely to follow plant-based and flexitarian dietary patterns than older generations in all four survey years.

3.2. Red Meat and Plant Protein Consumption

In 2016, the IFIC Food and Health Surveys asked consumers about their perceptions of the healthfulness of animal proteins and proteins from plant sources (i.e., "plant proteins") and added questions about the consumption of these products from 2019. Across all years surveyed (2016–2020), less than half of consumers (38.7% average) indicated that animal proteins were healthy (range: 34.9–42.8%), compared to more than two-thirds (73.5% average) that identified plant proteins as healthy (range: 69.4–75.4%). From 2016 to 2019, the percentage of consumers who stated that animal proteins were unhealthy increased from 10.3% to 16.4%, before dipping to 15.4% in 2020.

The consumption of animal and plant protein products was mixed across respondents. About one-quarter (24.1% average; 2019–2020) of respondents reported that they actively tried to consume animal proteins, while another one-quarter (23.3% average) tried to limit or avoid them; more than one-third of respondents (38.1% average) actively tried to consume plant proteins.

From 2020 to 2022, the percentage of respondents who reported eating somewhat or much more red meat in the past 12 months increased from 13.1% to 18.7% ($X^2[1, N = 2059] = 12.248$, $p < 0.001$). Red meat consumption increased over time among both women and men. In 2020, respondents were more than twice as likely to report decreased (31.3%) versus increased (13.1%) red meat intake. However, by 2022, this gap substantially decreased, as the percentage of respondents who reported less red meat intake dropped to 27.1% compared to 18.7% who reported eating more red meat. Women were more likely than men to report reduced red meat intake across all survey years. Younger consumers were substantially more likely to report increased red meat consumption in the past 12 months (25% average) compared to older adults (10% average) in all three survey years (Figure 2). In 2020 and 2021, individuals with lower incomes were more likely to report eating more red meat in the past 12 months than those with higher incomes (15.5% vs. 12.4% average). However, in 2022, more individuals with higher incomes reported increased meat intake (22.3%) compared to those with lower incomes (17.8%).



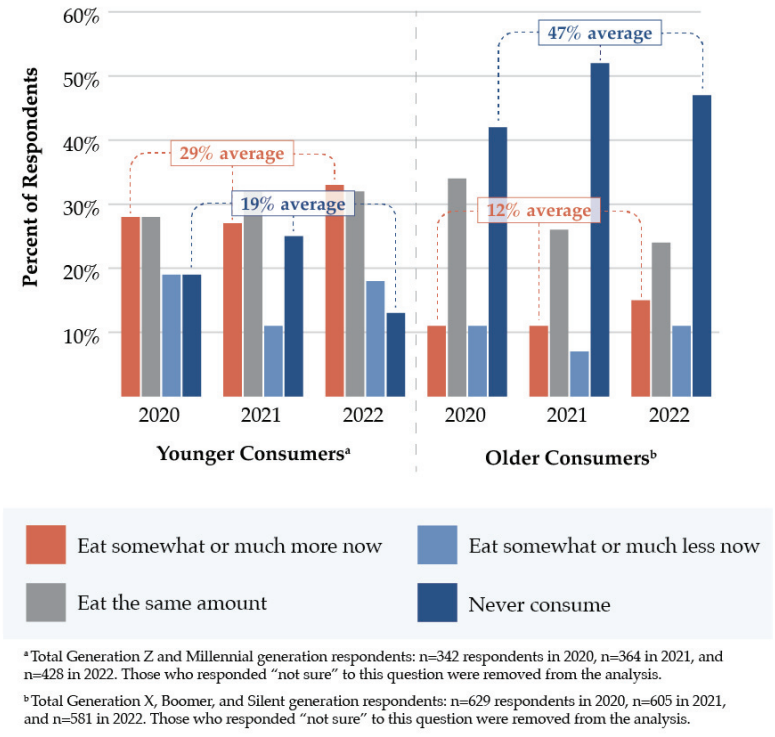
a Total Generation Z and Millennial generation respondents: n=349 respondents in 2020, n=366 in 2021, and n=436 in 2022. Those who responded "not sure" to this question were removed from the analysis.

b Total Generation X, Boomer, and Silent generation respondents: n=642 respondents in 2020, n=608 in 2021, and n=583 in 2022. Those who responded "not sure" to this question were removed from the analysis.

Figure 2. Changes in red meat consumption in the past 12 months among younger versus older consumers, as captured in the International Food Information Council Food and Health Surveys (2020–2022).

On average, nearly one fifth (18.8%) of respondents reported increased PBMA intake in the past 12 months (2020–2022). Across the survey years, the number of respondents who reported greater PBMA intake significantly increased (17.0% [2020] to 22.3% [2022], $X^2[1, N = 2059] = 9.184$, $p < 0.05$), particularly among men and individuals from high-income households. In the 2022 survey, the wording for this question was updated from "plant-based meat alternatives" to "plant-based meat and seafood alternatives", which may have contributed to this trend.

In 2020, 24.4% of respondents who reported increased PBMA intake also reported increased red meat intake in the previous 12 months. By 2022, 41.0% of those who reported increased PBMA consumption had also increased their red meat intake over the same 12-month period. Younger consumers were more likely than older consumers to report greater PBMA intake (29% vs. 12% average, 2020–2022), while older adults were substantially more likely to report that they never consumed PBMAs (Figure 3). From 2020 to 2021, 12-month PBMA intake was consistent between higher-income and lower-income groups and increased among both groups in 2022, but especially among those with higher household incomes.



[a] Total Generation Z and Millennial generation respondents: n=342 respondents in 2020, n=364 in 2021, and n=428 in 2022. Those who responded "not sure" to this question were removed from the analysis.

[b] Total Generation X, Boomer, and Silent generation respondents: n=629 respondents in 2020, n=605 in 2021, and n=581 in 2022. Those who responded "not sure" to this question were removed from the analysis.

Figure 3. Changes in plant-based meat alternative consumption in the past 12 months between younger and older consumers, as captured in the International Food Information Council Food and Health Surveys (2020–2022).

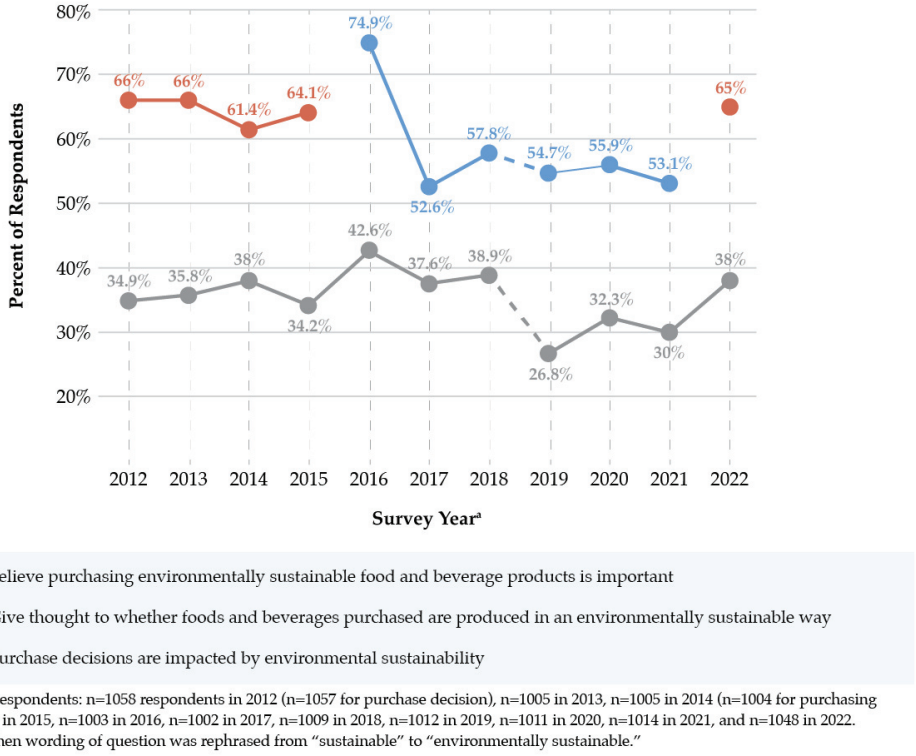
3.3. Sustainable Food and Beverage Purchases

From 2012 to 2018, sustainability was consistently ranked as the least important factor in US consumers' food and beverage purchase decisions following convenience, price, healthfulness, and taste. On average, only one third of consumers (37.4%) believed that sustainability had a substantial or great influence on their purchase decisions (range: 34.2–42.6%, 2012–2018). In the 2019–2022 surveys, "sustainability" was re-phrased to "environmental sustainability". Following this change, average consumer responses further declined to less than one third (31.8%) of respondents who indicated that environmental sustainability had a substantial or great impact on purchase decisions (range: 26.8–38.0%, 2019-2022) (Figure 4). Taste was the most important factor for consumers across all years (2012–2022). Women were consistently more likely than men to report that "sustainability" or "environmental sustainability" influenced their purchases over the 11-year survey period.

In comparison, over the past decade, more than 60% of US consumers, on average, indicated that healthfulness had a substantial influence on their food and beverage purchases (range: 59.4–70.7%, 2012–2022). However, between 2012 and 2015, the percentage of consumers who reported giving a lot of thought to the healthfulness of their food and beverage consumption steadily decreased from 57.8% to 48%, and this figure further decreased to 39.6% of consumers in 2022.

Most consumers, particularly women, considered whether food and beverage products were produced in an environmentally sustainable way, and this figure was steady across the survey years (64.4% average, 2012–2015). In 2022, the responses remained consistent, with 65% of respondents indicating that they gave at least a little thought to sustainability, 24.1% of whom gave a lot of thought to this issue (Figure 4). Yet, only half of respondents

(50.8%) reported a belief that their individual food and beverage purchases had a moderate or significant impact on the environment, up from 42.5% in 2021. Younger generations were more likely to state that their dietary choices had a significant environmental impact, which decreased with increasing generational age (2021–2022).



[a] Total survey respondents: n=1058 respondents in 2012 (n=1057 for purchase decision), n=1005 in 2013, n=1005 in 2014 (n=1004 for purchasing belief), n=1007 in 2015, n=1003 in 2016, n=1002 in 2017, n=1009 in 2018, n=1012 in 2019, n=1011 in 2020, n=1014 in 2021, and n=1048 in 2022.
- - - denotes when wording of question was rephrased from "sustainable" to "environmentally sustainable."

Figure 4. Consumer perceptions, beliefs, and behaviors towards the environmental sustainability impacts of food and beverage products, as captured in the International Food Information Council (IFIC) Food and Health Surveys (2012–2022).

When explicitly asked whether purchasing or consuming sustainably produced products was important, 74.9% of respondents reported that it was somewhat or very important in 2016. This value decreased in 2017 but remained consistent between 52.6% and 57.8% each year (2017–2021), even when "sustainable" was rephrased to "environmentally sustainable" for the 2019–2021 surveys (Figure 4). Women were more likely than men to report that purchasing or consuming sustainable products was important to them in each of the years surveyed.

Among consumers who identified sustainable production as being important, conserving natural habitat and reducing pesticide use were the most important sustainable food production aspects identified in all three of the years surveyed (2016–2018). Baby Boomers and Silent Generation respondents were more likely than younger generations to identify pesticide use as an important sustainability concern. Most consumers also indicated that knowing where their food came from influenced their decision to purchase certain foods and beverages (range: 52.7–56.2%, 2017–2020). In 2021 and 2022, consumers were also asked about the significance of knowing that food system workers were treated in a fair and equitable way on food purchases. More than half of respondents (59%) identified this as important in 2021, although this number decreased to 44.7% of respondents in 2022.

3.4. Access to Sustainable Food and Beverage Information

On average, nearly two-thirds (64.1%) of respondents, especially women, agreed that it was hard for consumers to know whether the food choices that they made were environmentally sustainable (2019–2020). Most respondents (61.2% average) also agreed that if it was easier to find this information, it would have had a greater influence on their food and beverage choices (2019–2021). Across the three years studied, younger respondents were more likely to agree with this statement than older adults. Less than one quarter of respondents indicated that they purposefully purchased foods labeled as organic (26.5% average, 2019–2021), locally sourced (25.7% average, 2019–2021), environmentally friendly (21% average, 2019–2020), or plant-based (15.5% average, 2020–2021).

Among individuals that identified environmentally sustainable food production methods as important (2019–2022), the most frequent identifiers of sustainably produced product were recyclable packaging and labels that indicated locally grown, sustainably sourced, and non-genetically modified organisms (GMO)/organisms that were not bioengineered (Table 2). Consumers' reported use of locally grown and organic labels to identify environmentally sustainable food products showed a consistent decline across the survey years, falling from 51.8% (2019) to 32.7% (2022) for locally grown labeling and from 43.4% (2019) to 30.7% (2022) for organic labeling (Table 2).

Table 2. Food product characteristics that consumers reported using to identify environmentally sustainable food products in the International Food Information Council Food and Health Surveys (2019–2022).

Response Option	Survey Year (*n* = Number of Respondents [1])				
	2019 (*n* = 554)	**2020 (*n* = 565)**	**2021 (*n* = 538)**	**2022 (*n* = 784)**	**2019–2022 Average**
Recyclable Packaging	43.9%	45.5%	53.0%	40.8%	45.8%
Minimal/Reusable Packaging	37.0%	35.6%	42.4%	29.6%	36.2%
Labeled as Organic	43.3%	40.4%	34.8%	30.7%	37.3%
Labeled as Being Locally Grown	51.8%	43.4%	38.1%	32.7%	41.5%
Labeled as Sustainably Sourced	46.0%	47.1%	45.2%	35.1%	43.4%
Labeled as Non-GMO/Not Bioengineered	46.2%	42.7%	35.7%	27.8%	38.1%
Labeled as Bioengineered/ Containing Bioengineered Ingredients [2]	N/A	17.0%	13.2%	16.5%	15.6%

GMO = Genetically modified organism. [1] This question was only asked to individuals who responded that it was "somewhat important" or "very important" to know that the products that they purchase or consume are produced in a sustainable way, so these totals do not align with the total survey participants for 2019–2022. [2] This response option was only offered in the 2020–2022 surveys.

When asked to compare two products with the same Nutrition Facts Panel, about one-third of consumers believed that a product labeled as "having a small carbon footprint" (32.7% average, 2021–2022) or one that was produced in an environmentally sustainable way (38.1% average, 2019–2021) was healthier than an otherwise identical, non-sustainable product. For both characteristics, younger consumers were more likely than older generations to identify these products as healthier for people and the planet. Similarly, more than 40% of consumers believed that a food labeled as "plant-based" was healthier than an identical alternative product (43.7% average, 2019–2021).

4. Discussion

The IFIC survey analysis is discussed in relation to other US-focused consumer research and in the context of future research to better understand consumers' sustainability-related perceptions, beliefs, and behaviors. Policy and practice recommendations are

provided to enhance the enabling environment for consumer behavior change with regard to plant-rich dietary patterns and practices.

4.1. Plant-Rich Dietary Pattern Adherence

The IFIC survey results indicate Americans' low overall adherence to plant-rich dietary patterns, although adherence significantly increased across the survey years and within specific populations. The finding that a small proportion of survey respondents followed a vegetarian or vegan dietary pattern aligns with other US surveys that indicated the low uptake of these patterns. Cramer et al. (2017) [38] found that an estimated 4% of Americans had previously followed a vegetarian or vegan diet for health reasons, with 1.9% having done so within the prior 12 months. Consumer surveys by Gallup (2018) and McKinsey and Company (2022) indicated that 5–8% of Americans surveyed followed a vegetarian or vegan diet [39,40].

Low adoption of plant-rich dietary patterns may be due to a lack of consumer awareness of these dietary patterns or knowledge of their health benefits. For instance, when the flexitarian dietary pattern was described in detail in a 2022 McKinsey and Company consumer survey, 46% of consumers reported following this eating pattern (which was also referred to as "casual vegetarianism") [39]. A taste preference for meat versus plant-based proteins and disparities in food access and agency (the ability to secure and prepare foods and meals based on one's context) could also play roles in the low adoption of plant-rich dietary patterns among Americans [27,41].

These findings indicate a need for the provision of greater consumer education by nutrition and health professionals regarding the health, environmental, and animal welfare benefits of adopting such patterns. Educational or social change campaigns like Veganuary [42] and the Have a Plant movement [10], which encourage reducing RPM intake and its replacement with minimally processed plant-based foods, could be used to increase consumer sustainability education and behavior change. While vegetarian dietary patterns that eliminate many or all animal-sourced products generally have the lowest environmental impact [7,8], these patterns may not be acceptable to many Americans. Coordinated efforts are needed to motivate consumers to adopt flexitarian plant-rich dietary patterns (Figure 1) to support both human and planetary health.

4.2. Red Meat and Plant Protein Consumption

Studies from the US and other high-income countries have identified low consumer awareness of the environmental impacts of meat production and consumption and low willingness to reduce meat consumption [27,43,44]. Similar to the IFIC Food and Health Survey findings, other recent studies and US consumer polls have indicated that Americans are willing to reduce their meat intake for human health benefits more often than for environmental or animal welfare concerns [27,39,45]. US men, particularly those from low-income households, had higher total and red meat consumption than women and were less likely to reduce meat consumption [45–47]. Greater red meat intake among men has been linked to cultural associations between red meat and masculinity [46,47], which may have contributed to the differences seen between genders in IFIC Surveys.

However, the IFIC Food and Health Survey data showed that a significant portion of consumers increased their red meat consumption in recent years, which aligns with analyses showing that per capita red meat consumption has increased in the US over the past decade [48,49]. The Coronavirus Disease of 2019 (COVID-19) pandemic led to decreased red meat production due to facility closures, workforce shortages, and increased sanitation and cleaning procedures, which subsequently contributed to increased red meat prices [50]. The finding that the percentage of Americans who reported greater red meat intake increased amid the COVID-19 pandemic (2020–2022) was, therefore, unexpected.

The IFIC Food and Health Survey results indicated consumer interest in plant-based proteins, coupled with increased consumption of PBMAs, in recent years. A separate 2022 IFIC survey on PBMA consumption found that 65% of Americans had consumed PBMAs

in the past year, with healthfulness and high-quality protein cited as the two top reasons for consuming these products [51]. The finding that young consumers reported greater PBMA intake than older adults aligns with prior studies that found that individuals who consumed PBMA products were more likely to be less than 35 years of age [52,53] and live in high-income households (>$100,000) [53]. However, these studies also found that PBMA consumers were more likely to be female [52,53], which was not supported by the IFIC Food and Health Survey findings. The finding that many respondents reported increased red meat and PBMA consumption within the same year supports the evidence suggesting that consumers may eat PBMA products in addition, to rather than in place of, traditional meat products [39,53].

The higher price of PBMA products compared to traditional meat products may have contributed to the smaller increase in PBMA consumption among individuals with lower compared to higher household incomes reported in the 2022 Food and Health Survey [54]. Likewise, nutrition insecurity and participation in federal nutrition assistance programs increased during the COVID-19 pandemic [55], showing that a large proportion of the US population faced financial burdens that may have been reflected in the differences in increased PBMA and red meat consumption between household income groups. Yet, given the increased meat prices during the COVID-19 pandemic [50], it was surprising to find that in the 2022 survey, both income groups reported increased red meat intake in the past 12 months (a reflection of their 2021–2022 intake). Government food assistance initiatives (e.g., the Farmers to Families Food Box initiative and the Emergency Food Assistance Program) that, during the COVID-19 pandemic, distributed US agricultural products, including meats, to individuals and families in need may have contributed to this increase [56]. The 2022 finding that individuals with lower incomes were less likely to report increased red meat intake aligns with findings from Ritzel & Mann (2021) [46]. These researchers found that household income has a negative effect on total and red meat consumption in the US [46]. However, the results of the 2020 and 2021 IFIC Surveys did not support this trend. Future research should study how income differences affect US consumers' willingness and capacity to reduce red meat intake and increase consumption of plant-based proteins.

Increased action is needed to nudge American consumers towards sustainable dietary changes. Taxes on high-environmental-impact products like RPM, subsidies for low-impact products, or making sustainable food choices the default at food outlets could be used to shift consumer behavior to support planetary health [27,44]. Adopting subsidies for healthy foods (i.e., fruits, vegetables, and whole grains) has the potential to reduce NCD deaths and improve food access and economic health disparities in the US [57]. Given concerns about the implications of highly processed PBMA products for human health, places, and the planet [26], additional research and US Government and expert guidance is needed to explain how consumers should incorporate these products into plant-rich dietary patterns.

4.3. Sustainable Food and Beverage Purchases

The findings of IFIC Food and Health Surveys indicate a discrepancy between consumers' perceptions of environmentally sustainable food and beverage products and their behaviors. Although most adult consumers reported thinking about whether the products that they purchased were produced in an environmentally sustainable way and supported purchasing sustainable products, these thoughts did not appear to influence many consumers' purchasing decisions. A 2022 McKinsey and Company consumer survey also found that while most US consumers (64%) identified sustainable solutions as important, less than half of these consumers reported a willingness to pay more for sustainable options or eat more sustainable products [39].

The past decade of IFIC Food and Health Surveys showed that US consumers ranked environmental sustainability far below many other metrics (i.e., convenience, healthfulness, price, and taste) that influenced their food and beverage purchase decisions. Similarly, a 2022 multi-country systematic review found that taste, price, and individual health influenced

consumers' food purchases more than environmental sustainability [43]. A 2022 assessment of how American consumers' shopping habits aligned with healthy diets for sustainable food systems found that taste and economic factors, such as affordability and access, ranked above environmental and social factors [58]. These results suggest that despite being interested in supporting environmentally and socially sustainable products, consumers either purchased fewer of these products or were unaware of how these products may support sustainable diets. The 2023 IFIC Food and Health Survey revealed that most Americans were not willing to pay more for healthier or socially sustainable products due to inflation and the consequent rising prices of groceries [59].

The decrease in Food and Health Survey respondents' recognition of the importance of fair and equitable worker treatment between 2021 and 2022 may have been a result of the COVID-19 pandemic. Vulnerabilities in the US food system and inequities and injustice among food system workers deemed essential during the pandemic were at the forefront of media coverage in 2020–2021 period [60,61].

Notably absent from the IFIC Food and Health Surveys were questions that addressed economic sustainability principles, such as the impact of food accessibility and affordability on consumers' sustainability actions. Shifting towards more sustainable diets that support human and planetary health may not be affordable for low-income Americans [62]. This highlights the need to consider the economic sustainability domain when assessing consumer behaviors and their policy implications [5]. Current research into sustainable dietary patterns emphasizes the environmental and health benefits of such diets [4,27], but additional research is needed to fully capture their economic and social implications for Americans.

4.4. Access to Sustainable Food and Beverage Information

The IFIC Food and Health Survey findings indicate that consumers are interested in but cannot access environmental sustainability information about the food and beverage products that they purchase and consume. Similarly, a 2022 McKinsey and Company consumer survey identified that nearly half of US consumers had trouble understanding what actions to take to be more sustainable [39]. The IFIC Survey results also indicate that consumers having a clearer understanding of how their dietary behaviors could influence sustainability and drive greater adoption of plant-rich dietary practices. Consumers need greater transparency from industry to access environmental and social sustainability information. Advocates and civil-society organizations should hold industry accountable for prioritizing the influence of their food and beverage products across all four sustainability domains, as well as for publicizing this information through the annual reporting of sustainability metrics.

Many US companies are adopting labeling schemes that highlight the ecological or social sustainability aspects of their products, such as carbon footprint labels [63]. These labeling schemes are voluntary and largely led by industry. The IFIC Survey results indicate that consumers may misconstrue products with environmental sustainability attributes (i.e., small carbon footprint labels, sustainable production methods) as being implicitly healthier, creating a "health halo" around these products. Research indicates that nutrition labeling can encourage consumers to make healthy choices and push industry to reformulate products [64]. Yet, the complexity around capturing a product's impacts across the four sustainability domains and the lack of unified, independent certification schemes and regulatory oversight raises concerns about the future of sustainability labeling by industry and political actors [65]. Additional research is needed regarding the impact of the US food and beverage industry's sustainability labels and product attributes on consumers' perceptions and behaviors.

The finding that consumers' use of locally grown and organic labels to identify environmentally sustainable products decreased across years (2019–2022) is unexpected, as consumer demand for local and organic products has grown over the past decade [66,67]. However, this result aligns with the finding that only one-quarter of all respondents, on

average, purposefully purchased organic or locally sourced food and beverage products. Consumers' use of all environmental sustainability food labeling characteristics declined between 2019 and 2022 (Table 2), which could indicate growing consumer confusion or distrust of food labels. There may be growing consumer awareness of the fraud or greenwashing that has historically surrounded organic labeling [68], as well as the lack of government oversight for many common food labels [69].

US government agencies are in the process of updating guidelines for sustainability and eco-labeling claims [70,71]. Therefore, nutrition and health professionals, advocates, and civil society should encourage the food and beverage industry to adopt independent sustainability labeling schemes based on clearly defined criteria certified by third-party organizations, such as the Cool Food Initiative adopted by Panera restaurant in partnership with the World Resources Institute [72]. These efforts are needed to help consumers to navigate through the abundant and unregulated labeling used to market food and beverage products to identify those that support sustainability. However, research indicates that given the sociocultural and economic barriers to accessing healthy and sustainable food and beverage products, coupled with the low cost of many meat products, further information alone will not drive consumers to adopt more sustainable behaviors [27,73]. Sustainability labeling and education campaigns should be used in coordination with more intrusive policy tools, such as taxes or food subsidies, to effectively drive behavioral change [73].

4.5. Strengths and Limitations and Recommendations for Future IFIC Food and Health Surveys

The strength of this study is the novel analysis of IFIC Food and Health Survey questions over a decade from a representative sample of US adults, providing insights into US consumers' sustainability-related perceptions, beliefs, and behaviors. The limitations of this study largely stem from the design of the Food and Health Surveys. The cross-sectional nature of the surveys limits researchers' capacity to analyze changes in individual consumers' perceptions, beliefs, and behaviors over time. Changes in the variety of questions asked and response options provided from year to year further limited our capacity to analyze trends and conduct more in-depth statistical analyses for certain questions. Across the decade of IFIC Surveys, many changes were made to the wording of certain questions and the response options provided. The authors have clarified where these changes occurred throughout this paper, as detailed in Supplementary Table S1. These changes may have impacted the results of this analysis.

The IFIC Surveys captured participant age data on a continuous scale, which the authors categorized into generations for the purpose of this analysis. The limitations in the representation of certain generational groups (i.e., low frequencies of Generation Z respondents in earlier survey years) may have impacted the presence or absence of generational trends observed across the surveys. While the IFIC Survey results are weighted to reflect certain characteristics of the US population, the responses captured from the ~1000 survey respondents in each survey year may not be reflective of the perceptions, beliefs, and behaviors of the entire US population. Some results presented in this survey, therefore, may have occurred due to the differences in the individuals sampled across survey years. The administration of the survey online also likely excluded those with low digital literacy skills and those who lacked access to the internet or digital technologies.

The IFIC Survey questions are also not based on a publicly reported conceptual framework for health behavioral change, which further limited our capacity to analyze certain cognitive and behavioral outcomes related to sustainability. Future Food and Health Surveys should standardize sustainability questions to allow for greater analysis of trends in consumer responses over time. IFIC should also consider utilizing a research-grounded conceptual framework for behavioral change to guide the formation of Food and Health Survey questions. Future IFIC Surveys should use standardized sustainable diet-relevant questions, so that the IFIC Surveys could serve as a reliable method for capturing ongoing sustainable diet metrics for US adults.

In addition to supporting human and environmental health, sustainable diets and food systems must also advance social equity and economic prosperity for current and future generations [4,6]. Future IFIC Food and Health Surveys should, therefore, include additional questions that address economic and social sustainability domains that have been under-represented in these surveys over the past decade. Additional consideration should be given to developing questions that can help to better assess Americans' perceptions of and interest in reducing RPM intake and adopting sustainable dietary principles in line with expert recommendations, such as the frequency, types, and portion sizes of animal and plant protein intake by Americans.

In the 2012 to 2018 IFIC Food and Health Surveys, "male" (described as "men") and "female" (described as "women") were the only two gender options from which survey participants could choose. In 2019, "other" and "prefer not to say" were added as options but were not included in this analysis (Table 1). Future IFIC surveys should incorporate additional gender options to be more inclusive of and better capture the breadth of the gender identities of US adults. Moreover, IFIC Survey findings may not be applicable to other high-income countries or to US children or adolescents.

5. Conclusions

The IFIC Food and Health Survey findings from the past decade indicate US consumer awareness of and interest in health, environmental, and social sustainability principles but low adoption of plant-rich dietary patterns or practices, especially to reduce RPM intake. Greater action is needed by health and nutrition professionals, industry, civil society, and governments to educate and nudge consumers to adopt plant-rich dietary patterns and reduce or replace RPM intake to support the health of people and the planet.

Supplementary Materials: The following supporting information can be downloaded via this link: https://www.mdpi.com/article/10.3390/nu15234990/s1, Table S1: International Food Information Council (IFIC) Food and Health Survey questions about perceptions, beliefs, and behaviors towards plant-rich dietary patterns and practices (2012–2022).

Author Contributions: Conceptualization, K.C.S.; methodology, K.C.S., V.I.K. and V.E.H.; formal analysis, K.C.S.; data curation, K.C.S.; writing—original draft preparation, K.C.S.; writing—review and editing, K.C.S., A.H., E.S., V.E.H. and V.I.K. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This research involved a secondary analysis of existing survey data; therefore, it was exempt from the institutional review board requirements for human subject research.

Informed Consent Statement: Not applicable.

Data Availability Statement: The International Food Information Council (IFIC) Survey data used in this analysis were obtained through a request from the organization. All requests for this data should, therefore, be directed to the IFIC.

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References

1. Searchinger, T.; Waite, R.; Hanson, C.; Ranganathan, J. *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050*; World Resources Institute: Washington, DC, USA, 2019; Available online: https://www.wri.org/research/creating-sustainable-food-future (accessed on 15 October 2023).
2. The Rockefeller Foundation. True Cost of Food: Measuring What Matters to Transform the U.S. Food System. July 2021. Available online: https://www.rockefellerfoundation.org/report/true-cost-of-food-measuring-what-matters-to-transform-the-u-s-food-system/ (accessed on 15 October 2023).
3. Hebinck, A.; Zurek, M.; Achterbosch, T.; Forkman, B.; Kuijsten, A.; Kuiper, M.; Nørrung, B.; van 't Veer, P.; Leip, A. A Sustainability Compass for policy navigation to sustainable food systems. *Glob. Food Secur.* **2021**, *29*, 100546. [CrossRef] [PubMed]
4. Drewnowski, A.; Finley, J.; Hess, J.M.; Ingram, J.; Miller, G.; Peters, C. Toward healthy diets from sustainable food systems. *Curr. Dev. Nutr.* **2020**, *4*, 4006010. [CrossRef] [PubMed]
5. Kraak, V.I.; Consavage Stanley, K. An economic lens for sustainable dietary guidelines. *Lancet Planet Health* **2023**, *7*, e350–e351. [CrossRef] [PubMed]
6. Food and Agriculture Organization of the United Nations; World Health Organization. *Sustainable Healthy Diets: Guiding Principles*; FAO: Rome, Italy, 2019. Available online: https://www.fao.org/3/ca6640en/ca6640en.pdf (accessed on 15 October 2023).
7. Reinhardt, S.L.; Boehm, R.; Blackstone, N.T.; El-Abbadi, N.H.; McNally Brandow, J.S.; Taylor, S.F.; DeLonge, M.S. Systematic review of dietary patterns and sustainability in the United States. *Adv. Nutr.* **2020**, *11*, 1016–1031. [CrossRef] [PubMed]
8. Jennings, R.; Henderson, A.D.; Phelps, A.; Janda, K.M.; van den Berg, A.E. Five U.S. dietary patterns and their relationship to land use, water use, and greenhouse gas emissions: Implications for future food security. *Nutrients* **2023**, *15*, 215. [CrossRef] [PubMed]
9. Blackstone, N.T.; El-Abbadi, N.H.; McCabe, M.S.; Griffin, T.S.; Nelson, M.E. Linking sustainability to the healthy eating patterns of the Dietary Guidelines for Americans: A modelling study. *Lancet Planet Health* **2018**, *2*, e344–e352. [CrossRef]
10. Produce for Better Health Foundation. Have a Plant: The Plant-Forward Eating Guide. n.d. Available online: https://fruitsandveggies.org/wp-content/uploads/2021/01/Have-A-Plant-Plant-Forward-Eating-Guide.pdf (accessed on 15 October 2023).
11. Lichtenstein, A.H.; Appel, L.J.; Vadiveloo, M.; Hu, F.B.; Kris-Etherton, P.M.; Rebholz, C.M.; Sacks, F.M.; Thorndike, A.N.; Van Horn, L.; Wylie-Rosett, J.; et al. 2021 Dietary guidance to improve cardiovascular health: A scientific statement from the American Heart Association. *Circulation* **2021**, *144*, e472–e487. [CrossRef]
12. EAT-Lancet Commission. Healthy Diets from Sustainable Food Systems. Summary Report of the EAT-Lancet Commission. 2019. Available online: https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf (accessed on 15 October 2023).
13. Dietary Guidelines Advisory Committee. *Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture*; U.S. Department of Agriculture, Agricultural Research Service: Washington, DC, USA, 2015. Available online: https://health.gov/sites/default/files/2019-09/Scientific-Report-of-the-2015-Dietary-Guidelines-Advisory-Committee.pdf (accessed on 15 October 2023).
14. Vega Mejía, N.; Ponce Reyes, R.; Martinez, Y.; Carrasco, O.; Cerritos, R. Implications of the western diet for agricultural production, health and climate change. *Front. Sustain. Food Syst.* **2018**, *2*, 88. [CrossRef]
15. Dietary Guidelines Advisory Committee. *Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and Secretary of Health and Human Services*; U.S. Department of Agriculture, Agricultural Research Service: Washington, DC, USA, 2020. [CrossRef]
16. Qian, F.; Riddle, M.C.; Wylie-Rosett, J.; Hu, F.B. Red and processed meats and health risks: How strong is the evidence? *Diabetes Care* **2020**, *43*, 265–271. [CrossRef]
17. Neuenschwander, M.; Ballon, A.; Weber, K.S.; Norat, T.; Aune, D.; Schwingshackl, L.; Schlesinger, S. Role of diet in type 2 diabetes incidence: Umbrella review of meta-analyses of prospective observational studies. *BMJ* **2019**, *366*, l2368. [CrossRef]
18. World Cancer Research Fund International, American Institute for Cancer Research. Continuous Update Project. Recommendations and Public Health and Policy Implications. May 2018. Available online: https://www.wcrf.org/wp-content/uploads/2021/01/Recommendations.pdf (accessed on 15 October 2023).
19. Poore, J.; Nemecek, T. Reducing food's environmental impacts through producers and consumers. *Science* **2018**, *360*, 987–992. [CrossRef] [PubMed]
20. Carey, C.N.; Paquette, M.; Sahye-Pudaruth, S.; Dadvar, A.; Dinh, D.; Khodabandehlou, K.; Liang, F.; Mishra, E.; Sidhu, M.; Brown, R.; et al. The environmental sustainability of plant-based dietary patterns: A scoping review. *J. Nutr.* **2023**, *153*, 857–869. [CrossRef] [PubMed]
21. Dinu, M.; Abbate, R.; Gensini, G.F.; Casini, A.; Sofi, F. Vegetarian, vegan diets and multiple health outcomes: A systematic review with meta-analysis of observational studies. *Crit. Rev. Food Sci. Nutr.* **2017**, *57*, 3640–3649. [CrossRef] [PubMed]
22. Toh, D.W.K.; Srv, A.; Henry, C.J. Unknown impacts of plant-based meat alternatives on long-term health. *Nat. Food* **2022**, *3*, 90–91. [CrossRef] [PubMed]

23. Ismail, I.; Hwang, Y.H.; Joo, S.T. Meat analog as future food: A review. *J. Anim. Sci. Technol.* **2020**, *62*, 111–120. [CrossRef] [PubMed]
24. Heller, M.C.; Keoleian, G.A. Beyond Meat's Beyond Burger Life Cycle Assessment: A Detailed Comparison Between a Plant-Based and an Animal-Based Protein Source. University of Michigan Center for Sustainable Systems. 14 September 2018. Available online: https://gastronomiaycia.republica.com/wp-content/uploads/2018/09/diferencias_hamburguesa_vegetal_carne_impacto_medioambiental.pdf (accessed on 15 October 2023).
25. The Good Food Institute. Plant-based Meat for a Growing World. 2019. Available online: https://gfi.org/wp-content/uploads/2021/02/GFI-Plant-Based-Meat-Fact-Sheet_Environmental-Comparison.pdf (accessed on 15 October 2023).
26. Prescott, S.L.; D'Adamo, C.R.; Holton, K.F.; Ortiz, S.; Overby, N.; Logan, A.C. Beyond plants: The ultra-processing of global diets is harming the health of people, places, and planet. *Int. J. Environ. Res. Public Health* **2023**, *20*, 6461. [CrossRef] [PubMed]
27. Kenny, T.A.; Woodside, J.V.; Perry, I.J.; Harrington, J.M. Consumer attitudes and behaviors toward more sustainable diets: A scoping review. *Nutr. Rev.* **2023**, *81*, 1665–1679. [CrossRef]
28. Miki, A.J.; Livingston, K.A.; Karlsen, M.C.; Folta, S.C.; McKeown, N.M. Using evidence mapping to examine motivations for following plant-based diets. *Curr. Dev. Nutr.* **2020**, *4*, nzaa013. [CrossRef]
29. Centers for Disease Control and Prevention, National Center for Health Statistics. About the National Health and Nutrition Examination Survey.pdf. Updated 31 May 2023. Available online: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm (accessed on 15 October 2023).
30. Sollid, K.; Webster, A.D.; Paipongna, M.; Smith, K. Food perceptions, beliefs, and behaviors amid a global pandemic: Results of the International Food Information Council 2021 Food & Health Survey. *Nutr. Today* **2022**, *57*, 26–33. [CrossRef]
31. Hornick, B.A.; Childs, N.A.; Smith Edge, M.; Reinhardt, K.W.; Dooher, C.; White, C. Is it time to rethink nutrition communications? A 5-year retrospective of Americans' attitudes toward food, nutrition, and health. *J. Acad. Nutr. Diet.* **2012**, *113*, 14–23. [CrossRef]
32. Goldberg, J.P.; Tanskey, L.A.; Sanders, E.A.; Smith Edge, M. The IFIC Foundation Food & Health Survey 2015: 10-year trends and emerging issues. *J. Acad. Nutr. Diet.* **2016**, *117*, 355–360. [CrossRef] [PubMed]
33. Food Insight. 2021 IFIC Food & Health Survey. International Food Information Council. 19 May 2021. Available online: https://foodinsight.org/2021-food-health-survey/ (accessed on 15 October 2023).
34. Food Insight. 2022 Food & Health Survey. International Food Information Council. 18 May 2022. Available online: https://foodinsight.org/2022-food-and-health-survey/ (accessed on 15 October 2023).
35. Carpenter, A. Cross-Tabulation Analysis: A Researcher's Guide. Qualtrics, n.d. Available online: https://www.qualtrics.com/experience-management/research/cross-tabulation/ (accessed on 15 October 2023).
36. IBM. IBM SPSS Statistics Documentation. n.d. Available online: https://www.ibm.com/docs/en/spss-statistics (accessed on 15 October 2023).
37. Dimock, M. Defining Generations: Where Millennials End and Generation Z Begins. Pew Research Center. 17 January 2019. Available online: https://www.pewresearch.org/short-reads/2019/01/17/where-millennials-end-and-generation-z-begins/ (accessed on 15 October 2023).
38. Cramer, H.; Kessler, C.S.; Sundberg, T.; Leach, M.J.; Schumann, D.; Adams, J.; Lauche, R. Characteristics of Americans choosing vegetarian and vegan diets for health reasons. *J. Nutr. Educ. Behav.* **2017**, *49*, 561–567.e1. [CrossRef] [PubMed]
39. Grimmelt, A.; Moulton, J.; Pandya, C.; Snezhkova, N. Hungry and Confused: The Winding Road to Conscious Eating. McKinsey Company. 5 October 2022. Available online: https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/hungry-and-confused-the-winding-road-to-conscious-eating (accessed on 15 October 2023).
40. Reinhart, R. Snapshot: Few Americans Vegetarian or Vegan. Gallup. 1 August 2018. Available online: https://news.gallup.com/poll/238328/snapshot-few-americans-vegetarian-vegan.aspx (accessed on 15 October 2023).
41. Wolfson, J.A.; Lahne, J.; Raj, M.; Insolera, N.; Lavelle, F.; Dean, M. Food agency in the United States: Associations with cooking behavior and dietary intake. *Nutrients* **2020**, *12*, 877. [CrossRef] [PubMed]
42. Veganuary. About Us. n.d. Available online: https://veganuary.com/about/ (accessed on 15 October 2023).
43. van Bussel, L.M.; Kuijsten, A.; Mars, M.; van't Veer, P. Consumers' perceptions on food-related sustainability: A systematic review. *J. Clean Prod.* **2022**, *341*, 130904. [CrossRef]
44. Hartmann, C.; Siegrist, M. Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends Food Sci. Technol.* **2017**, *61*, 11–25. [CrossRef]
45. Mccarthy, J.; Dekoster, S. Nearly One in Four in U.S. Have Cut Back on Eating Meat. Gallup. 27 January 2020. Available online: https://news.gallup.com/poll/282779/nearly-one-four-cut-back-eating-meat.aspx (accessed on 15 October 2023).
46. Ritzel, C.; Mann, S. The old man and the meat: On gender differences in meat consumption across stages of human life. *Foods* **2021**, *10*, 2809. [CrossRef] [PubMed]
47. Nakagawa, S.; Hart, C. Where's the beef? How masculinity exacerbates gender disparities in health behaviors. *Socius Sociol. Res. Dyn. World* **2019**, *5*, 237802311983180. [CrossRef]
48. Economic Research Service, US Department of Agriculture. Per Capita Red Meat and Poultry Consumption Expected to Decrease Modestly in 2022. Updated 15 April 2022. Available online: https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=103767#:~:text=The%2520latest%2520USDA%2520forecast%2520indicates,than%2520the%25202012%E2%80%9321%2520average (accessed on 15 October 2023).

49. Our World in Data. Per Capita Meat Consumption in the United States. n.d. Available online: https://ourworldindata.org/grapher/per-capita-meat-usa (accessed on 15 October 2023).
50. Whitehead, D.; Brad Kim, Y.H. The Impact of COVID 19 on the Meat Supply Chain in the USA: A Review. *Food Sci. Anim. Resour.* **2022**, *42*, 762–774. [CrossRef]
51. International Food Information Council. Consumption Trends, Preferred Names and Perceptions of Plant-Based Meat Alternatives. November 2021. Available online: https://foodinsight.org/wp-content/uploads/2021/11/IFIC-Plant-Based-Meat-Survey.November-2021.pdf (accessed on 15 October 2023).
52. Onwezen, M.C.; Bouwman, E.P.; Reinders, M.J.; Dagevos, H. A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite* **2021**, *159*, 105058. [CrossRef]
53. Neuhofer, Z.T.; Lusk, J.L. Most plant-based meat alternative buyers also buy meat: An analysis of household demographics, habit formation, and buying behavior among meat alternative buyers. *Sci. Rep.* **2022**, *12*, 13062. [CrossRef]
54. Nezlek, J.B.; Forestell, C.A. Meat substitutes: Current status, potential benefits, and remaining challenges. *Curr. Opin. Food Sci.* **2022**, *47*, 100890. [CrossRef]
55. Caspi, C.; Seligman, H.; Berge, J.; Ng, S.W.; Krieger, J. COVID-19 Pandemic-Era Nutrition Assistance: Impact and Sustainability. *Health Affairs*. 5 May 2022. Available online: https://www.healthaffairs.org/do/10.1377/hpb20220330.534478/full/ (accessed on 15 October 2023).
56. Leone, L.A.; Fleischhacker, S.; Anderson-Steeves, B.; Harper, K.; Winkler, M.; Racine, E.; Baquero, B.; Gittelsohn, J. Healthy food retail during the COVID-19 pandemic: Challenges and future directions. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7397. [CrossRef] [PubMed]
57. Peñalvo, J.L.; Cudhea, F.; Micha, R.; Rehm, C.D.; Afshin, A.; Whitsel, L.; Wilde, P.; Gaziano, T.; Pearson-Stuttard, J.; O'Flaherty, M.; et al. The potential impact of food taxes and subsidies on cardiovascular disease and diabetes burden and disparities in the United States. *BMC Med.* **2017**, *15*, 208. [CrossRef] [PubMed]
58. Lusk, J.L.; Polzin, S. Consumer Food Insights. Center for Food Demand Analysis and Sustainability. Purdue University. 1 January 2022. Available online: https://ag.purdue.edu/next-moves/consumer-food-insights/?_ga=2.134760241.1325228140.1645811973-1258680646.1645811973 (accessed on 15 October 2023).
59. Food Insight. 2023 Food & Health Survey. International Food Information Council. 23 May 2023. Available online: https://foodinsight.org/2023-food-and-health-survey/ (accessed on 15 October 2023).
60. Jordan, M. Farmworkers, Mostly Undocumented, Become 'Essential' During Pandemic. *The New York Times*. 10 April 2020. Available online: https://www.nytimes.com/2020/04/02/us/coronavirus-undocumented-immigrant-farmworkers-agriculture.html (accessed on 15 October 2023).
61. Stuesse, A. Coronavirus Can Afflict The Powerful. Yet Food Workers Remain The Most Vulnerable. *The Washington Post*. 4 October 2020. Available online: https://www.washingtonpost.com/outlook/2020/10/04/covid-19-can-afflict-powerful-yet-food-workers-remain-most-vulnerable/ (accessed on 15 October 2023).
62. He, P.; Feng, K.; Baiocchi, G.; Sun, L.; Hubacek, K. Shifts towards healthy diets in the US can reduce environmental impacts but would be unaffordable for poorer minorities. *Nat. Food* **2021**, *2*, 664–672. [CrossRef]
63. Wolfrom, J. Companies bet carbon labels can help the climate. Will consumers catch on? *The Washington Post*. 17 June 2021. Available online: https://www.washingtonpost.com/climate-solutions/2021/06/17/carbon-footprint-emissions-label/ (accessed on 15 October 2023).
64. Shangguan, S.; Afshin, A.; Shulkin, M.; Ma, W.; Marsden, D.; Smith, J.; Saheb-Kashaf, M.; Shi, P.; Micha, R.; Imamura, F.; et al. A meta-analysis of food labeling effects on consumer diet behaviors and industry practices. *Am. J. Prev. Med.* **2019**, *56*, 300–314. [CrossRef] [PubMed]
65. Brown, K.A.; Harris, F.; Potter, C.; Knai, C. The future of environmental sustainability labelling on food products. *Lancet Planet Health* **2020**, *4*, e137–e138. [CrossRef] [PubMed]
66. Economic Research Center, US Department of Agriculture. Organic Agriculture Overview. Updated 13 February 2023. Available online: https://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/ (accessed on 15 October 2023).
67. Brinkmeyer, E.; Dankbar, H.; Bloom, J.D. Local Food Systems: Clarifying Current Research. North Carolina State Extension. 11 August 2023. Available online: https://content.ces.ncsu.edu/local-food-systems-clarifying-current-research (accessed on 15 October 2023).
68. Reiley, L. USDA Moves to Crack Down on 'Organic' Fraud. *The Washington Post*. 19 January 2023. Available online: https://www.washingtonpost.com/business/2023/01/19/usda-rule-organic-fraud/# (accessed on 15 October 2023).
69. Tufts University. Decoding Food Labels. Updated August 2016. Available online: https://sustainability.tufts.edu/wp-content/uploads/Decoding-Food-Labels.pdf (accessed on 15 October 2023).
70. Federal Trade Commission. FTC Seeks Public Comment on Potential Updates to its 'Green Guides' for the Use of Environmental Marketing Claims. 14 December 2022. Available online: https://www.ftc.gov/news-events/news/press-releases/2022/12/ftc-seeks-public-comment-potential-updates-its-green-guides-use-environmental-marketing-claims (accessed on 15 October 2023).
71. US Department of Agriculture. USDA Publishes Strengthening Organic Enforcement Final Rule. 18 January 2023. Available online: https://www.usda.gov/media/press-releases/2023/01/18/usda-publishes-strengthening-organic-enforcement-final-rule (accessed on 15 October 2023).

72. Waite, R.; Vennard, D.; Pozzi, G. Tracking Progress Toward the Cool Food Pledge: Setting Climate Targets, Tracking Metrics, Using the Cool Food Calculator, and Related Guidance for Pledge Signatories, World Resources Institute. September 2019. Available online: https://www.wri.org/research/tracking-progress-toward-cool-food-pledge (accessed on 15 October 2023).
73. Ammann, J.; Arbenz, A.; Mack, G.; Nemecek, T.; El Benni, N. A review on policy instruments for sustainable food consumption. *Sustain. Prod. Consum.* **2023**, *36*, 338–353. [CrossRef]

nutrients

MDPI

Correction

Correction: Acosta et al. Plant-Based Dietary Indices in Relation to Nutrient and Food Group Intakes in Preschool-Aged Children. *Nutrients* 2023, *15*, 4617

Patricia F. C. Acosta [1,†], Olivia A. Landon [1,†], Zachary J. Ribau [1], Jess Haines [2], David W. L. Ma [1], Alison M. Duncan [1,*] and on behalf of the Guelph Family Health Study [‡]

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Figure Legend

In the original publication [1], there was a mistake in the caption for Figure 1, as published. The caption for Figure 1 is missing a permission statement. The corrected caption appears below.

Figure 1. Summary of the PDI metrics scoring process. Abbreviations used: oPDI, overall plant-based dietary index; hPDI, healthful plant-based dietary index; lhPDI, less healthful plant-based dietary index. Created with Canva, adapted with permission from Sarah E. Jarvis.

The authors state that the scientific conclusions are unaffected. This correction was approved by the academic editor. The original publication has also been updated.

Reference

1. Acosta, P.F.C.; Landon, O.A.; Ribau, Z.J.; Haines, J.; Ma, D.W.L.; Duncan, A.M.; on behalf of the Guelph Family Health Study. Plant-Based Dietary Indices in Relation to Nutrient and Food Group Intakes in Preschool-Aged Children. *Nutrients* **2023**, *15*, 4617. [CrossRef] [PubMed]

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