Characterizing First Nations' Traditional Food Environments Across Canadian Ecozones: A Latent Class Analysis

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Table of contents

Abstract (English) 3

Résumé (Français) 5

List of Abbreviations and Tables 7

Acknowledgments 8

Contribution of Authors 10

Introduction 11

Literature Review 12

- First Nations' Diversity and History 12
- Traditional Foods of First Nations and the Shift in their Dietary Patterns 16
- First Nations' Complex Contemporary Nutrition 24
- Health Consequences of the Dietary Shift in First Nations 31
- Measuring First Nations' Complex Food Environments 35
- Research Objective and Hypothesis 38

Methods 40

- Latent Class Analysis Overview 40
- Conceptual Framework 40
- Parent Study: First Nations Food, Nutrition and Environment Study (FNFNES) 41
- Ethical Approvals 43
- Latent variable: Traditional Food Environment 44
- Traditional foods recategorization based on Ohén:ton Karihwatéhkwen 45
- Covariates 47
- Data Analysis Procedure 49

Results 51

Participants Characteristics 51

Exploratory Latent Class Analysis 62

Sensitivity analysis 62

Latent Class Analysis 64

Associations Between Latent Classes and Covariates 67

Bivariate Analyses 82

Discussion 93

Strengths 97

Limitations 98

Significance 99

Conclusions 101

References 102

Abstract (English)

Traditional foods remain crucial to First Nations' health and wellbeing and contribute to cultural identity, diet quality, and nutrition-related disease incidence. Many policies in Canada intentionally impacted the intergenerational transmission of First Nations' culture, profoundly affecting their traditional food environments. Therefore, understanding contemporary traditional food environments - collective physical, social, economic, cultural and political factors shaping dietary choices and nutritional status within a community - is essential for improving nutrition and population health. We aimed to identify and describe First Nations' traditional food environments and their associations with individual participants' demographics and health characteristics. Traditional food environments were characterized using data from the First Nations Food, Nutrition, and Environment Study (FNFNES) (N=6487, 92 communities across Canada). Traditional food items (k=226) from the FNFNES Food Frequency Questionnaire were grouped into nine categories based on an Indigenous conceptual framework. Exploratory Latent Class Analysis (LCA) was conducted with six traditional food categories, using model fit statistics to determine the optimal number of classes (e.g., AIC, BIC, LMR, BLRT), which was then used in a Latent Class Analysis model with all nine Traditional Food categories. Exploratory Latent Class Analysis determined that five classes (patterns) were optimal for the full Latent Class Analysis using model fit statistics. Lastly, the patterns were characterized using means and proportions of sociodemographic and health variables (e.g., anthropometry, physical activity and food security status), with ANOVA and chi-squared tests to assess significant differences. The five patterns describing First Nations' traditional food environments and their % population distributions within the study sample were "robust traditional food environment" (14.27%), "four sisters traditional food environment" (6.21%), "rich traditional protein environment" (26.74%), "fish, animals and fruits traditional food environment" (35.30%) and "limited access to traditional food environment" (17.46%). This research is the first to wholistically describe First Nations' traditional food environments based on individual consumption patterns in Canada. It is also the first to use an Indigenous conceptual framework to categorize Traditional Foods. This research can inform future

interventions to enhance food sovereignty efforts and promote greater traditional food access and consumption, aligning with First Nations' preferences.

Résumé (Français)

Les aliments traditionnels demeurent essentiels à la santé et au bien-être des Premières Nations et contribuent à l'identité culturelle, à la qualité de l'alimentation et à l'incidence des maladies liées à la nutrition. De nombreuses politiques au Canada ont intentionnellement eu un impact sur la transmission intergénérationnelle de la culture des Premières Nations, affectant profondément leurs environnements alimentaires traditionnels. Par conséquent, la compréhension des environnements alimentaires traditionnels contemporains - facteurs physiques, sociaux, économiques, culturels et politiques collectifs qui façonnent les choix alimentaires et l'état nutritionnel au sein d'une communauté - est essentielle pour améliorer la nutrition et la santé de la population. Nous avons cherché à identifier et à décrire les environnements alimentaires traditionnels des Premières Nations et leurs associations avec les caractéristiques démographiques et de santé des participants. Les environnements alimentaires traditionnels ont été caractérisés à l'aide des données de l'Étude sur l'alimentation, la nutrition et l'environnement des Premières Nations (FNFNES) (N = 6 487, 92 communautés à travers le Canada). Les aliments traditionnels (k = 226) du questionnaire de fréquence de consommation alimentaire de la FNFNES ont été regroupés en neuf catégories basées sur un cadre conceptuel autochtone. Une analyse exploratoire des classes latentes a été menée avec six catégories d'aliments traditionnels, en utilisant des statistiques d'ajustement du modèle pour déterminer le nombre optimal de classes (p. ex., AIC, BIC, LMR, BLRT), qui a ensuite été utilisé dans un modèle d'analyse des classes latentes avec les neuf catégories d'aliments traditionnels. L'analyse exploratoire des classes latentes a déterminé que cinq classes (modèles) étaient optimales pour l'analyse complète des classes latentes en utilisant des statistiques d'ajustement du modèle. Enfin, les modèles ont été caractérisés en utilisant des moyennes et des proportions de variables sociodémographiques et de santé (p. ex., anthropométrie, activité physique et statut de sécurité alimentaire), avec des tests ANOVA et chi carré pour évaluer les différences significatives. Les cinq modèles décrivant les environnements alimentaires traditionnels des Premières Nations et leurs répartitions en pourcentage de la population au sein de l'échantillon de l'étude étaient «environnement

alimentaire traditionnel robuste» (14,27 %), «environment alimentaire traditionnel des quatre sœurs» (6,21 %), «environnement riche en protéines traditionnelles» (26,74 %), «environnement alimentaire traditionnel de poissons, d'animaux et de fruits» (35,30 %) et «accès limité à l'environnement alimentaire traditionnel» (17,46 %). Cette recherche est la première à décrire de manière holistique les environnements alimentaires traditionnels des Premières Nations en fonction des habitudes de consommation individuelles au Canada. Elle est également la première à utiliser un cadre conceptuel autochtone pour catégoriser les aliments traditionnels. Cette recherche peut éclairer les interventions futures visant à renforcer les efforts de souveraineté alimentaire et à promouvoir un meilleur accès et une plus grande consommation d'aliments traditionnels, en adéquation avec les préférences des Premières Nations.

List of Abbreviations and Tables

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FNFNES	First Nations' Food, Nutrition and Environment Study
FNs	First Nations
TF	Traditional food
AFN	Assembly of First Nations
LCA	Latent class analysis
eLCA	Exploratory latent class analysis
BMI	Body Mass Index

List of Tables

Table 1	The Ohén:ton Karihwatéhkwen categories and the inclusion criteria for each
Table 2	Percentage of the participants who have never or ever consumed traditional foods included in each of the Ohén:ton Karihwatéhkwen categories
Table 3	Sociodemographic, anthropometrics and health variables of FNFNES participants across AFN regions
Table 4	Exploratory LCA ran with chosen traditional food categories
Table 5	Conditional probabilities of food environment categories for each latent class
Table 6	Summary of the covariates based on class membership
Table 7	Statistically significant differences across sociodemographics between classes 1 and 5
Table 8	Statistically significant differences across anthropometrics and health status between classes 1 and 5
Table 9	Statistically significant differences across health and food security status between classes 1 and 5

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Contribution of Authors

Ferial Hamdi conducted the literature review, performed the formal analysis, data visualization and contributed to the interpretation of findings. She also wrote the original draft and participated in the review and editing of the manuscript. Dr. Brittany Wenniserí:iostha Jock oversaw the methodology, project administration, and inclusion of the Ohén:ton Karihwatéhkwen and other Kanien'kehà:ka (Mohawk) knowledge. She provided the statistical software (Mplus), and supervision, and also played a significant role in interpreting findings as well as reviewing and editing this work. Dr. Karen Bandeen-Roche (Johns Hopkins University, Department of Biostatistics) provided consultations in shaping the methodology, interpreting findings, and participating in the review and editing process. Dr. Malek Batal (Université de Montréal, Department of Nutrition), a principal investigator in the original First Nations' Food, Nutrition and Environment Study (FNFNES), provided essential resources and contributed to both the interpretation of findings and the review and editing of the manuscript.

Introduction

Traditional foods remain crucial to First Nations' health and wellbeing and contribute to cultural identity diet quality, and reducing the risk of nutrition-related diseases. Understanding contemporary traditional food environments - collective physical, social, economic, cultural and political factors shaping dietary choices and nutritional status within a community - is essential for improving nutrition and population health. Previous research has not described First Nations' traditional food environments as a latent variable. In this study, First Nations' Traditional Food Environment is considered a latent variable because it is not directly observable in and of itself, but is measurable through a collection of highly-correlated indicator variables: traditional food consumption patterns. Traditional food items (k=226) from the First Nations' Food, Nutrition and Environment Study (FNFNES) Food Frequency Questionnaire were grouped into nine categories based on an Indigenous conceptual framework. This study aimed to describe the traditional food environments of First Nations living on-reserve and their latent subgroups as well as the associations between First Nations' traditional food environments and demographic characteristics and health outcomes. We hypothesized that FNFNES participants are reflective of several distinct and homogenous subgroups, each defined by unique patterns of traditional food activities and access to traditional food environment indicators. We expected there to be demographic differences between the people with higher traditional food consumption and people with lower traditional food consumption. Furthermore, we hypothesized that adults in the higher consumption group tend to be older, live in larger households, report better self-perceived health and higher activity levels, and have lower BMI values and a reduced prevalence of type 2 diabetes.

Literature Review

First Nations' Diversity and History

Indigenous Peoples in Canada collectively comprise three groups, as recognized by the Canadian constitution: First Nations, Inuit, and Métis (Crown-Indigenous Relations and Northern Affairs Canada). First Nations, or as legally defined, "Indians", refers to peoples who either share reserve lands, have historically lived on Indian lands prior to May 26, 1874, and the arrival of Europeans, or are their descendants, including legal children or wives, as defined by the Indian Act (Government of Canada, 1985; Younging, 2018). The term "First Nations" gained prominence in the 1970s and '80s, and is now widely preferred over the term "Indian", a shift reflecting a response to the complex and often pejorative use of the term Indian, which is now considered outdated or, in some contexts, offensive (Vowel, 2016). The 2021 Census estimated that there are approximately 1.8 million Indigenous Peoples in Canada, making up almost 5% of the national population, with First Nations representing the largest subgroup, totalling about 1.1 million individuals (Crown-Indigenous Relations and Northern Affairs Canada; Parrott, 2023; Statistics Canada, 2022).

First Nations are the youngest and fastest-growing population in Canada at a higher rate than that of the non-Indigenous population, according to the 2021 census. (Crown-Indigenous Relations and Northern Affairs Canada; Statistics Canada, 2021), thereby necessitating an increased focus on addressing their healthcare needs and health inequities alongside those of the general Canadian population; In 2021 and for the first time, the census recorded over 1 million First Nations peoples in Canada, indicating a 9.7% increase from 2016 (Statistics Canada, 2023a). The Indigenous populations (including First Nations, Métis, and Inuit) are predominantly young. In the same census, nearly 28% of the Indigenous individuals fell below the age of 25, leading to an average age of 33.6 among Indigenous communities, as opposed to the non-Indigenous population, where the average age stood at 41.8 years (Statistics Canada, 2023a), presenting a significant opportunity to implement early and effective disease prevention strategies to promote long-term

well-being and reduce health inequities between Indigenous Peoples and the general Canadian population.

Throughout history, Indigenous Peoples were restricted from accessing their ancestral lands and, in some cases, forcibly relocated by their colonizers to new areas (Royal Commission on Aboriginal Peoples, 1996a). Despite these systematic challenges and assimilationist policies, Indigenous Peoples consistently exhibit resilience in various ways, with this resilience being deeply ingrained in their cultural identity (Kirmayer et al., 2011). This resilience is perhaps most evident in the preservation and growth in their languages, a strong aspect of cultural endurance. To date, more than 70 Indigenous languages are being spoken by approximately 237 thousand speakers, able to engage in conversations in these languages, on top of a 3% increase in the number of people who speak their native language as a second language (Statistics Canada, 2023b), underscoring not only the resilience among Indigenous Peoples, but also reflecting the distinct differences. Moreover, First Nations demonstrate a remarkable diversity in social structures, food procurement and dietary practices, housing, transportation methods, clothing, as well as spiritual beliefs (Government of Canada, 2017) highlighting the need for tailored research approaches from nation to nation. This diversity is further exemplified in the context of food and nutrition by the historical division of First Nations into six groups based on the locations of their ancestral territories (Government of Canada, 2017): The similar environmental conditions within each group led to shared food procurement practices, such as farming, fishing, and hunting (Government of Canada, 2017). Overall, there are 619 First Nations and 634 First Nations communities in Canada, which represent over 50 nations (Assembly of First Nations; Crown-Indigenous Relations and Northern Affairs Canada; Indigenous Services Canada, 2020; Statistics Canada, 2022).

When addressing the inequities in chronic diseases between Indigenous Peoples and the general Canadian population, it is important to recognize that governmental national surveys sample First Nations living off-reserve (Centre for Indigenous Statistics and Partnerships, 2023). For example, the 2004 and 2015 Canadian Community Health Survey (CCHS) did not include First Nations living on reserve (Statistics Canada, 2017). However, a significant proportion (40.6%) of

First Nations individuals reside on reserve (Indigenous Services Canada, 2023), leading to gaps in understanding and addressing their specific needs. Consequently, these communities might be underrepresented in research projects, leading to studies that may not accurately reflect their unique health inequities, which can differ significantly from those experienced by First Nations living off-reserve.

A comprehensive study conducted with First Nations on-reserve and frequently referenced throughout this thesis is the First Nations' Food, Nutrition and Environment Study (FNFNES). FNFNES is a nationwide representative survey of First Nations adults across Canada, conducted between the years 2008 to 2018, on 92 randomly selected communities. A measure of remoteness is The Indigenous and Northern Affairs Canada Remoteness Index Zone (INACRIZ), as employed by FNFNES (Alasia et al., 2017). The INACRIZ categorizes communities into four groups: Zone 1, where First Nations are connected to a service centre within 50 kilometres by road; Zone 2, where year-round roads connect First Nations to service centres located 50-350 kilometres away; Zone 3, where communities have year-round access to service centres more than 350 kilometres away; and Zone 4, which consists of fly-in communities with no year-round access to service centres. Although the exact number of remote, fly-in-only communities across Canada is unknown, 18% of the 92 communities participating in the FNFNES were located in Zone 4 (Chan et al., 2019). According to FNFNES, communities in Zone 4 experience a higher food insecurity prevalence, serving as an example and underscoring the need for critical research on First Nations to be representative of these more distant communities.

The relationship between Indigenous communities and non-Indigenous scholars has been filled with a sense of objectification, exploitation, and a lack of respect, resulting in a sense of rightful mistrust towards research amongst these Peoples. "*We've been researched to death*" is a sentiment commonly expressed by many Indigenous Peoples (Goodman et al., 2018; Mihesuah, 1993). However, the majority of research has been conducted *on* them rather than collaboratively *with* them by non-Indigenous and Western academics, in which Indigenous values, worldviews and profits have been marginalized, and a colonial perspective was instead imposed (Drawson et al.,

2017; Getty, 2010; Government of Canada Panel on Research Ethics, 2022b): Indigenous ways of knowledge were systematically deemed inferior and were devalued, undermined and dismissed by their colonizers when compared with Western worldviews, which were regarded as the legitimate form of knowledge (Smith, 1999).

Indigenous communities also endured ongoing exploitation through the invasion of their territories, extraction of their natural resources, without any tangible benefits or respectful engagement (Schnarch, 2004; Smith, 1999). These researchers would distort and portray Indigenous populations and their ways of living inaccurately, without consent, approval or feedback from the communities, (Schnarch, 2004; Smith, 1999), hence, the "helicopter" approach (Bharadwaj, 2014). A notable instance of this self-serving and immoral research is the 1947-1948 James Bay Survey. This study, conducted on the Attawapiskat and Rupert's House Cree First Nations, took place amid severe malnutrition in these communities. Despite the significant severity of hunger, researchers viewed the situation as an unprecedented research opportunity, which ultimately benefitted their careers without providing any tangible help to the affected communities (Mosby, 2013). As a result of this and many similar instances, Indigenous Peoples harbored feelings of distrust and resentment towards research, perceiving it as invasive, exploitative, and unethical, and regarding researchers as intruders who are using the community to "further their own career" or their own gain. (Getty, 2010; Government of Canada Panel on Research Ethics, 2022b; Maynard, 1974; Mihesuah, 1993; Smith, 1999) In light of the challenging history of research involving Indigenous Peoples, it has become essential to develop additional frameworks to ensure that research is conducted with respect and cultural sensitivity, and to ensure Indigenous populations' participation in research about themselves.

There now exist frameworks that actively incorporate Indigenous Peoples and their traditional knowledge into the research endeavours focused on them. Community-Based Participatory Research (CBPR) is an approach that emerged as a response to the historically intrusive, extractive, oppressive and dehumanizing research conducted on Indigenous populations. CBPR centers around equitably sharing power with the community and involving the community at

every stage of the research process (Barbara A. Israel, 2005). It is a long-term commitment, in which all involved partners contribute expertise with the goal of increasing knowledge and improving the health of community members (Barbara A. Israel, 2005). There are also principles, protecting Indigenous Peoples' rights to data sovereignty and research, namely OCAP: Ownership, Control, Access and Possession principles, as outlined by the First Nations Information Governance Centre (FNIGC) (Kukutai & Taylor, 2016; Schnarch, 2004). The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) shares alignment with the principles articulated in OCAP, underscoring the recognition and protection of Indigenous peoples' rights to self-determination, land, resources, and cultural heritage (United Nations General Assembly, 2007). Additionally, the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), chapter 9 highlights the importance of community engagement and respect for Indigenous Peoples and communities, within research projects (Government of Canada Panel on Research Ethics, 2022a). Indigenous frameworks, such as the Two-Row Wampum and Two-Eyed Seeing (Delormier et al., 2024), provide pathways for incorporating Indigenous knowledge systems into research, emphasizing collaboration, mutual respect, and the integration of Indigenous and Western perspectives within the research process (Hill Sr & Coleman, 2019).

Traditional Foods of First Nations and the Shift in their Dietary Patterns

First Nations Peoples are going through a "Nutrition Transition"; a shift from traditional diets that are rich in protein, fibre, vitamins and minerals to western diets that are characterized by high levels of saturated fat, total sugars, sodium and processed, high-energy foods (Batal et al., 2018; Compher, 2006), accompanied by a rise in rates of related, non-communicable diseases such as obesity, cardiovascular disease and diabetes (Popkin, 2002). Kuhnlein et al. also depict the factors influencing dietary change and its consequences among Indigenous Peoples, demonstrating how the loss of cultural knowledge transfer to youth and reduced land use and harvesting contribute to a decline in the use of traditional food systems (Kuhnlein & Receveur, 1996). Traditional foods are

locally and naturally available food from animal or plant-based resources, accessible through activities such as hunting, gathering, fishing, trapping or harvesting; they also have cultural significance as traditional foods (Willows, 2005): they support communities' connections with each other, other beings and the Creator (Blue Bird Jernigan et al., 2021), reflecting First Nations' significant relationship with the land. Traditional diets are typically high in protein, vitamins and minerals and low in saturated fats, carbohydrates and sodium while Western diets are typically high in saturated fat, sodium, and sugar and low in fibre (Batal et al., 2018; L. Chan et al., 2021; Kuhnlein & Receveur, 1996).

At the individual level, numerous factors influence dietary choices, among which cultural preferences, affordability, and biological requirements could be seen. In terms of cultural preference, it is essential to acknowledge that food choices are also expressions of culture and certain qualities are associated to them (Kuhnlein & Receveur, 1996). For many First Nations communities, traditional foods is an important way to express their cultural identity (Power, 2008). For Indigenous Peoples, food serves as a means of expressing affection, power, or even rebellion. Social and personal considerations also include the occasion where the food is served and if it is shared (Kuhnlein & Receveur, 1996). An illustration of this point is the large number of First Nations individuals who participate in traditional food gathering activities: A study based in 6 British Columbia communities enrolled in FNFNES revealed that approximately 71% of the participants took part in traditional food gatherings, out of which 34% reported fishing and 23% collecting beach food (Marushka et al., 2019).

For thousands of years, Indigenous Peoples have maintained a healthy diet through engaging with their traditional food systems by practices such as hunting, fishing and gathering (Burnette et al., 2018). Federal policies have had an impact on culture, which in turn, impacts traditional food systems as a key part of the culture. Among these cultural drivers of the Nutrition transition in First Nations are the Indian Act (Wiedman, 2012) and the Residential Schools (Churchill, 2004). Through the Indian Act, First Nations were forced to relocate to reservations, where Federal Indian Agents who were responsible for distributing food to First Nations and who introduced them to foods that were high in calories but had no nutritional value (Wiedman, 2012).

This relocation also disrupted First Nations' engagement with their traditional food systems and created a dependence on foods provided by the government (Wiedman, 2012), forcing an adverse shift in First Nations' dietary patterns. The same pattern could be seen in the forced relocation of Indigenous children to residential and boarding schools, where they were disconnected from their culture of consuming traditional foods and were instead provided with low-quality diets (Churchill, 2004). These disruptions underscore the complex interplay between historical injustices and contemporary nutritional challenges faced by Indigenous communities.

As the effects of colonization extend beyond cultural loss, it has deeply disrupted Indigenous Peoples' connections to their traditional food systems. Factors such as climate change, capitalism, legal changes, and socio-cultural shifts have all played a role in this disconnection (Malli et al., 2023; Matheson et al., 2022).

Furthermore, FNFNES found that despite a strong interest in consuming traditional foods more regularly and in larger quantities, 71% of respondents reported barriers to accessing these foods (Batal, Chan, Fediuk, Ing, et al., 2021b; L. Chan et al., 2021). These barriers included a shortage of hunters, insufficient resources, and limitations in time and availability (L. Chan et al., 2021). The same study also revealed that most First Nations individuals across Canada highly valued traditional foods for their health benefits, safety, and cultural significance, whereas store-bought foods were mainly regarded as convenient and readily available, with fewer than 5% of the participants considering them nutritionally beneficial (L. Chan et al., 2021).

Traditional food systems vary significantly when compared to Western food systems. In contrast to Western worldviews, to Indigenous Peoples, land and the natural world are sacred and are viewed as an integral component of life and well-being (Lambert & Wenzel, 2007). For many First Nations communities, traditional food is a symbolic bridge to maintaining the identity of their culture and holds significant spiritual value (Power, 2008; Willows, 2005). To Indigenous Peoples, even traditional food procurement is a means of sustaining social relationships and cultural practices (Willows, 2005), demonstrating important differences between traditional and Western foods. Keeping in line with these unique values, Indigenous traditional food systems, pertain to locally cultivated foods that hold cultural acceptance and significance (Kuhnlein & Receveur,

1996). These systems encompass the sociocultural meanings, processing techniques, usage, nutritional composition of these foods, and their impact on consumers (Kuhnlein & Turner, 2020). Overall, it is essential to recognize the distinct differences between Western and Indigenous food systems when conducting research, or developing policies and programs related to Indigenous Peoples' nutrition and dietary habits.

"Consumers" are linked to these food systems through their food environments (Herforth & Ahmed, 2015; Swinburn, Vandevijvere, et al., 2013). Literature has demonstrated that food environments play a significant role in shaping individuals' dietary habits and consumption patterns (Story et al., 2008; Swinburn et al., 2011). Since its introduction, the concept of food environments has evolved significantly. The definition that best fits within the conceptual framework of this study is provided by Swinburn as such "collective physical, economic, policy and socio-cultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status" (Swinburn, Sacks, et al., 2013). Food environments encompass factors beyond physical presence or access to food. Downs et al. provide six clear dimensions of this concept and how it is situated in relation to food systems (Downs et al., 2020): "the consumer interface with the food system that encompasses the availability, affordability, convenience, promotion and quality, and sustainability of foods and beverages in wild, cultivated, and built spaces that are influenced by the socio-cultural and political environment and ecosystems within which they are embedded" (Downs et al., 2020). The key components of food environments can be detailed as follows: Promotion involves how products are presented and labelled, which affects their appeal. Affordability relates to the cost of foods, while availability pertains to whether a food item is accessible within a certain physical area. Additionally, other essential aspects of food environments include convenience, quality, and sustainability. Convenience involves the time and effort required to obtain, prepare, and consume food, making it easier or harder to include in daily routines. Quality pertains to the attributes of food, such as freshness, safety, and sensory characteristics. Sustainability considers the environmental and social impacts of food production and consumption (Downs et al., 2020). This definition may vary when applied to Indigenous

traditional food environments, as these systems differ from Western food systems where food is predominantly purchased through supermarkets and other commercial outlets. This is supported by the authors' acknowledgment of the definition's largely conceptual nature, emphasizing the need for future research to develop new, and refine existing, methodological approaches for an accurate assessment of the variety of food environments (Downs et al., 2020).

Similarly, Indigenous traditional food environments represent complex systems that extend far beyond availability. They reflect an interplay of availability, cultural knowledge and social networks in communities. Factors such as the knowledge and ability to identify, gather, process and prepare traditional foods play an important role in shaping individuals' diets (Kuhnlein & Receveur, 1996). Traditional food knowledge, establishes food traditional food environments as multidimensional cultural systems (Malli et al., 2023). Therefore, we conceptualize traditional food environments as being characterized by annual traditional food intakes, which inherently reflect the intersection of individual knowledge and skills, interpersonal sharing of traditional foods, as well as the presence of traditional food species in the environment.

Examples of food environment studies and their contribution to understanding underlying factors in health promotion could be found, such as the study by Reeds et al. where dietary patterns and their associations with Type 2 Diabetes Mellitus were assessed in a First Nations Community in Ontario (Reeds et al., 2016). The study found that 540 out of the 606 participants in the Sandy Lake Health and Diabetes Project (SLHDP) who were not diagnosed with diabetes, were assessed via a 3-month food frequency questionnaire (FFQ) that included both traditional and market foods, anthropometric data and fasting and non-fasting blood samples (Reeds et al., 2016). Over the course of a 10-year follow-up, the 86 participants who received a diagnosis of incident diabetes were characterized by significantly older age, higher BMIs, larger waist circumferences and lower adiponectin levels (Reeds et al., 2016). The 3 dietary patterns observed using factor analysis (FA) were 1) Balanced market foods pattern 2) Beef and processed foods and 3) Traditional foods. Consumption of beef and processed food patterns was linked to a higher risk of developing type 2 diabetes, after adjusting for factors such as age, gender, waist circumference, interleukin-6, and

adiponectin (Reeds et al., 2016). Similarly, food environments could be assessed to examine the availability of healthy and unhealthy food options and their proximity to the consumers, possibly demonstrating one of the reasons why unhealthy foods are more consumed within a population. In a mixed-methods study by Chodur et al, this access was compared between 94 American Indian tribal and non-tribal areas in California (Chodur et al., 2016). After categorizing the food establishments into healthy, intermediate, and unhealthy outlets, the bivariate analysis results indicated that both healthy and unhealthy food establishments were fewer within tribal lands (Chodur et al., 2016). Adjusting for community-level urbanicity and average per capita income, the results indicated significantly fewer healthy food businesses per square mile in the tribal, as opposed to non-tribal areas (Chodur et al., 2016). However, tribal and non-tribal areas had no significant differences in terms of unhealthy food options (Chodur et al., 2016).

Despite their importance, the First Nations' traditional food environment was and still remains an understudied area. According to the Royal Commission on Aboriginal Peoples and Meriam Report, Indigenous Peoples' poor nutrition quality had long been a matter of discussion both in Canada and the United States (Meriam, 1928; Royal Commission on Aboriginal Peoples, 1996b), underscoring the fact that this longstanding issue has never been adequately addressed and the urgency to act now, especially given the continuously growing Indigenous population and the opportunities for meaningful change: Acknowledging and assessing First Nations traditional food environments is a crucial step in addressing the longstanding nutritional issues and their consequences faced by these communities.

In addition to their cultural significance, there is growing research demonstrating the nutritional benefits of a traditional food diet. The nationwide study of FNFNES revealed that on days when traditional food was consumed, there was a significantly greater intake of protein, iron, zinc, magnesium, copper, potassium, phosphorus, vitamins A, D and C, folate, riboflavin, niacin and vitamins B6 and B12 (Batal, Chan, Ing, et al., 2021b) all the while a significantly lower intake of total saturated fat, cholesterol, total sugar and sodium (L. Chan et al., 2021). Another study within 256 adults from 3 Syilx Okanagan Nation found that traditional food consumers exhibited notably higher

intakes of key nutrients such as protein, omega-3 fatty acids, dietary fibre, and various vitamins and minerals including copper, magnesium, manganese, phosphorus, potassium, zinc, niacin, riboflavin, and vitamins B6, B12, D, and E (Blanchet et al., 2020). Additionally, traditional food consumers were more likely to meet the estimated average requirement for copper and vitamins C and D (Blanchet et al., 2020).

Additionally, a body of literature focuses on the contribution of specific traditional foods to diet, across Canada or different regions. These studies employ Dietary Reference Intakes (DRIs) to demonstrate their significance. DRIs could be defined as "reference values that are quantitative estimates of nutrient intakes to be used for planning and assessing diets for healthy people" (National Academies of Sciences, 1998). They could be further categorized as Recommended Dietary Allowance (RDA), Adequate Intake (AI), Tolerable Upper Intake Level (AI) and Estimated Average Requirement (EAR) (National Academies of Sciences, 1998). Included in these studies is a study based on FNFNES, which assessed the contribution of seafood to the nutrient requirements of First Nations across Canada (Marushka et al., 2021). In this study, fish and seafood were classified as "excellent sources" if they provided 20% or more of the recommended daily intake (DRI) for a nutrient, and as "good sources" if they supplied 10-19% of the DRI. The findings suggest that in both food secure and insecure categories, fish and seafood served as "excellent" sources of essential nutrients (Marushka et al., 2021). They provided significant amounts of Vitamin B12 (37.9% for food secure and 39.2% for food insecure), and were also "good" sources of n-3 PUFA (17.9% and 19.9%), niacin (13.4% and 14.4%), and selenium (12.8% and 14.1%) (Marushka et al., 2021). Additionally, fish and seafood contributed up to 10% of protein, vitamin D, zinc, and vitamin A (Marushka et al., 2021). A similar FNFNES study on specific kinds of seafood has been conducted within First Nations in British Columbia, concluding that in general, seafood provided significant amounts of nutrients, fulfilling 79–184% of EPA+DHA, 84–152% of vitamin B12, 28–55% of niacin, and 29–55% of selenium recommendations across various gender and age categories (Marushka et al., 2019). Additionally, seafood emerged as a notable source of vitamin D and protein, meeting between 15% and 30%, and 14% and 30% of the respective dietary requirements

(Marushka et al., 2019). The top 20 types of seafood contributed between 50-92% to men's and 53-92% of women's different nutrient intakes (Marushka et al., 2019). While the top 10 seafood items collectively accounted for 16% and 13% of protein, 4% and 3% of vitamin A, 4.5% and 4.0% of zinc, and 3.9% and 1.9% of iron among men and women respectively, they were not deemed substantial sources of these nutrients (Marushka et al., 2019). Of the seafoods assessed in the study, sockeye salmon accounted for 44% and 24% of EPA and DHA, 43% and 23% of vitamin B12, 16% and 8.5% of vitamin D, 11% and 7% niacin, 12% and 6.5% of selenium, in men and women, respectively (Marushka et al., 2019). Halibut contributed a range of 0.5% to 6.5% of nutrients (Marushka et al., 2019). Clams and crabs were rich sources of vitamin B12, contributing to a total of 19% and 13% in men, and 17% and 6% in women. Prawns contributed 0.2% to 2% to the recommended nutrient intake (Marushka et al., 2019).

Alongside the strong focus on seafood in the literature, the nutritional benefits of several other types of Indigenous traditional foods across Canada have been assessed in the literature, among which is caribou. A study among the adults in the Vuntut Gwitchin First Nation community of Old Crow, Alaska, Canada, found that caribou consumption fulfilled around 50% of the estimated average requirement for protein and zinc, approximately two-thirds for vitamin A, nearly 100% for iron, and two and a half times for vitamin B12 in men (Schuster et al., 2011). It was however considered a low source of vitamin A, potassium manganese, magnesium, sodium, calcium, and copper (Schuster et al., 2011). In women of childbearing age, the intake of caribou meat and kidney supplied a median of over 50% of the estimated average protein and zinc requirement and approximately half for iron (Schuster et al., 2011). For women over 40 years old, caribou meat, kidney, and liver provided a median of almost two-thirds of the estimated average requirement for protein and zinc and more than three-quarters for iron (Schuster et al., 2011). The median niacin equivalent intake closely approached the estimated average requirement, while the vitamin B12 intake was 2.5 times higher than the estimated average requirement for both groups of women (Schuster et al., 2011). Although this study was conducted with a limited sample of 26 participants, its findings are supported by a larger mixed-methods research study involving a

greater number of Inuit individuals. (Kenny et al., 2018). The study is based on dietary data from 2,796 randomly selected adult, non-pregnant participants from the 2007-2008 cross-sectional Inuit Health Survey (IHS) in Inuit Nunangat (Kenny et al., 2018). The findings suggest that caribou was the top dietary source of protein in Nunavut, contributing up to 35% of the total intake and a leading dietary source of iron (14.3% to 36.5%), zinc (17.7%-41.3%), copper (12.1%-38.5%), riboflavin (15.4%-39.3%), phosphorus (7.3%-22.1%), vitamin B12 (26.6%-52%) and vitamin B6 (7.0%-22.9%), across Inuvialuit Settlement Region (ISR), Nunavut and Nunatsviavut (Kenny et al., 2018). With a contribution of 8.8% to 17.4%, Caribou was among the top three dietary sources of potassium in Nunavut and the ISR (Kenny et al., 2018).

First Nations' Complex Contemporary Nutrition

One of the tools for comprehensive diet quality assessment, also used in some of the studies with First Nations, is the Healthy Eating Index (HEI). Based on its original definition, introduced by the US Department of Agriculture (USDA) in 1995, the Healthy Eating Index assesses the overall diet quality by taking into account the diversity in an individual's diet alongside how closely it is aligned with the serving recommendations of the USDA Food Guide Pyramid, saturated fat and overall fat consumption as a percentage of the overall energy intake, and cholesterol and sodium intake (T Kennedy et al., 1995). The highest obtainable score in the HEI system is 100, indicating a better diet quality (T Kennedy et al., 1995). Although this description revolves around American guidelines, several studies have adopted HEI throughout the years 1995 to 2010 for use in the Canadian population (HEI-C) (Garriguet, 2009; Glanville & Mcintyre, 2006; Jessri et al., 2017; Woodruff & Hanning, 2010).

The dietary consequences of limited access to traditional and healthy foods could be vividly seen in a study based on the FNFNES, in which on average, men and women across all regions attained an HEI score of less than 50, a score categorized as "low", however, some regions had a 50-80 HEI, which is an "average" HEI score (Batal, Chan, Ing, et al., 2021a). Fewer than 1% of the

participants achieved HEI scores higher than 80, while 54% scored less than 50 and 48% scored between 50-80 (Batal, Chan, Ing, et al., 2021a). Differences could also be observed among different age groups. On average, First Nations aged 19-50 obtained a "low" HEI score, however this score improves within First Nations older than 51, and is categorized as an "average" HEI score (L. Chan et al., 2021). This is especially important as those aged 51 and above also have a higher traditional food consumption when compared to the younger group (L. Chan et al., 2021). This is supported by another First Nations project, stemming from the Okanagan Salmon and Our Health Study which encompassed half of the six Syilx communities. The study reported c-HEI scores of adults residing in all or random households within each community (Blanchet et al., 2020) where the participants obtained a mean score of 50.5 (SE 0.8), with a range of 20.3 to 92.7, with differences among traditional food consumers and non-consumers (Blanchet et al., 2020). Although the reported average Healthy Eating Index (HEI) deviates from the findings of FNFNES, the results still imply an average diet quality among Syilx First Nations. Moreover, this difference may be attributed to the variance in population sizes, with FNFNES encompassing a comprehensive representation of the entire Canadian First Nations population. The study, however, still associated traditional food consumption with better diet quality. In the First Nations adults in the Syilx Okanagan, traditional food consumption was associated with higher HEI-C scores, indicating better overall diet quality (Blanchet et al., 2020) and the beneficial nutritional qualities of traditional foods. Using the national, cross-sectional data by Statistics Canada on the Canadian Community Health Survey in 2004 and 2015, Olstad et al. found that the Indigenous adults overall exhibited the lowest HEI-2015 scores in both 2004 (44.2) and 2015 (51.9), when compared to 6 other ethnic groups, although Indigenous peoples' HEI scores had significantly improved within the 2 years of comparison (Olstad et al., 2023). All groups except Indigenous adults and "other" ethnicities had higher HEI-2015 scores than White adults (Olstad et al., 2023). The HEI scores are reported to be "low" among the general Canadian population as well, obtaining an average of 43.1% among those aged 2 and above (Brassard et al., 2022), possibly underscoring the health implications of Western dietary patterns for both groups.

The potential consequences of barriers to traditional food appear to be more pronounced among younger generations of First Nations. FNFNES found that on average, both genders between the ages of 19 and 50 had an HEI score lower than 50, while those aged 51+ had HEI scores between 50-80 (Batal, Chan, Ing, et al., 2021a). Riedriger et al. highlight that this substandard diet quality is in fact, an inequity (Riediger et al., 2022). This repeated cross-sectional study, compared the diet quality between off-reserve Indigenous ethnicities, including First Nations, Métis, Inuit and non-Indigenous youth, aged 2-17 years old, using 2004 and 2015 Canadian Community Health Surveys (CCHS) (Riediger et al., 2022). Overall, the study examined 12839 youths in 2004 and 5350 in 2015 (Riediger et al., 2022). Compared to non-Indigenous children and youth, First Nations participants, had significantly lower HEI scores, after matching for time period, energy intake, sex, age, household education and income adequacy (Riediger et al., 2022).

It is important to consider that food security can impact dietary quality, with food security being positively associated with improved diet quality. Recent studies have found that households with higher levels of food security tend to exhibit improved nutritional outcomes and HEI scores, possibly due to increased access to high-quality food. This is especially important as almost half (47.9%) of all participants in FNFNES were found to be food insecure (Batal, Chan, Fediuk, Ing, Berti, Mercille, et al., 2021) This connection is supported by Riedrieger et al. who found that First Nations children and youth have the lowest HEI scores among all ethnicities, prior to adjusting for food security status (Riediger et al., 2022). However, after the adjustment, the significant difference in First Nations participants was no longer observed (Riediger et al., 2022). Another example of this could be found within the Inuit population, where a study assessed diet quality with food security considerations within random homes in all 36 communities of Inuvialuit Settlement Region, Nunavut and Nunatsiavut. Diet and nutrition were assessed using HEI-c, 24-hour recalls and FFQ encompassing both market and traditional foods available in each region, alongside the 18-item USDA food security survey, modified for the Inuit population. (Huet et al., 2012) The participants from food-insecure homes (including severe food insecurities), attained an average HEI score of 52.6 whereas food-secure participants had an HEI score of 55.3, indicating a lower dietary quality

among food-insecure households (Huet et al., 2012). A comparison made between food-secure and insecure homes in all 36 communities of Inuvialuit Settlement Region, Nunavut and Nunatsiavut confirms this by outlining their diet: Along with severely food insecure households, food-insecure populations tended to consume more energy from high-sugar foods, although their intake of high-sugar drinks was similar to that of adults in food secure households. (Huet et al., 2012) This high-sugar dietary pattern has also been found in 2-5-year-old American Indian children and adults, in a cross-sectional study in urban and rural communities in the United States (Tomayko et al., 2017). Adults and children living in food-insecure households tended to consume more sugar-sweetened beverages and sports drinks (Tomayko et al., 2017).

First Nations' diets are also more broadly compared to the Eating Well with Canada's Food Guide – First Nations, Inuit and Métis. FNFNES found that across Canada, First Nations did not meet recommendations for vegetables and fruits, grain products, milk and alternatives and meat and alternatives (L. Chan et al., 2021).

Lack of access to healthy food is also associated with documented micronutrient deficiencies among First Nations populations. The FNFNES compared the macronutrient intakes of different age and sex groups within First Nations communities to the Acceptable Macronutrient Distribution Range (AMDR) (L. Chan et al., 2021). According to the results, carbohydrate deficiencies could be observed within 73.6% of men aged above 71 (L. Chan et al., 2021). All groups except 50 to 70-year-old females had a higher than recommended average intake of fat (L. Chan et al., 2021). Both males and females in age groups between 19 to 50 and above 71 had a higher energy intake of saturated fat (L. Chan et al., 2021).

Due to many barriers to traditional food consumption, such as access, insufficient resources, time and regulations, First Nations Peoples' contemporary diet is marked by elevated consumption of ultra-processed foods (UPFs) (L. Chan et al., 2021). UPFs are the 4th and most processed food group of NOVA classifications (Monteiro et al., 2010). The United States Department of Agriculture defines processed foods as any food that has undergone any changes to

its natural state (Harvard T.H. Chan School of Public Health, 2023). Ultra-processed foods go a step beyond; on top of salt, sugar, oils and fats, they include ingredients not used in culinary preparations and additives that are used to mask the undesirable traits of the final product such as flavourings, nonsugar sweeteners, and colorants (Steele et al., 2016). Although NOVA categorizes foods based on their levels of processing rather than nutritional content (Monteiro et al., 2010), UPFs have been found to be calorie-dense while containing high levels of fat, saturated fat and sugar low levels of protein, fibre and micronutrients and thus, having little nutritional value, possibly due to the additives used in the process of their production (Gibney et al., 2017; Martini et al., 2021). The literature pertaining to the consumption of ultra-processed foods (UPFs) strongly suggests that it is associated with negative health outcomes in the general population, including cardiometabolic diseases, obesity, cancer, cardiovascular disease, type 2 diabetes, and potentially increased mortality (Elizabeth et al., 2020). This statement is further supported by the statistics based on data from First Nations peoples.

One of the most important food groups missing in First Nations' contemporary diet, is fruits and vegetables, resulting in a significant decrease in their fibre, vitamins and minerals consumption. FNFNES concluded that consumption of vegetables, fruits, and milk fell below fifty percent of the recommended servings, while grain product intake approximated the recommended levels. Consumption of meat and alternatives surpassed the recommended quantities by over thirty percent (Batal, Chan, Ing, et al., 2021a). This issue is not limited to First Nations adults. Based on the findings from off-reserve Indigenous and non-Indigenous youth, aged 2-17 years old, using 2004 and 2015 Canadian Community Health Surveys, the Indigenous children and youth significantly consumed fewer fruits and vegetables, dark green or orange vegetables and milk products in 2004. (Riediger et al., 2022)

Evidence of high levels of UPF consumption could be found in FNFNES (Batal, Chan, Ing, et al., 2021a). Based on the results of 24-hour recalls, UPF constituted 53.9% of FNs' dietary intake, with a predominant contribution of energy derived from fast food and pre-prepared meals (15.9%), commercial breads (9.3%) and energy and fruit drinks (8.0%) (Batal et al., 2018). Using three-

dimensional food models as well as 24-hour recalls, FNFNES found that 55% of daily energy of the participants came from Ultra-processed foods (Batal, Chan, Ing, et al., 2021a). Studies among selected and randomized group of First Nations adults residing in three communities within the Syilx Okanagan region of Canada confirmed these findings on a smaller scale, stating that on average UPF accounted for 60.6% of energy intake, while unprocessed or minimally processed foods contributed 27.6%, processed foods contributed 6.6%, and culinary ingredients contributed 5.1% to energy intake (Blanchet et al., 2020). The high UPF consumption is also the case in the Indigenous populations, combined. In a secondary analysis of the nation-wide, cross-sectional data from the Canadian Community Health Survey in 2004 and 2015, between 6 minorities, Indigenous participants had the highest proportion of energy from ultra-processed foods in both 2004 (58.2%) and 2015 (51.9%) (Olstad et al., 2023).

Significant deficiencies have also been identified in the contemporary diet of First Nations peoples in their intake of micronutrients. Based on FNFNES, diets rich in ultra-processed foods had 3.5 times less vitamin A, 2.4 less vitamin K and 2.2 times less protein while 2.3 times more free sugars and 1.8 times more sodium (Batal et al., 2018). Cross-sectional research conducted by Slater et al. examined vitamin D dietary intake within First Nation residents of Lac Brochet, Manitoba, through Food Frequency Questionnaire (FFQ), and compared the findings to the Adequate Intake (AI), Recommended Dietary Allowance (RDA), and Dietary Reference Intake (DRI) (Slater et al., 2013). The FFQ included vitamin D containing foods, both available through the market and wild foods, and was administered in winter and summer to take potential seasonal variations in diet into account. (Slater et al., 2013) 47.8% of the participants met adequate intakes in summer and 40% in winter, with reference to the 1997 AI values (Slater et al., 2013). However, only 13% of the participants met the 2011 RDA requirements in summer and 11% in winter (Slater et al., 2013).

Before the arrival of Europeans, First Nations were able to meet their nutritional needs by exercising their own practices (Government of Canada). Alongside assimilationist policies, the globalization of food systems meant that authority over food systems was given to neo-liberal

national forces and organizations that drove this to benefit the agribusiness industry (Coté, 2016). To indicate the importance of combating these forces that did little to solve world hunger, the concept of "food sovereignty" emerged in a 1996 conference in Tlaxcala, Mexico (Coté, 2016). The definition has ever since undergone several alterations, however: as defined in the Nyéléni Declaration, Food Sovereignty is "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Declaration of Nyéléni, 2007). Although the principle of sovereignty is crucial to Indigenous food practices, this definition seems to be deeply rooted in the western philosophies (Coté, 2016). Most importantly, it does not take into account the complex relationship between Indigenous Peoples and their environments, that is based on respect and reciprocity (Coté, 2016). Indigenous Peoples have always recognized the dangers of worldviews that overlook the sacredness of the natural environment (Coté, 2016). To indigenize, four main concepts were introduced by The Working Group on Indigenous Food Sovereignty (WGIFS) and the British Columbia Food Systems Network (BCFSN), emphasizing on the sacredness of food, Indigenous Peoples' responsibility towards the ecosystem, Indigenous self-determination and reconciling colonial laws and Indigenous cultural values (Coté, 2016). "Indigenous Food Sovereignty" also encompasses the complex relationships of Indigenous Peoples with the land (Coté, 2016). It emphasizes their efforts to re-establish ties with their environment and ecological knowledge systems to enhance their wellbeing (Coté, 2016).

As demonstrated, when it comes to research with Indigenous Peoples, it is crucial to contextualize and define concepts critically, through the lens of Indigenous philosophies and values. Moreover, First Nations communities have long acknowledged traditional food systems and food sovereignty as integral to their health and well-being. The disruption of these systems has been linked to adverse health outcomes, creating growing interest in traditional food systems among Indigenous Peoples and a need for research supporting Indigenous food sovereignty initiatives.

Health Consequences of the Dietary Shift in First Nations

The nutrition transition has been accompanied by a shift in the burden of diseases or "epidemiologic shift" (McKeown, 2009). The consequences of this transition are complex and span from elevated chronic diseases to nutritional deficiencies or a combination of the two (Kuhnlein & Receveur, 1996). This forced transition from traditional food to Westernized dietary patterns has led to significant health inequities among First Nations. Among these health inequities are obesity (Batal & Decelles, 2019; L. Chan et al., 2021; Statistics Canada, 2018), type 2 diabetes (Diabetes Canada, 2023, 2024), Cardiovascular disease (Anand et al., 2001) and hypertension (Public Health Agency of Canada, 2024).

FNFNES concluded that among the randomly selected First Nations individuals living south of the 60th parallel on reserve, half (50%) were obese and one-third (33%) were overweight (L. Chan et al., 2021), leaving only 17% of the population living with normal weight. In contrast, in 2018 and with the conclusion of FNFNES, Statistics Canada reported 26.8% of Canadian adults living with obesity and 36.3% with overweight (Statistics Canada, 2018). All classes of obesity combined (I,II and III), Quebec and Labrador had more obese participants (65%) and British Columbia had the least (43%) (Batal, Chan, Fediuk, Ing, et al., 2021a). Class 3 obesity was more than twice as high in Quebec as any other region (Batal, Chan, Fediuk, Ing, et al., 2021a), highlighting the substantial differences across Canada. Moreover, these health inequities also exist among First Nations living off reserve when compared to the general Canadian population. Based on the statistics provided by a 2011-2014 survey of Statistics Canada, First Nations adults living off-reserve experience an obesity prevalence of 30%, more than the 27% of the general public, as measured in 2017 (Lytvyak et al., 2022; Statistics Canada, 2016). These numbers have also risen among off-reserve First Nations adults by 2.2%, since the earlier survey conducted in 2007-2010 (Statistics Canada, 2016). Moreover, FNFNES found that 46% of First Nations adults living on-reserve are living with obesity. A higher percentage when compared to the total population of Indigenous Peoples, with an obesity prevalence of 18% (Batal et al., 2018; Statistics Canada, 2016). The prevalence of obesity seems to differ based on food security status. A study based on FNFNES in British Columbia,

Manitoba, Alberta and Ontario found that those living in marginally food insecure households had the highest, and food secure households had the lowest rates of obesity, among both men and women (Domingo, Spiegel, et al., 2021). This outlines the two-fold importance of addressing food security and weight management issues, as First Nations, especially those living on-reserve experience a significantly higher prevalence of food insecurity compared to the general population (Batal & Decelles, 2019).

Overweight and obesity are suggested to be strongly linked with other health conditions, among which is diabetes (Field et al., 2001; Visscher & Seidell, 2001), a relationship that has also been evidenced within the First Nations populations (Rosella et al., 2020). In fact, the strength of the obesity-diabetes association led Zimmet et al. to coin the term "diabesity" (Zimmet et al., 2001). FNFNES highlights that First Nations adults living on reserve experience a diabetes prevalence of 21% (L. Chan et al., 2021), and out of those living with diabetes, 68% are living with type 2 diabetes. Statistics Canada reported that between 2011-2014, 8.2% of the First Nations living off-reserve dealt with diabetes, including type 1, 2 and gestational diabetes (Statistics Canada, 2016). A 2024 article by Diabetes Canada estimates that 12.7% of First Nations peoples living off-reserve and 17.2% on-reserve are affected by type 1 and type 2 diabetes (Diabetes Canada, 2024), serving as an example of the difference in the prevalence of health inequities, between First Nations off and on-reserve. This further highlights the need for further research into on-reserve populations, to pinpoint the possible underlying causes, in the food environments as well. Although there is no data on the stratification of this number by the type of diabetes within those residing off-reserve, First Nations Information Governance Centre and First Nations Regional Health Survey (FNRHS) 2008-2010 reported that within First Nations living on reserve and afflicted with all types of diabetes combined, 80.8% are diagnosed with type 2 and 5.8% with gestational diabetes (First Nations Information Governance Centre (FNIGC), 2012). According to FNFNES, nationwide, self-reported type 1 and 2 diabetes combined, ranged from 17% in Alberta to 26% in Ontario, excluding British Columbia with the lowest prevalence of 10%. Stratified by age, 8% of the respondents under 40 and 29% of those older than 40 reported diabetes. The majority of adults

who reported having diabetes specified it as type 2, although 22% were unsure about the type they had (Batal, Chan, Fediuk, Ing, et al., 2021a).

Another study based on the FNFNES studied the high type 2 diabetes prevalence among First Nations: Using the Diabetes Population Risk tool (DPoRT) and the phase 3 data cross-sectional survey from the adult Regional Health Survey (RHS), Rosella et. al characterized the risk of type 2 diabetes in First Nations communities living on-reserve, in Ontario (Rosella et al., 2020). Among the 936 individuals surveyed, 228 were found to have diabetes, while 708 indicated they did not have any types of diabetes at the time of the research (Rosella et al., 2020). The study also projected, using the DRoPT model, that by 2025/2026 there will be approximately 3,501 new cases of type 2 diabetes among First Nations adults, representing an incidence rate of 9.6% (Rosella et al., 2020). Of these new cases, half are expected to occur in adults aged 45-64, with one third occurring in those aged 20-44 (Rosella et al., 2020), emphasizing the importance of early prevention among First Nations. In addition to the significant projected increase in diabetes cases, these figures—substantially higher than the 5% prevalence reported in the general population by Diabetes Canada in 2024—highlight the urgent need to address type 2 diabetes (Diabetes Canada, 2024).

One approach to addressing this issue is to concentrate on the dietary patterns of First Nations communities. In the study by Rosella et al, alongside other risk factors, those diagnosed with diabetes tended to experience hypertension at a higher rate (Rosella et al., 2020), marking a comorbidity with another one of the consequences of the nutritional transition in First Nations. Statistics Canada reports that in 2017, 17.5% of First Nations (North American Indian), living off-reserve report experiencing high blood pressure (Statistics Canada, 2020). This number is comparable to the prevalence reported by Padwal et al. According to this study, almost 1 in 4 Canadians in dealing with high blood pressure (Padwal et al., 2016).

Based on an article from Statistics Canada, 15% of First Nations people living off-reserve reported dealing with two chronic conditions while 14% of them reported 3 or more (Tara

Hahmann, 2022). For instance, according to the 2018 Regional Health Survey (Phase 3), almost 3 in every 4 (73%) First Nations adults with one health condition are also obese or overweight, a figure that increases to 80.9% among those with two or more health conditions (First Nations Information Governance Centre (FNIGC), 2018), highlighting the crucial need to address these core nutritional inequities among First Nations.

Moreover, according to Statistics Canada data from 2017, 57.4% out of 491 thousand First Nations (North American Indian) self-reported living with long-term health problems (Statistics Canada, 2020). In this survey, long-term health problems are defined as "whether or not a person has reported that a health professional has diagnosed him or her with a long-term or chronic medical condition. Long-term or chronic conditions are those which have lasted, or are expected to last, six months or more" (Statistics Canada, 2020). In a study based on the FNFNES, participants assessed their health status using a 5-point scale. In total, 27% of participants indicated excellent or very good health, 39% reported good health, and 33% rated their health as fair or poor (Batal, Chan, Fediuk, Ing, et al., 2021a).

It is important to emphasize that, despite providing valuable information about First Nations' and Indigenous Peoples' health, the previously mentioned studies and statistics, do not incorporate Indigenous concepts or their wholistic definitions of health. Hence, incorporating Indigenous worldviews in research is vital because Indigenous Peoples have unique systems and perceptions of health that differ from Western frameworks. As demonstrated above, most existing statistics and research on Indigenous Peoples fail to follow this wholistic approach, leading to incomplete and potentially misleading conclusions, such as neglecting the importance of other dimensions of Indigenous health, which are not measurable merely through the presence or absence of disease. By acknowledging and integrating these perspectives, research can more accurately reflect the comprehensive nature of Indigenous health and wellbeing.

Measuring First Nations' Complex Food Environments

There is a growing interest in assessing food environments (McKinnon et al., 2009). However, the emphasis in the literature on food environment assessment has primarily been on non-Indigenous populations. Through two systematic reviews, covering a scope of 25 years (1990-2015), McKinnon et al, Lytle and Sokol, identified stores as the most studied food environments, alongside schools from 1990 to 2007 (Lytle & Sokol, 2017; McKinnon et al., 2009). Some systematic reviews offer a comprehensive overview of the methods employed to characterize these concepts. In the same systematic review McKinnon et al. identified the various measures of the Food Environment, from January 1990 to August 2007 (McKinnon et al., 2009). McKinnon and colleagues grouped the ways of food environment measurements as instruments or methodologies. These instruments included 1- checklists, based on a pre-defined list of indicator foods; 2- market baskets, based on pre-defined lists of foods representing the total diet; 3- inventories, representing all foods and 4- interviews or questionnaires, pre-determined and focused on the environment (McKinnon et al., 2009). Methodologies include 1- sales analysis, including cashier receipts and food service reporting forms; 2- menu analysis, encompassing specific food and beverages in a menu; 3- nutrient analysis, focusing on data on calories and nutrients and 4- geographic analysis (McKinnon et al., 2009). Although these methods seem to be widely used in numerous studies on food environments, they are based on market and store-bought foods, not taking into account First Nations peoples traditional food environments and their traditional food gathering activities.

Picking up where the work of McKinnon et al stopped, Lytle and Sokol assessed the studies conducted on measurement of Food Environments, published between 2007-2015, demonstrating more recent trends in food environment measurement methods (Lytle & Sokol, 2017). Almost 30% of the articles utilized checklists, almost double that amount in the previous study, making it the most used tool, followed by interviews/ questionnaires, market baskets and inventories. Following the same course as the McKinnon study, geographical analysis was the predominant methodology for studying the Food Environment, employed in approximately 65% of

the articles. 25.9% of the articles assessed in this systematic review discussed the reliability of the measures, while 28.2% addressed their validity (Lytle & Sokol, 2017). The methods outlined in this study were also not based on First Nations populations, and could not be applied to their traditional food environments as they are based on market and store-bought foods.

In a similar fashion, a systematic review aimed to identify the methodologies and approaches used for measurement of Food Environments, specifically within Canada (Vaillancourt et al., 2024). The authors identified 220 articles, with the distribution of focus as follows: 40% on the retail food environment, 23% on marketing, 19% on composition, 19% on provision, and 14% on prices (Vaillancourt et al., 2024). The consumer retail food environment was evaluated in 27% of the retail articles, with 19 studies focusing on stores and 6 on restaurant settings. 81% of the studies evaluated community retail Food Environment, which included 27 papers on census tracts or dissemination areas, 24 papers around schools, 26 papers around residences and 2 around recreation centres or workplaces (Vaillancourt et al., 2024). This further underscores the importance of conducting food environment assessments for Indigenous Peoples, particularly given the size and rapid growth of their population. And although individually or when combined, these measurements provide valuable insight into food environments, they do not take into account the complex relationship between Indigenous Peoples and their food environments.

Examples of contextualization on Indigenous food could be seen across research on different concepts. A systematic review examined the literature from 1996 to 2021 on the means of measuring Indigenous food sovereignty and identified the Indigenous research methodologies across the globe and in any language (Abdul et al., 2023). At least 1 of the 4 Indigenous food sovereignty domains (community ownership, inclusion of traditional foods, inclusion of cultural food knowledge and environmental sustainability) had to be used or descriptions on how Indigenous food sovereignty has been assessed outside of these domains. Following the implementation of the exclusion criteria, 34 papers were left for further assessment. Most results were retrieved from Canada (Abdul et al., 2023). Moreover, the authors found that Indigenous food sovereignty was mostly assessed with interviews (n=29), focus groups (n=23) and surveys (n=13),

(Photovoice =n=10), dietary assessments (n=7), observations (n=5), knowledge circles (n=5), storytelling (n=3) and questionnaires (n=2) (Abdul et al., 2023). Only one study employed quantitative assessments alone, while 50% of the papers utilized qualitative approaches alone (n=17), closely trailed by mixed-method approaches (n=16) (Abdul et al., 2023). It can be suggested that studies supporting food initiatives may benefit from incorporating more quantitative assessments to provide additional insights into this issue.

Few studies examine Indigenous food environments in a wholistic way, without focusing only on market food systems. Jock et al. conducted a study to describe the perceived Food Environments of Native Americans, using baseline data from the Obesity Prevention Research and Evaluation of InterVention Effectiveness in NaTive North Americans 2 (OPREVENT2). This study focused on 300 adults serving as the primary food purchaser or preparer for their household from three participating communities in the Midwest and Southwest United States. This was the first research using Latent Class Analysis (LCA) to characterize Indigenous Peoples Food Environment (Jock et al., 2020). The exploratory LCA categorized the participants into 2 main classes, based on their patterns of access to the 26 food items listed in the survey: “higher access household Food Environment” and “lower access household Food Environment”. The 2nd class contained more than half (58%) of the participants in the study. The consumer patterns in each of these classes were similar: The "higher access" group had greater access to nearly all the food items included in the survey. Specifically, within the “higher access food group”, fruits and vegetables and fruits syrup and juice were purchased more frequently. “Higher access” and “lower access” group had 22-37% for getting fresh fruit and 18-35% for fresh vegetable. The "higher access" group had a significantly higher likelihood, ranging from 84% to 93%, of obtaining whole grains such as pasta and high-fiber cereals, compared to a range of 44% to 66% among the "low” access group. Another notable food item gotten more by the “higher access” group was high-fibre rice, with a frequency of 90% versus 54% in the “lower access” group. Proteins were more (22-84%) accessible to the “higher access” group than the “lower access” group (5-55%). With a similar pattern, game meat was also among the items more accessible to the “higher access” group. (63% versus 43%). “Higher access” group

indicated greater availability of drinks such as milks and sugar-free drinks, and natural fruit juice. Low-fat milks were equally accessible to both groups. Snacks, nuts, cooking spray or low-fat dressings were also more commonly available to the "higher access" groups. Both groups had similar patterns of taking part in the food assistance programs (Jock et al., 2020). Also taking both traditional and market foods into account and with the same approach, another study assessed the barriers to both market and traditional food within 1711 Yukon First Nations, Dene/Métis and Inuit women living in 44 communities across the Canadian Arctic, using secondary data from three large cross-sectional studies by Centre for Indigenous Peoples' Nutrition and Environment (CINE). According to the results, region played a significant role in the ability to afford food, as well as hunting or fishing equipment. Between 40 to 70% of the participants across all regions could afford enough food. Approximately up to half of the responses highlighted insufficient availability of fishing and hunting gear, while nearly half of the participants (up to 46%) expressed financial constraints preventing them from engaging in hunting or fishing activities (Lambden et al., 2006).

Research Objective and Hypothesis

Previous food environment research has predominantly focused on market foods, and therefore fails to take into account traditional foods and the ways of engaging with the traditional food environment that significantly differs from Westernized food environments which encompass mainly store-bought foods. Moreover, while all of the aforementioned methodologies (sales analysis, menu analysis, nutrient analysis, geographic analysis) and instruments (checklists, market baskets, inventories, interviews or questionnaires) (Lytle & Sokol, 2017; McKinnon et al., 2009) provide comprehensive characterizations of one dimension of food environment, they do not provide a wholistic assessment. Although the paper by Jock et al. (Jock et al., 2020) provides a more wholistic assessment of these environments compared to previous literature, its scope is confined to Native Americans in the United States. To the best of our knowledge, no such study has been conducted to describe the complex traditional food environments of First Nations in

Canada. This study aims to fill this gap in the literature on First Nations traditional food environments by incorporating a wholistic and indigenized way of characterization, thereby offering a more accurate evaluation of First Nations dietary patterns and their underlying differences. The aim of this study is to (1) describe traditional food environments and their latent subgroups and (2) describe the associations between First Nations' traditional food environments and demographic characteristics and health outcomes. We hypothesize that the participants in the FNFNES communities consist of several distinct and homogenous subgroups, each defined by unique patterns of traditional food consumption. We also hypothesize that adults in the higher consumption group tend to be older, live in larger households, report better self-perceived health and higher activity levels, and have lower BMI values and a reduced prevalence of type 2 diabetes.

Methods

Latent Class Analysis Overview

Latent class analysis (LCA), is a methodology used to detect and describe underlying subgroups within a population, using a set of correlated observable variables or "indicators" (McCutcheon, 1987; Sinha et al., 2021). Although LCA is conceptually similar to more empirical methods such as cluster analysis, it differs in the sense that LCA is driven by the hypothesis that there exists an underlying and latent cause of the observed similar patterns in each class of the population which explains the correlations among the observable variables—a "homogeneity" assumption (McCutcheon, 1987), whereas Cluster Analysis explores naturally occurring groups based on patterns, without the assuming that underlying cause exists (Wilmink & Uytterschaut, 1984). In this study, First Nations' Traditional Food Environment is considered a latent variable because it is not directly observable in and of itself, but is measurable through a collection of highly-correlated indicator variables: traditional food consumption patterns. Previous studies have demonstrated that LCA shows promise for providing a wholistic characterization of food environments for Indigenous populations (Jock et al., 2020).

LCA has previously been employed to understand latent variables among Indigenous populations, including Native Americans' food environments in the United States (Jock et al., 2020), Inuit concepts of health and well-being (Bertheussen et al., 2024), and the risk of mental health outcomes as an adult in people with Adverse Childhood Experiences (Elma et al., 2021). Moreover, LCA has also been used to describe food environments in non-Indigenous populations (DeWeese et al., 2018; Park et al., 2020; Sánchez et al., 2022).

Conceptual Framework

We used the Ohén:ton Karihwatéhkwen as the conceptual framework guiding our understanding of relationships with aspects of Indigenous traditional food environments,

andincorporates origin, use and nutritional characteristics. The Ohén:ton Karihwatéhkwen, in Kanien'keha (Mohawk language) translates to "The words which come before all else," is a Haudenosaunee practice that expresses gratitude, love, and respect for all elements of creation. Ohén:ton Karihwatéhkwen offers a wholistic perspective on the relationships of Haudenosaunee with their environment, and this study leverages this depth to offer a wholistic understanding of the traditional food environments. Dr. Brittany Wenniserí:iostha Jock, the supervisor of this project and a member of the Kanien'kehà:ka Mohawk Nation, brings Kanien'kehà:ka knowledge to this research.

Parent Study: First Nations Food, Nutrition and Environment Study (FNFNES)

The First Nations Food, Nutrition, and Environment Study (FNFNES) is a nationwide representative study of 6487 First Nations adults living on 92 reserves in Canada, south of the 60th parallel conducted between 2008 and 2018. The study included 11 ecozones across eight Assembly of First Nations (AFN) regions including British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec-Labrador and Atlantic regions (including New Brunswick, Newfoundland, Nova Scotia and Prince Edward Island). FNFNES did not include the Northwest Territories, Yukon and Nunavut regions in the study since the knowledge gap existed for the communities south of the 60th parallel: The Inuit communities in these regions participated in the Inuit Health Survey and a program funded by Nutrition North collected dietary data in the Yukon and Northwest territories. This study had 4 aims: 1) describe the dietary patterns of traditional and market food consumption in each of the AFN regions 2) determine the dietary intake of certain chemical contaminants by testing traditional food and drinking water from each AFN region 3) to estimate the nutrient intake for certain micronutrients as well as protein, fat and carbohydrates 4) assess food security within each AFN region. (H. M. Chan et al., 2021).

The study used a combination of random and purposeful selection of communities to ensure that study findings were generalizable (H. M. Chan et al., 2021). The communities were

grouped by AFN regions and were further divided into 11 ecozones to ensure communities would represent the variety of diets. Ecozones are areas characterized by distinct patterns of plants and animal distributions, as well as geographical features, and climate. Across each region, the communities were selected by a calculation that proportionally represented the square root of the number of eligible communities with on-reserve populations during the initial sampling period. In ecozones with many communities, the communities included in the final sample were randomly selected, while the communities in ecozones with "a very small number of communities" (L. Chan et al., 2021) were all recruited. Lastly, 8 First Nations were purposefully chosen due to a lack of "previously published data" (Nuxalk Nation) and to ensure "cultural and ecosystem diversity" (Skidegate, Unamen Shipu) and "contamination concerns" (Mikisew Cree First Nation, Onion Lake, Grassy Narrow, Aamjiwnaang) (L. Chan et al., 2021) to also properly address some of the other objectives of FNFNES. The results from purposefully-selected communities were not weighted.

Within each participating community, 125 households were randomly selected. In cases where a community had fewer than 125 households, all households were selected to ensure a total of 100 households were included (H. M. Chan et al., 2021). From each household with more than one eligible participant present at the time of data collection, the individual whose birthday was next was selected. Eligible participants included those self-identifying as First Nations individual, older than 19 years old, and living on-reserve at the time of the study (H. M. Chan et al., 2021).

Data collection occurred in the fall months (September to mid-December) between the years of 2008-2016, for the results to be seasonally comparable across communities over the course of the study. Data collection was done at multiple levels in each community: household and community level. The FNFNES collected household data through five methods over a visit of 1 to 2 hours. Household surveys including questions about their traditional food consumption through a food frequency questionnaire (FFQ), market food consumption through 24-hour recalls, health, lifestyle, socioeconomic status, household composition (number of members, their age and their job status) and food security. To get a better estimate of the day-to-day variations in diet and to "partially adjust for ultra-individual variations", 20% of the participants were invited for a follow-up

session on 24-hour recalls (Chan, 2011). All participants provided informed, written consent to participate. Although the biggest incentive among community members was helping the community and each other, the participants were also offered gifts as a compensation for their time (Chan et al., 2019).

Ethical Approvals

The FNFNES study is aligned with the First Nations principles of Ownership, Control, Access and Possession (OCAP), meaning FNFNES established formal agreements to affirm First Nations data stewardship before any data was collected. Moreover, agreements with communities outlined that First Nations authorities held and governed their data. Communities controlled how the findings were used and access was assured by returning data and building local capacity to use it (H. M. Chan et al., 2021). Prior to the initiation of the study, Chiefs-in-Assembly at the Assembly of First Nations Annual General Assembly and Regional Chiefs gave their approval to the project. Provincial/territorial organizations were also engaged in consultation to enhance the study's effectiveness in addressing particular local environmental issues and requirements. They were able to provide feedback on the study's methodology and objectives in such a way that would assist in addressing their needs and also guide the researchers in creating a more fitting research survey based on the foods consumed in their region. The study was reviewed and approved by participating communities. Each participating community signed a Community Research Agreement, Funding Transfer Agreement, and, if considered necessary by the First Nations, a Band Council Resolution, with adjustments made to the wording as needed. While the project funding and training were provided by the FNFNES, First Nations took on the responsibility of data gathering and administration of funds within their own communities. (H. M. Chan et al., 2021). This research was designed and conducted in accordance with the 1964 Helsinki Declarations (World Medical Association, 1964). Procedures involving human participants were approved by the ethical standards of Ethical Review Boards at Health Canada (REB 2008-0003), the University of Northern

British Columbia (E2008.0526.114), the University of Ottawa (H06-13-18), and the Université de Montréal (CERSES-20-159-D).

For the purposes of this study, a list of variables was selected from the household survey to represent the food environment indicators and covariates. Variable sections from the following sections were requested, approved and compiled: the traditional food questionnaire, the social, health and lifestyle questionnaire, and the food security questionnaire. A data request proposal was submitted to the Assembly of First Nations and the FNFNES team on June 27th, 2024 and was approved on June 28th, 2024.

Latent variable: Traditional Food Environment

The traditional food environments were understood through consumption of 226 traditional food items included in the FFQ of FNFNES. The FNFNES questionnaire collected data on the traditional food consumption of First Nations across Canada, through FFQs, i.e. asking each individual if they have consumed each specific traditional food item in the past year, and if so, how many times per season The original FNFNES FFQs include 12 categories of food variables: 1-Fish species, 2-land mammal species, 3-wild bird species, 4-wild berries, nuts, seeds and fruits, 5-wild plants, roots, shoots and greens, 6-tree foods, 7-mushrooms, 8-shellfish, crustaceans, squid, seal 9-beach food species, 10-sea mammal species, 11-bird eggs, 12-cultivated traditional food, 5 of which are mutual between all regions (Fish species, land mammal species, wild bird species, tree foods and mushrooms), with the number of variables ranging from 151 in Alberta to 208 in British Columbia. Each regional survey was tailored to include the most commonly consumed traditional foods, resulting in region-specific categorizations. The traditional food items on the survey were developed following consultations with community representatives to verify the species present in each region. For the traditional food items, participants were asked if they had consumed each item in a list of traditional foods items in each season, and how many times per season.

Traditional foods recategorization based on Ohén:ton Karihwatéhkwen

Based on the Ohén:ton Karihwatéhkwen, we categorized the traditional food items into nine groups:

Table 1: The Ohén:ton Karihwatéhkwen categories and the inclusion criteria for each.

Ohén:ton Karihwatéhkwen Category	Eligibility
Kahi'shon:'a / Fruits	Food items that developed from the flowering part of a plant (e.g., blueberries, crabapple, cactus fruit) Excludes sumac because it is not consumed as fruit. Also excludes sunflower seeds, as they are nutritionally more similar to nuts.
Kentsion'shon:'a / Fish	Edible aquatic species and their eggs (e.g., clams, catfish and eel) Excludes sea mammals, aquatic plants and algae (e.g., sea lion meat, seaweed)
Kontirio / Animals	Food items derived from terrestrial or aquatic mammals (e.g., deer kidney, sea lion meat, black bear fat)
Otsi'ten'okon:'a / Birds	Birds and bird eggs (e.g., ducks, loon, bird eggs)
Karonta'shon:'a / Trees	Edible parts of trees or tree products. Including sap, nuts, pitch (e.g., hazelnut, pine pitch, maple syrup) Includes sunflower seeds because of their similar nutritional composition as other nuts

	Excludes tree parts and products used for tea
Ohtera'shon:'a / Roots	Edible underground plant structures, Including all items that specified the root (e.g., sarsaparilla root, balsam root, wild onion) Excludes items used for tea
Ohonte'shon:'a / Grasses	Plants with long stems that do not develop woody stems, and die during winter seasons (e.g., wild iris, dandelions, rhubarb) Excludes items used for tea
Kionhehkwen / Sustenance Foods	Foods considered staple foods by Indigenous communities, including the Three Sisters (corn, beans, and squash) and wild rice Excludes animal and fish protein sources
Ononhkwa'shon:'a / Medicines	Items used for medicinal purposes/ not consumed as foods on their own. Includes items that specifically mentioned tea (e.g., cherry bark tea, alder tea, tamarack gum)

The categories and the definition of each were first developed and applied in the categorization of traditional food items. The inclusion criteria in each category were then refined through discussions on the meanings of each category in the Kanien'kéha language with a knowledge expert. Discrepancies were initially discussed and resolved within our team, with guidance from Knowledge Carrier Kathy Herne from the Akwesasne Mohawk Nation.

Covariates

Covariates were chosen based on the available variables from the Social, Health and Lifestyle questionnaire, and the Food Security questionnaire included in the FNFNES household survey. The following groups of variables were used as covariates: demographics, anthropometry, health behaviours, health status and food security).

1. Demographics: The demographics included in the FNFNES were participants' gender, age and age group (19-30 or 31-50 or 51-70 or 71+ years old) and their household composition, referring to the number of people living in the household based on their age, i.e. less than 15 years of age or between 15-65 or over 65. The questionnaire also collected data on whether there are any children (<18 years of age) in the household (Yes/No). Female participants also provided information on their pregnancy and breastfeeding status separately (both questions with Yes/No). Participants were asked to provide demographic characteristics for the number of years of education and their highest attained education level in categories (high school diploma, GED, vocational training certificate, CEGEP, Bachelor's degree, Master's degree, Doctorate degree). The questionnaire includes data on the number of people in the household who were employed both full-time (≥ 35 hours/week) and part-time (< 35 hours/week) and the participants' source of income (wages/ salary/ self-employment, pension/ senior benefits, social assistance, worker's compensation/ employment insurance, none or other sources). Participants could refuse to provide information on their main source of income. Moreover, each participant's AFN region, community ID and ecozone of residence were recorded.

2. Anthropometry: Anthropometrics included height, weight and Body Mass Index (BMI) of each participant. Anthropometrics were measured (height in cm, weight in pounds) when participants allowed or were self-reported (height in cm or inch and feet, weight in pounds) when they did not consent to measurement. Overall, 3549 (53.32%) individuals had both their height and weight measured, while 2244 (34.59%) participants only self-reported their height and/or weight. In cases where both measured and reported height and/or weight were available, the measured values were

preferred in the calculation of BMI. Based on their BMI, participants were then categorized into underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), or obese (30<). We then categorized the obese participants into obesity classes 1 (30-34.9), 2 (35-39.9) and 3 (40<).

3. Health status: Information on self-perceived health status was gathered through 5 questions. These questions were on self-reported health with categorical responses of excellent, very good, good, fair and poor. Participants also indicated whether they had been diagnosed with any form of diabetes (excluding gestational diabetes). If yes, they specified whether it was type 1, type 2, or if they were unsure.

4. Behavioural variables: As for the traditional food activities, participants were asked separately if they or any other household member hunted or set snares (Yes/No), fished (Yes/No), collected wild plant food (Yes/No), collected seafood (Yes/No) or planted a garden (Yes/No). For this analysis, we combined each traditional food activity category of the main participants and other household members into one variable named household traditional food activity. Participants also answered questions on activity levels with categorical responses of heavy work, carrying light loads or climbing, standing or walking a lot, sitting and not much walking and their evaluation of how their activity level compared to that of others in their age group (more active, less active, average, do not know). They were also asked if they have smoked the day before (Yes/No, if yes, the number of cigarettes).

5. Food security: Lastly, participants were asked 18 questions about their food security, categorizing them as food secure or marginally, moderately or severely food insecure based on the Household Food Security Survey Module (HFSSM) used in the Canadian Community Health Survey (CCHS) (Health Canada, 2012), and the threshold adopted by PROOF (PROOF Food Insecurity Policy Research, 2018).

Data Analysis Procedure

To conduct the exploratory LCA, variables were dichotomized. For the purposes of our analyses, we calculated the annual consumption of each Traditional food (TF) and each Ohén:ton Karihwatéhkwen category by adding the consumption frequencies per each season (i.e. [TF consumption] in spring + summer + fall + winter). A Never vs Ever dichotomization cut-off was chosen based on the Ohén:ton Karihwatéhkwen category distributions and was justified given the high frequency of zero consumption throughout a year. The visual inspections confirmed that a "never" (i.e. not having consumed a specific traditional food at all throughout the year) versus "ever" (i.e. having consumed a specific traditional food at least once throughout the year) dichotomization works best across all 9 Ohén:ton Karihwatéhkwen categories, given the high percentage of participants who had never consumed specific traditional foods at all at the time when the FFQ was conducted, as shown in Table 2.

Table 2: Percentage of the participants who have never or ever consumed traditional foods included in each of the Ohén:ton Karihwatéhkwen categories.

	% Never	% Ever
Kahi'shon:'a / Fruits	29.07	70.93
Kentsion'shon:'a / Fish	28.81	71.19
Kontirio / Animals	22.86	77.14
Otsi'ten'okon:'a / Birds	62.05	37.95
Karonta'shon:'a / Trees	84.71	15.29
Ohtera'shon:'a / Roots	84.48	15.52
Ohonte'shon:'a / Grasses	87.11	12.89

Kionhehkwen / Sustenance Foods	80.98	19.02
Ononhkwa'shon:'a / Medicines	82.21	17.79

Exploratory Latent Class Analysis

To choose the number of classes needed to achieve within-class homogeneity, an exploratory LCA (eLCA) was conducted with 6 of the 9 Ohén:ton Karihwatéhkwen categories to assure an adequate sample size in the resulting food consumption patterns for goodness of fit analysis. These categories included fruits, birds, sustenance foods, animals, fish and medicine. They were chosen in such way to represent the range of traditional food nutritional profiles and the diverse complex relationships with the land and consumption methods. We ran an eLCA model using Mplus version 8 (Muthén, n.d.) and maximum log likelihood with 1-9 class models and extracted model fit statistics including Bayesian information criterion (BIC), Lo–Mendell–Rubin (LMR), bootstrap likelihood ratio test (BLRT), the number of patterns with extreme standardized residuals (SR) (>1.96), and model precision (based on the size of standard errors of probability estimates) to compare 1-9 class models.

Latent Class Analysis and Describing the Latent Classes

Once the number of classes was selected, we conducted LCA using all 9 Ohén:ton Karihwatéhkwen categories to each of the classes. To further describe the latent classes based on the covariates, we assigned individuals to a latent class, based on their highest probability of class membership and calculated means or proportions for each covariate. We tested for similarity between classes using Chi-Squared and one-way ANOVA with a significance level of $\alpha = 0.05$. All analyses were conducted using STATA version 18.5 (StataCorp, 2024) and Mplus version 8 (Muthén, n.d.).

Results

Participants Characteristics

Table 3 describes the characteristics of First Nations individuals participating in FNFNES. Overall, 6487 participants from a total of 92 communities were included in the study. Their representation in each AFN region is as follows: 17% in British Columbia, 9.39% in Alberta, 16.06% in Saskatchewan, 10.00% in Manitoba, 8.83% in Quebec, 22.03% in Ontario and 15.08% in Atlantic Territories.

The study sample consisted of 4277 females representing the majority (65.93%), Quebec had the highest proportion (73.30%) of female participants whereas Ontario had the lowest (62.70%). Across all regions, 2.17% of the participants were pregnant and 1.88% were breastfeeding.

The average age of the participants was 44.25, and approximately, half (46.22%) of individuals were aged between 31 to 50. On average, households were comprised of 3.76 adults, with more than half (58.72%) of the households reporting having children.

Overall, less than 1 person in each household was employed full-time and half-time. Roughly half (49.84%) of the participants relied on income through wages, salary or self-employment. Almost three-quarters (42%) have education levels of high school or less, with around 11 years spent on average on education.

Almost half of the participants (48.04%) were considered obese, with an overall BMI average of 30.48. Among obese participants, 43.2% were living with type 1 obesity and 33.3% were living with type 3. Nearly half of the participants (42.67%) reported their daily physical activity mostly involved standing or walking frequently, without lifting. Although 40.79% of the participants perceived their health as “good”, 25.91% considered it “fair”. More than half (53.60%) of the individuals were smokers, with an average of 10 cigarettes smoked the previous day. One-fifth (18.59%) were diagnosed with diabetes, with type 2 diabetes representing 71.21% of the cases.

Table 3: Sociodemographic, anthropometrics and health variables of FNFNES participants across AFN regions

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
% Ecozone (n)*								
Pacific Maritime	7.49%	44.06%	-	-	-	-	-	-
	(486)	(486)	-	-	-	-	-	-
Boreal Cordillera	1.23%	7.25%	-	-	-	-	-	-
	(80)	(80)	-	-	-	-	-	-
Montane Cordillera	4.83%	28.38%	-	-	-	-	-	-
	(313)	(313)	-	-	-	-	-	-
Taiga Plains	2.34%	9.25%	8.21%	-	-	-	-	-
	(152)	(102)	(50)	-	-	-	-	-
Boreal Plains	19.24%	11.06%		49.23%	26.49%	-	-	-

[1] %- percent, SD- Standard deviation, BMI- Body Mass Index

[2] AB- Alberta, AT- Atlantic, BC- British Columbia, MB- Manitoba, ON- Ontario, QC- Quebec, SK- Saskatchewan

*statistically significant differences across regions at α=0.05

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
	(1248)	(122)	69.95% (426)	(513)	(187)	-	-	-
Prairies	8.89%	-		26.30%	24.08%	-	-	-
	(577)	-	21.84% (133)	(274)	(170)	-	-	-
Taiga Shield	4.19%	-		8.83%	16.57%	10.99%	-	-
	(272)	-	-	(92)	(117)	(63)	-	-
Boreal Shield	20.30%	-	-	15.64%	32.86%	20.59%	49.20%	9.85%
	(1317)	-	-	(163)	(232)	(118)	(703)	(101)
Hudson Plains	4.96%	-	-	-	-	9.77%	18.61%	-
	(322)	-	-	-	-	(56)	(266)	-
Mixedwood Plains	10.50%	-	-	-	-	38.57%	32.19%	-
	(681)	-	-	-	-	(221)	(460)	-
Atlantic Maritime	16.02%	-	-	-	-	20.07%	-	90.15%
	(1039)	-	-	-	-	(115)	-	(924)
% Sample size (n)	6487	17.00% (1103)	9.39% (609)	16.06% (1042)	10.00% (706)	8.83% (573)	22.03% (1429)	15.80% (1025)

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
% Female (n)*	65.93%	64.01%	63.55	69.19	67.56%	73.30%	62.70%	65.37%
	(4277)	(706)	(387)	(721)	(477)	(420)	(896)	(670)
Breastfeeding*	2.17%	2.72%	4.27%	2.30%	1.42%	3.49%	1.40%	1.07%
	(141)	(30)	(26)	(24)	(10)	(20)	(20)	(11)
Pregnant*	1.88%	1.27%	1.97%	2.78%	2.12%	1.57%	1.61%	1.95%
	(122)	(14)	(12)	(29)	(15)	(9)	(23)	(20)
Mean age in years (SD)*	44.25 (14.92)	43.83 (14.38)	43.75 (13.84)	43.19 (14.80)	42.33 (14.46)	45.83 (15.45)	46.40 (15.87)	43.89 (14.10)
% Age group (n)*								
19-30	18.18%	16.25%	17.14%	21.05%	22.31%	16.50%	15.95%	18.96%
	(1053)	(148)	(96)	(204)	(137)	(85)	(204)	(179)
31-50	46.22%	47.86%	50.71%	44.79%	48.70%	43.88%	32.32%	47.03%
	(2677)	(436)	(284)	(434)	(299)	(226)	(554)	(444)
51-70	29.75%	30.95%	24.64%	30.24%	26.06%	30.87%	31.98%	29.87%
	(1723)	(282)	(138)	(293)	(160)	(159)	(409)	(282)

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
71+	5.47% (317)	3.73% (34)	6.43% (36)	3.82% (37)	2.93% (18)	8.74% (45)	8.68% (11)	3.81% (36)
Mean household size (SD)*	3.76 (2.31)	3.43 (2.01)	4.67 (2.84)	4.53 (2.56)	4.39 (2.61)	3.34 (2.07)	3.37 (2.00)	3.10 (1.80)
Mean number of members <15 years old		0.98 (1.28)	1.77 (1.98)	1.69 (1.71)	1.74 (1.83)	1.07 (1.41)	1.00 (1.41)	0.91 (1.30)
Mean number of members 15-65 years old		2.28 (1.31)	2.67 (1.59)	2.67 (1.53)	2.50 (1.43)	2.04 (1.27)	2.14 (1.33)	2.08 (1.15)
Mean number of members 65+ years old		0.16 (0.46)	0.22 (0.64)	0.16 (0.44)	0.14 (0.53)	0.21 (0.52)	0.23 (0.61)	0.10 (0.33)
% Households with children (< 18 years old) (n)*	58.72% (3809)	58.39% (644)	67.82% (413)	69.58% (725)	73.23% (517)	55.15% (316)	49.20% (703)	47.90% (491)
Mean number of people in each household who are employed (SD)								
Full-time*	0.76	0.75	0.85	0.77	0.66	0.90	0.82	0.64

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
	(0.89)	(0.89)	(0.93)	(0.89)	(0.84)	(0.93)	(0.91)	(0.81)
Part-time*	0.26	0.34	0.19	0.22	0.16	0.27	0.24	0.35
	(0.56)	(0.64)	(0.45)	(0.52)	(0.51)	(0.56)	(0.51)	(0.66)
% Participants' main source of income (n)*								
Wages/ salary/ self-employment	49.84%	55.97%	49.75%	45.57%	40.14%	54.97%	51.76%	48.87%
	(3206)	(605)	(301)	(473)	(281)	(315)	(735)	(496)
Workers compensation/ employment insurance	6.36%	6.57%	2.31%	3.28%	3.14%	6.63%	8.94%	10.15%
	(409)	(71)	(14)	(34)	(22)	(38)	(127)	(103)
Pension/ seniors' benefits	11.86%	10.64%	12.56%	8.57%	9.00%	15.01%	17.82%	7.98%
	(763)	(115)	(76)	(89)	(63)	(86)	(253)	(81)
Social Assistance	29.35%	25.72%	32.23%	38.73%	46.14%	17.98%	18.45%	32.02%
	(1888)	(278)	(195)	(402)	(323)	(103)	(262)	(325)
Other	2.58%	1.11%	3.14%	3.85%	1.57%	5.41%	3.03%	0.99%

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
% Highest attained education level (n)*								
Less than high school	42.00% (2543)	35.51% (250)	49.75% (302)	47.59% (493)	58.49% (410)	40.35% (230)	42.42% (604)	25.07% (254)
Vocational training	8.90% (539)	19.32% (136)	18.78% (114)	4.15% (43)	9.56% (67)	4.04% (23)	6.18% (88)	19.32% (136)
High school diploma or equivalent	32.98% (1997)	41.05% (289)	18.95% (115)	36.10% (374)	29.24% (205)	31.58% (180)	29.56% (421)	40.77% (413)
Post-secondary degree	16.12% (976)	4.12% (29)	12.52% (76)	12.16% (126)	2.71% (19)	24.04% (137)	21.84% (311)	27.44% (278)
Mean number of school years completed (SD)*	10.96 (3.21)	10.81 (2.75)	10.40 (3.00)	10.85 (2.78)	9.77 (2.45)	11.09 (3.70)	11.14 (3.77)	11.80 (3.20)
Mean BMI ($^{kg}/_{m^2}$)(SD)*	30.48 (6.50)	29.61 (6.47)	29.86 (6.38)	30.32 (6.50)	30.60 (6.41)	31.96 (7.38)	30.81 (6.14%)	30.54 (6.46)
% BMI status (n)*								
Underweight (<18.5$^{kg}/_{m^2}$)	0.91%	1.43%	1.96%	1.24%	0.49%	0.97%	0.31%	0.53%

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
	(53)	(13)	(11)	(12)	(3)	(5)	(4)	(5)
Normal weight (18.5-24.9 $^{kg}/_{m^2}$)	18.61%	22.50%	19.46%	19.30%	18.89%	14.17%	16.18%	19.15%
	(1078)	(205)	(109)	(187)	(116)	(73)	(207)	(181)
Overweight (25-29.9 $^{kg}/_{m^2}$)	32.44%	35.02%	34.46%	31.37%	30.62%	28.93%	33.54%	31.43%
	(1879)	(319)	(193)	(304)	(188)	(149)	(429)	(297)
Obese (30 $^{kg}/_{m^2}$<)	48.04%	41.05%	44.11%	48.09%	50.00%	55.92%	49.96%	48.89%
	(2783)	(374)	(247)	(466)	(307)	(288)	(639)	(452)
Obese class 1 (30-34.9 $^{kg}/_{m^2}$)	43.20%	37.46%	46.28%	48.24%	42.61%	37.86%	42.25%	43.36%
	(1502)	(212)	(137)	(260)	(170)	(131)	(357)	(235)
Obese class II (35-39.9 $^{kg}/_{m^2}$)	23.50%	18.90%	23.65%	23.38%	21.30%	26.01%	23.95%	27.68%
	(817)	(107)	(70)	(126)	(85)	(90)	(189)	(150)
Obese class III (40 $^{kg}/_{m^2}$<)	33.30%	43.64%	30.07%	28.39%	36.09%	36.13%	30.80%	28.97%
	(1158)	(247)	(89)	(153)	(144)	(125)	(243)	(157)
% Self-perceived major physical activity (n)*								
Sitting, not walking around much	19.81%	16.91%	16.91%	16.89%	22.62%	22.38%	22.79%	20.10%

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
	(1282)	(185)	(103)	(176)	(159)	(128)	(325)	(206)
Standing or walking a lot, no lifting	43.67%	39.03%	43.19%	48.85%	50.64%	44.76%	42.29%	40.20%
	(2826)	(427)	(263)	(509)	(356)	(256)	(603)	(412)
Lifting lightweights, climbing or walking often	26.13%	33.27%	27.91%	25.53%	17.50%	25.35%	24.05%	27.32%
	(1691)	(364)	(170)	(266)	(123)	(145)	(343)	(280)
Heavy work or lifting heavy loads	10.38%	10.79%	11.99%	8.73%	9.25%	7.52%	10.87%	12.39%
	(672)	(118)	(73)	(91)	(65)	(43)	(155)	(127)
% Self-perceived health compared to others with the same age (n)*								
Excellent	8.47%	12.07%	6.57%	10.46%	6.52%	9.25%	6.16%	7.80%
	(549)	(133)	(40)	(109)	(46)	(53)	(88)	(80)
Very good	18.78%	19.15%	16.75%	15.93%	15.04%	24.78%	18.12%	22.63%
	(1218)	(211)	(102)	(166)	(106)	(142)	(259)	(232)

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
Good	40.79% (2645)	37.75% (416)	38.42% (234)	40.40% (421)	41.28% (291)	42.58% (244)	45.14% (645)	38.44% (394)
Fair	25.91% (1680)	25.68% (283)	30.21% (184)	27.74% (289)	29.79% (210)	19.37% (111)	24.42% (349)	24.78% (254)
Poor	6.06% (393)	5.35% (59)	8.05% (49)	5.47% (57)	7.38% (52)	4.01% (23)	6.16% (88)	6.34% (65)
% Smoked the previous day (n)*	53.60% (3477)	45.96% (504)	57.96% (353)	67.56% (704)	62.89% (444)	40.49% (232)	50.66% (724)	50.34% (516)
Mean number of cigarettes smoked in the previous day (SD)*	10.03 (7.46)	8.44 (7.60)	9.23 (7.21)	9.46 (6.80)	10.22 (6.70)	10.04 (8.41)	9.80 (7.20)	13.07 (8.05)
% Diagnosed diabetes (n)*	18.59% (1206)	5.98% (66)	17.41% (106)	17.47% (182)	19.26% (136)	18.32% (105)	26.52% (379)	22.63% (232)
Type 1	11.40% (137)	14.06% (9)	7.55% (8)	13.74% (25)	8.21% (11)	7.62% (8)	12.40% (47)	12.50% (29)
Type 2	71.21%	60.94%	77.36%	67.58%	67.16%	72.38%	71.24%	75.86%
Unknown								

Mean (SD) or % (n)[1]	Overall	AFN Regions[2]						
		BC	AB	SK	MB	QC	ON	AT
	(856)	(39)	(82)	(123)	(90)	(76)	(270)	(176)
	17.39%	25.00%	15.09%	18.68%	24.63%	20.00%	16.36%	11.64%
	(209)	(16)	(16)	(34)	(33)	(21)	(62)	(27)

Exploratory Latent Class Analysis

The model fit statistics comparing 1-9 class models are shown in Table 4. The 5 and 7-class models show the most promising results in terms of fit statistics. The 5 class model has the lowest BIC, significant LMR and BLRT while showing a decrease in the number of extreme standardized residuals (>+/-1.96).

Sensitivity analysis

The 7-class model had low BIC. Moreover, it showed statistically significant LMR and BLRT, demonstrating a better fit than the 6-class model. There are no patterns with extreme standardized residuals (#SR), and although the BIC is not at its absolute minimum, it is still among the lower values. However, the seven-class model offered no improvement in class distinction, so we opted for the more parsimonious model.

Table 4: Exploratory LCA ran with chosen traditional food categories (n=6) (Fruits, Birds, Sustenance, Fish, Animals, Medicine)

	Total possible patterns: 2^6= 64				Observed patterns: 57			
Classes	**#S**	**LL**	**-2LL**	**AIC**	**BIC**	**LMR**	**BLRT**	**#SR**
1	6	-21792.595	43585.19	43597.191	43637.856	N/A	N/A	41
2	13	-20310.760	40621.52	40647.520	40735.629	0.000*	0.000*	27
3	20	-20190.010	40380.02	40420.021	40555.572	0.000*	0.000*	24
4	27	-20106.456	40212.912	40449.905	40449.905	0.000*	0.000*	13
5	34	-20073.417	40146.834	40214.835	40445.27 [a]	0.0026*	0.000*	4
6	41	-20055.727	40111.454	40193.454	40471.334	0.3167	0.000*	2
7	48	-20039.855	40079.71	40175.711[a]	40501.033	0.0170*	0.000*	0
8	55	-20035.856	40071.712	40181.713	40554.478	0.0111*	1.000	0
9	62	-20032.611	40065.222	40189.223	40609.431	0.0939	0.3077	0

#S—number of free parameters, LL— Log Likelihood, AIC— Akaike information criterion, BIC—Bayesian information criterion, LMR—Lo–Mendell–Rubin, BLRT—bootstrap likelihood ratio test, #SR—number of patterns with standardized residuals ≥ 1.96; [a] in AIC/BIC: the lowest value for the latent variable, * in LMR/BLRT: fits significantly better than a k-1 class model

Latent Class Analysis

Table 5 reports the latent class prevalence and the conditional probabilities of food environment categories for each latent class. Latent Class Analysis (LCA) identified five distinct classes that captured varying levels of traditional food access: class 1 (with 14.27% of the participants), class 2 (26.74%), class 3 (6.21%), class 4 (35.30%), and class 5 (17.46%). We named latent class 1 "robust traditional food environment", as it had a higher than 65% access to almost every food group. It was composed of patterns of 98% access to fruits and animals and 85% access to fish. It also showed above 50% access to birds, medicine and roots. Participants in latent class 1 also had 25% access to sustenance foods, 31% access to trees and 30% to roots.

Latent class 5 or the "limited access to traditional food environments", demonstrated the lowest access. Participants in this class had lower than 25% access to every food group. Their highest-access food group was fruits, with 24.9%. There was 22.5% access to sustenance foods, 21.3% access to animals and almost 20% to fish.

Latent classes 2, 3 and 4 demonstrated mixed access to traditional food environments. Latent class 2, or "rich traditional protein environment", consisted of participants who had a higher than 50% access to birds (100%), fish (86.4%), animal (97.9%) and fruits (74.6%). Latent class 3 predominantly stood out as the only class with a high access (70.2%) to sustenance foods and was therefore named "The Four Sisters traditional food environment", referring to the Three Sisters (corn, beans and squash) and wild rice. Latent class 4 resembled latent class 2, with the difference being in a 0% access to birds. With a 76.2% access to fruits, 76.3% to fish and 79.6% to animals, this class was named "fish, animals and fruits traditional food environment".

Table 5: Conditional probabilities of food environment categories for each latent class

	LC 1 (SE)	LC 2 (SE)	LC 3 (SE)	LC 4 (SE)	LC 5 (SE)
# people	926	1735	403	2290	1133
% population	14.275%	26.746%	6.212%	35.301%	17.466%
Name given	"Robust traditional food environment"	"Rich traditional protein environment"	"The Four Sisters traditional food environment"	"Fish, animals and fruits traditional food environment"	"Limited access to traditional foods environment"
Fruits	0.981 (0.008)	0.746 (0.013)	0.825 (0.028)	0.762 (0.015)	0.249 (0.027)
Birds	0.654 (0.025)	1 (0.000)	0.21 (0.036)	0 (0.000)	0.031 (0.008)
Sustenance Foods	0.25 (0.024)	0.065 (0.007)	0.702 (0.061)	0.133 (0.013)	0.225 (0.225)
Fish	0.854 (0.015)	0.864 (0.009)	0.802 (0.027)	0.763 (0.017)	0.199 (0.028)
Animals	0.989 (0.006)	0.979 (0.005)	0.741 (0.035)	0.796 (0.017)	0.213 (0.030)
Medicine	0.686 (0.028)	0.168 (0.013)	0.171 (0.040)	0.054 (0.008)	0.007 (0.006)

Trees	0.316 (0.029)	0.056 (0.008)	0.885 (0.067)	0.059 (0.016)	0.033 (0.010)
Roots	0.773 (0.036)	0.042 (0.013)	0.132 (0.038)	0.054 (0.009)	0.010 (0.005)
Grasses	0.307 (0.026)	0.023 (0.005)	0.402 (0.048)	0.125 (0.009)	0.024 (0.007)

Associations Between Latent Classes and Covariates

Table 6 depicts the participants' characteristics across the 5 latent classes. The overall sample was female-dominated (65.93%); Class 5 (limited access) contained the highest proportion of females (71.05%). Average age across the entire sample was 46.58 years (SD = 14.55); Class 2 (rich protein) had on average older (48.61) and Class 3 (The Four Sisters) younger (43.29) participants. When comparing the age groups, Classes 2 and 4 (fish, animals and fruits) contained a larger number of individuals aged 31–50, and Class 5 contained a higher proportion of those aged 19–30. Representation by ecozone also differed greatly among classes: Boreal Plains, for instance, accounted for one-third of the respondents in Class 1 (robust), while the Atlantic Maritime ecozone was better represented in Class 3 (The Four Sisters) (41.44%) and Class 5 (limited access) (26.39%).

On average, households had a size of 3.96 members (SD = 2.46), being larger in the "robust" class (4.16) and smaller in "rich protein" class (2.99). Over half the sample (58.72%) reported having children under the age of 15, although this number ranged from 44.91% in "The Four Sisters" class to 65.07% in "rich protein" class. Wages or self-employment were the most common sources of income (49.84%), and nearly a third used social assistance (29.35%), most frequently in Classes "fish, animals and fruits" and "limited access" classes. Education levels also varied by class, with 42.00% of the total sample not completing high school but a higher percentage (56.06%) in "rich protein" class and more post-secondary diplomas (32.23%) in "The Four Sisters" class. Mean BMI was 30.39 (SD = 6.18), and nearly half of participants (48.04%) were obese, most notably in "rich protein" class (53.41%). The majority (43.67%) indicated their principal physical activity to be walking or standing without lifting, and 26.13% had previously reported lifting light loads or climbing regularly. Smoking was prevalent (53.60%), and "rich protein" class comprised the largest percentage of smokers (56.89%) and the highest mean number of cigarettes smoked (12.57 per day). Diabetes was present in 18.59% of the population, particularly in "The Four Sisters" class (25.06%) and "rich protein" (21.84%), with Type 2 diabetes being the most common type. In terms

of food security, 55.31% of the households were food secure, although the percentage varied between 48.24% for “robust” class and 64.81% for “limited access” class. Participation in traditional food activities varied widely, as “robust” and “rich protein” classes had high involvement in hunting and fishing, “The Four Sisters” class relatively involved in gathering wild plant foods and sea foods, while “limited access” class had the least involvement in almost all traditional activities. Combined, these findings highlight the multi-faceted nature of access to traditional foods, associating demographic, socioeconomic, and health characteristics with levels of involvement with traditional food environments in Canada's First Nations populations.

Table 6: Summary of the covariates (sociodemographics, behavioral variables, anthropometrics and health variables) based on class membership

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
% Sample size (n)	6487 (100%)	14.27% (926)	26.74% (1735)	6.21% (403)	35.30% (2290)	17.46% (1133)
% Female (n)*	65.93% (4277)	64.69% (599)	61.73% (1071)	64.76% (261)	67.29% (1541)	71.05% (805)
Breastfeeding*	2.17% (141)	1.84% (17)	2.42% (42)	1.49% (6)	2.31% (53)	2.03% (23)
Pregnant*	1.88%	1.84%	1.56%	1.49%	2.23%	1.85%

[1] %- percent, SD- Standard deviation, BMI- Body Mass Index

*statistically significant differences across classes at a=0.05

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
	(122)	(17)	(27)	(6)	(51)	(21)
% Ecozone (n)*						
Pacific Maritime	7.49%	13.82%	1.15%	2.73%	13.67%	1.24%
	(486)	(128)	(20)	(11)	(313)	(14)
Boreal Cordillera	1.23%	0.65%	1.50%	0.74%	1.97%	-
	(80)	(6)	(26)	(3)	(45)	
Montane Cordillera	4.83%	5.51%	1.67%	1.24%	9.39%	1.15%
	(313)	(51)	(29)	(5)	(215)	(13)
Taiga Plains	2.34%	6.37%	1.96%	-	2.27%	0.62%
	(152)	(59)	(34)		(52)	(7)
Boreal Plains	19.24%	32.61%	23.80%	2.48%	15.46%	14.92%
	(1248)	(302)	(413)	(10)	(354)	(169)
Prairies	8.89%	9.61%	7.38%	5.21%	8.86%	12.00%

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
	(557)	(89)	(128)	(21)	(203)	(136)
Taiga Shield	4.19%	2.92%	9.97%	-	2.71%	0.88%
	(272)	(27)	(173)		(62)	(10)
Boreal Shield	20.30%	15.77%	31.76%	10.42%	18.08%	14.47%
	(1317)	(146)	(551)	(42)	(414)	164
Hudson Plains	4.96%	0.54%	16.89%	-	0.61%	0.88%
	(322)	(5)	(293)		(14)	(10)
Mixedwood Plains	10.50%	6.05%	1.67%	35.73%	6.16%	27.45%
	(681)	(56)	(29)	(144)	(141)	(311)
Atlantic Maritime	16.02%	6.16%	2.25%	41.44%	20.83%	26.39%
	(1039)	(57)	(39)	(167)	(477)	(299)
Mean age in years (SD)*	44.25	46.58	44.05	48.61	43.29	43.01
	(14.92)	(14.55)	(14.92)	(16.27)	(14.46)	(15.17)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
% Age group (n)*						
19-30	18.18%	13.67%	18.58%	14.44%	18.68%	21.78%
	(1053)	(117)	(286)	(54)	(376)	(220)
31-50	46.22%	45.21%	46.72%	36.63%	48.19%	45.94%
	(2677)	(387)	(719)	(137)	(970)	(464)
51-70	29.75%	35.16%	28.46%	39.84%	28.61%	25.64%
	(1723)	(301)	(438)	(149)	(576)	(259)
71+	5.47%	5.84%	6.11%	8.56%	3.92%	6.14%
	(317)	(50)	(94)	(32)	(79)	(62)
Mean household size (SD)*	3.76	3.96	4.16	2.99	3.60	3.56
	(2.31)	(2.46)	(2.46)	(1.81)	(2.17)	(2.28)
Mean number of members <15 years old*		1.28	1.51	0.77	1.17	1.17
		(1.62)	(1.69)	(1.19)	(1.50)	(1.56)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
Mean number of members 15-65 years old*		2.46 (1.51)	2.45 (1.44)	12.00 (1.34)	2.28 (1.30)	2.21 (1.37)
Mean number of members 65+ years old*		0.22 (0.60)	0.19 (0.58)	0.21 (0.50)	0.14 (0.42)	0.16 (0.48)
% Households with children (n)*	58.72% (3809)	59.61% (552)	65.07% (1129)	44.91% (181)	57.99% (1328)	54.63% (619)
Mean number of people in each household who are employed (SD)						
Full-time*	0.76 (0.89)	0.86 (0.98)	0.79 (0.88)	0.82 (0.93)	0.72 (0.84)	0.72 (0.89)
Part-time*	0.26 (0.56)	0.27 (0.61)	0.23 (0.51)	0.30 (0.57)	0.28 (0.59)	0.26 (0.55)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
% Participants' main source of income (n)*						
Wages/ salary/ self-employment	49.84% (3206)	53.22% (488)	49.48% (855)	53.60% (216)	49.43% (1119)	47.14% (528)
Workers compensation/ employment insurance	6.36% (409)	4.14% (38)	5.96% (103)	6.70% (27)	7.82% (177)	5.71% (64)
Pension/ seniors' benefits	11.86% (763)	13.41% (123)	12.04% (208)	18.86% (76)	10.07% (228)	11.43 (364)
Social assistance	29.35% (1888)	26.17% (240)	29.46% (509)	19.85% (80)	30.70% (695)	32.50% (364)
Other	2.58% (166)	3.05% (28)	3.07% (53)	0.99% (4)	1.99% (45)	3.21% (36)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
Mean number of school years completed (SD)*	10.96 (3.21)	11.24 (3.37)	9.95 (3.23)	12.29 (3.45)	11.02 (2.96)	11.37 (3.03)
% Highest attained education level (n)*						
Less than high school	42.00% (2543)	37.23% (331)	56.06% (935)	22.08% (87)	38.55% (766)	37.96% (424)
Vocational training	8.90% (539)	10.69% (95)	7.61% (127)	5.84% (23)	10.37% (206)	7.88% (88)
High school diploma or equivalent	32.98% (1997)	33.75% (300)	26.08% (435)	39.85% (157)	35.93% (714)	35.00% (391)
Post-secondary degree	16.12% (976)	18.34% (163)	10.25% (171)	32.23% (127)	15.15% (301)	19.16% (214)
Mean BMI ($^{kg}/_{m^2}$)(SD)*		30.39	31.14	30.66	30.19	30.09

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
		(6.18)	(6.64)	(6.16)	(6.47)	(6.63)
% BMI status (n)*						
Underweight (<18.5 $^{kg}/_{m^2}$)	0.91%	0.93%	0.78%	0.27%	1.19%	0.79%
	(53)	(8)	(12)	(1)	(24)	(8)
Normal weight (18.5-24.9 $^{kg}/_{m^2}$)	18.61%	17.52%	15.59%	16.84%	19.81%	22.38%
	(1078)	(150)	(240)	(63)	(399)	(226)
Overweight (25-29.9 $^{kg}/_{m^2}$)	32.44%	33.88%	30.21%	30.48%	33.71%	32.77%
	(1879)	(290)	(465)	(114)	(679)	(331)
Obese (30 $^{kg}/_{m^2}$<)	48.04%	47.66%	53.41%	52.41%	45.28%	44.06%
	(2783)	(408)	(822)	(196)	(912)	(445)
Obese class I (30-34.9 $^{kg}/_{m^2}$)	43.20%	49.58%	44.20%	50.67%	40.49%	38.73%
	(1502)	(237)	(450)	(114)	(481)	(220)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
Obese class II (35-39.9 $^{kg}/_{m^2}$)	23.50% (817)	22.59% (108)	22.59% (230)	25.33% (57)	23.40% (278)	25.35% (144)
Obese class III (40 $^{kg}/_{m^2}$<)	33.30% (1158)	27.82% (133)	33.20% (338)	24.00% (54)	36.11% (429)	35.92% (204)
% Household traditional food activity (n)*						
Hunting or setting snares	40.84% (2649)	60.04% (556)	60.98% (1058)	29.03% (117)	33.36% (764)	13.59% (154)
Fishing	49.55% (3214)	67.93% (629)	61.04% (1059)	47.15% (190)	46.77% (1071)	23.39% (265)
Collecting wild plant foods	28.84% (1871)	63.07% (584)	24.21% (420)	41.69% (168)	26.46% (606)	8.21% (93)
Collecting seafood	7.23% (469)	10.91% (101)	4.84% (84)	11.41% (46)	8.65% (198)	3.53% (40)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
Planting a garden	18.62% (1208)	37.37% (346)	11.64% (202)	35.98% (145)	16.94% (388)	11.21% (127)
% Self-perceived major physical activity (n)*						
Sitting, not walking around much	19.81% (1282)	13.43% (124)	22.09% (382)	19.11% (77)	18.60% (425)	24.23% (274)
Standing or walking a lot, no lifting	43.67% (2826)	44.20% (408)	46.96% (812)	38.46% (155)	42.67% (975)	42.09% (476)
Lifting light weights, climbing or walking often	26.13% (1691)	29.79% (275)	21.52% (372)	30.77% (124)	28.01% (640)	24.76% (280)
Heavy work or lifting heavy loads	10.38% (672)	12.57% (116)	9.43% (163)	11.66% (47)	10.72% (245)	8.93% (101)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
% Self-perceived health compared to others with the same age (n)*						
Excellent	8.47%	10.59%	7.27%	9.43%	9.65%	5.83%
	(549)	(98)	(126)	(38)	(221)	(66)
Very good	18.78%	21.95%	16.03%	21.84%	18.56%	19.77%
	(1218)	(203)	(278)	(88)	(425)	(224)
Good	40.79%	37.84%	44.18%	41.94%	38.47%	42.28%
	(2645)	(350)	(766)	(169)	(881)	(479)
Fair	25.91%	24.43%	27.16%	20.10%	26.55%	25.95%
	(1680)	(226)	(471)	(81)	(608)	(294)
Poor	6.06%	5.19%	5.36%	6.70%	6.77%	6.18%
	(393)	(48)	(93)	(27)	(155)	(70)

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
% Smoked the previous day (n)	53.60% (3477)	52.81% (489)	56.89% (987)	40.69% (164)	53.97% (1236)	53.05% (601)
Mean number of cigarettes smoked in the previous day (SD)*		9.65 (6.78)	8.92 (6.66)	12.57 (8.47)	10.13 (7.66)	11.28 (8.17)
% Diagnosed diabetes*	18.59% (1206)	18.68% (173)	21.84% (379)	25.06% (101)	15.41% (353)	17.65% (200)
Type 1	11.40% (137)	6.98% (12)	12.70% (48)	6.00% (6)	11.36% (40)	15.50% (31)
Type 2	71.21% (856)	75.00% (129)	65.87% (249)	78.00% (78)	73.86% (260)	70.00% (140)
Unknown	17.39% (209)	18.02% (31)	21.43% (81)	16.00% (16)	14.77% (52)	14.50% (29)
% Food security status (n)*						

Mean (SD) or % (n)[1]	Overall	Latent Classes				
		1	2	3	4	5
		Robust traditional food environment	Rich traditional protein environment	The Four Sisters traditional food environment	Fish, animals, and fruits traditional food environment	Limited access to traditional food environment
Secure	55.31%	48.24%	51.46%	62.41%	55.08%	64.81%
	(3461)	(439)	(844)	(249)	(1220)	(709)
Marginal	9.59%	12.31%	9.94%	7.77%	9.48%	7.68%
	(600)	(112)	(163)	(31)	(210)	(84)
Moderate	26.08%	27.58%	30.24%	21.80%	26.14%	20.02%
	(1632)	(251)	(496)	(87)	(579)	(219)
Severe	9.03%	11.87%	8.35%	8.02%	9.30%	7.50%
	(565)	(108)	(137)	(32)	(206)	(82)

Bivariate Analyses

Tables 7, 8 and 9 compare the sociodemographic, anthropometric, health status, health behaviour and food security variables between the highest and lowest access to traditional food environment classes, i.e. class 1, "robust traditional food environment", and class 5, "limited access to traditional foods environment". Overall, there were a significantly higher number of participants in the "robust" class than the "limited" class. There was a significant difference in the gender of the participants in both groups; however, among female participants, the percentage of breastfeeding and pregnant individuals were similar. Although the First Nations in the "limited access" group were significantly younger, there were no significant differences in the mean number of household members with less than 15 years of age and the percentage of the households with children. However, there are significant differences in household compositions in terms of the household size, mean number of members aged 15-65, and older than 65 years old. On average, "robust" class had bigger households, and a higher number of members aged 15-65 and older than 65. The "robust traditional food environment" members were significantly more employed full-time, but the part-time employment rates were similar in both classes. These classes were also similar in terms of education, in both length and the highest achieved degrees. Regarding traditional food activities, members in the "robust" class had a significantly higher participation in hunting or setting snares, fishing, collecting wild plant foods and planting gardens. However, the 2 classes were similar in terms of engaging with their traditional food environments by collecting seafood.

There were no significant differences between the BMI and BMI categories (underweight, normal weight, overweight, obese) of the people in these classes. However, there were statistically significant differences in the levels of obesity (I, II and III) among those living with obesity. Overall, a higher percentage of the "robust traditional food environment" members were living with class I obesity, when compared to the obese participants in the "limited access" class. However, these percentages were higher in the "limited access" members across obesity class II and III.

In terms of health, the 2 classes had similar rates of diagnosed diabetes. However, members of the "robust" class had a significantly better self-perception of their health and considered themselves significantly more physically active when compared to people in their own age. Although the number of participants who were smokers were similar, First Nations' individuals in the "limited access" class tended to smoke significantly more than their peers in the "robust" class.

Food security category distributions also significantly differed between the "robust" and "limited access" class. Members of the "limited access to traditional food environments" had more food security, and fewer of them experienced marginal, moderate and severe food insecurity.

Table 7: Statistically significant differences across sociodemographics between class 1, "robust traditional food environment" and class 5, "limited access to traditional foods environment"

Mean (SD) or % (n)[1]	**Latent Classes**		**p-value***
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
% Sample size (n) *	14.27% (926)	17.46% (1133)	0.0497
% Female (n)*	64.69% (599)	71.05% (805)	0.0113
Breastfeeding*	1.84% (17)	2.03% (23)	0.9657

[1] %- percent, SD- Standard deviation, BMI- Body Mass Index

*statistically significant differences between classes at a=0.05

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Pregnant*	1.84% (17)	1.85% (21)	0.9982
Mean age in years (SD)*	46.58 (14.55)	43.01 (15.17)	<0.0001
% Age group (n)			
19-30	13.67% (117)	21.78% (220)	<0.0001
31-50	45.21% (387)	45.94% (464)	
51-70	35.16% (301)	25.64% (259)	
71+	5.84% (50)	6.14% (62)	
% Ecozone (n)			
Pacific Maritime	13.82% (128)	1.24% (14)	<0.0001
Boreal Cordillera	0.65% (6)	-	
Montane Cordillera	5.51% (51)	1.15% (13)	
Taiga Plains	6.37% (59)	0.62% (7)	

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Boreal Plains	32.61% (302)	14.92% (169)	
Prairies	9.61% (89)	12.00% (136)	
Taiga Shield	2.92% (27)	0.88% (10)	
Boreal Shield	15.77% (146)	14.47% (164)	
Hudson Plains	0.54% (5)	0.88% (10)	
Mixedwood Plains	6.05% (56)	27.45% (311)	
Atlantic Maritime	6.16% (57)	26.39% (299)	
Mean household size (SD)	3.96 (2.46)	3.56 (2.28)	0.0002
Mean number of members <15 years old*	1.28 (1.62)	1.17 (1.56)	0.1179
Mean number of members 15-65 years old*	2.46 (1.51)	2.21 (1.37)	0.0001
Mean number of members 65+ years old*	0.22 (0.60)	0.16 (0.48)	0.0138

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
% Households with children (n)	59.61% (552)	54.63% (619)	0.0858
Mean number of people in each household who are employed (SD)			
Full-time	0.86 (0.98)	0.72 (0.89)	0.0008
Part-time	0.27 (0.61)	0.26 (0.55)	0.6994
% Participants' main source of income (n)			
Wages/ salary/ self-employment	53.22% (488)	47.14% (528)	<0.0001
Workers compensation/ employment insurance	4.14% (38)	5.71% (64)	
Pension/ seniors' benefits	13.41% (123)	11.43 (364)	
Social assistance	26.17% (240)	32.50% (364)	
Other	3.05% (28)	3.21% (36)	
Mean number of school years completed (SD)	11.24 (3.37)	11.37 (3.03)	0.3656

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
% Highest attained education level (n)			0.191
Less than high school	37.23% (331)	37.96% (424)	
Vocational training	10.69% (95)	7.88% (88)	
High school diploma or equivalent	33.75% (300)	35.00% (391)	
Post-secondary degree	18.34% (163)	19.16% (214)	

Table 8: Statistically significant differences across anthropometrics and health status between class 1, "robust traditional food environment" and class 5, "limited access to traditional foods environment"

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Mean BMI ($^{kg}/_{m^2}$) (SD)	30.39 (6.18)	30.09 (6.63)	0.3124
% BMI status (n)			
Underweight (<18.5 $^{kg}/_{m^2}$)	0.93% (8)	0.79% (8)	
Normal weight (18.5-24.9 $^{kg}/_{m^2}$)	17.52% (150)	22.38% (226)	0.072
Overweight (25-29.9 $^{kg}/_{m^2}$)	33.88% (290)	32.77% (331)	
Obese (30$^{kg}/_{m^2}$<)	47.66% (408)	44.06% (445)	
Obese class I (30-34.9$^{kg}/_{m^2}$)	49.58% (237)	38.73% (220)	0.001

%- percent, SD- Standard deviation, BMI- Body Mass Index

*statistically significant differences between classes at a=0.05

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Obese class II (35-39.9 $^{kg}/_{m^2}$)	22.59% (108)	25.35% (144)	
Obese class III (40 $^{kg}/_{m^2}$<)	27.82% (133)	35.92% (204)	
% Self-perceived health compared to others with the same age (n)			
Excellent	10.59% (98)	5.83% (66)	
Very good	21.95% (203)	19.77% (224)	
Good	37.84% (350)	42.28% (479)	0.001
Fair	24.43% (226)	25.95% (294)	
Poor	5.19% (48)	6.18% (70)	
% Diagnosed diabetes	18.68% (173)	17.65% (200)	0.7968
Type 1	1.29% (12)	2.73% (31)	0.4580
Type 2	13.93% (129)	12.35% (140)	0.3594

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Unknown	3.34% (31)	2.55% (29)	0.7123

Table 9: Statistically significant differences across health behaviours and food security status between class 1, "robust traditional food environment" and class 5, "limited access to traditional foods environment"

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
% Household traditional food activity (n)			
Hunting or setting snares	60.04% (556)	13.59% (154)	<0.0001
Fishing	67.93% (629)	23.39% (265)	<0.0001
Collecting wild plant foods	63.07%	8.21%	<0.0001

[1] %- percent, SD- Standard deviation, BMI- Body Mass Index

*statistically significant differences between classes at a=0.05

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
	(584)	(93)	
Collecting seafood	10.91%	3.53%	0.1635
	(101)	(40)	
Planting a garden	37.37%	11.21%	0.0000
	(346)	(127)	
% Self-perceived major physical activity (n)			
Sitting, not walking around much	13.43%	24.23%	<0.0001
	(124)	(274)	
Standing or walking a lot, no lifting	44.20%	42.09%	
	(408)	(476)	
Lifting light weights, climbing or walking often	29.79%	24.76%	
	(275)	(280)	
Heavy work or lifting heavy loads	12.57%	8.93%	
	(116)	(101)	
% Smoked the previous day (n)	52.81%	53.05%	0.9371
	(489)	(601)	
Mean number of cigarettes smoked in the previous day (SD)	9.65	11.28	0.0003
	(6.78)	(8.17)	
% Food security status (n)			<0.0001
Secure	48.24%	64.81%	<0.0001
	(439)	(709)	

Mean (SD) or % (n)[1]	Latent Classes		p-value*
	1	5	
	"Robust traditional food environment"	"Limited access to traditional foods environment"	
Marginal	12.31% (112)	7.68% (84)	0.2918
Moderate	27.58% (251)	20.02% (219)	0.0558
Severe	11.87% (108)	7.50% (82)	0.3196

Discussion

In this study, we used latent class analysis to wholistically characterize First Nations' traditional food environments across Canada. In summary, we found that the FNFNES participants could be categorized into 5 distinct groups, based on their homogeneous patterns of traditional food consumption. This finding also supports the utility of latent class analysis in studying food environments. These 5 patterns ranged from "robust" to "limited access to traditional food environments". To examine the differences in demographic characteristics, health behaviors, and health status, we further compared "robust" and "limited access to traditional food environments". Although mean BMI, the prevalence of type 2 diabetes and prevalence of smokers was not significantly different, we found that participants in the "robust" class had a significantly lower level of food security and had better self-perceived health compared to the "limited access" class. In the following sections, we will discuss these findings and their alignment with the broader literature.

First, we estimated the FNFNES participants to be comprised of 5 latent and distinct subgroups based on their traditional food environments. Model fit statistics (AIC, BIC, LMR, BLRT) demonstrated that multiple classes produced a useful categorization of latent traditional food environments. Further, since a 1-class model was not supported, this supported our initial hypothesis positing multiple latent subgroups within the population and supporting the usefulness of LCA in studying First Nations' food environments. This is a strength of LCA as a methodology, as it allows analyses to integrate multiple variables simultaneously rather than relying on any single factor, therefore providing a wholistic classification of latent variables (McCutcheon, 1987). These findings are aligned with a 2020 study with three Native American communities in the United States, also demonstrating the utility of LCA to characterize the food environments through examining food getting of both store-bought and traditional foods (Jock et al., 2020). LCA has also previously been used to describe food environments and dietary patterns of non-Indigenous Peoples. A study among a representative sample of American adults found 3 classes based on the content in their snack inventories and 3 classes based on the size of the household snack

inventories by employing LCA (Hermstad et al., 2021). Use of LCA is particularly helpful given the diversity in the traditional food environments and food systems of Indigenous peoples across Canada, which are necessarily shaped by their environmental resources, ultimately creating an array of dietary patterns (Kuhnlein & Receveur, 1996). We found that the five classes differed in their reliance on different aspects of traditional food categories, which aligns with the previously described impacts of colonial policies which deliberately restricted Indigenous Peoples' access to their lands, forcing Western diets and ultimately a nutrition transition upon them (Dennis & Robin, 2020; Kuhnlein & Receveur, 1996; Popkin, 2002), and impacting access to traditional and market foods (First Nations Information Governance Centre (FNIGC), 2018). This limited access to traditional food environments alongside socioeconomic conditions have created dependence on the market foods system (Batal et al., 2018; Kuhnlein & Receveur, 1996).

We named the latent subgroups describing First Nations' traditional food environments as "robust traditional food environment", "rich traditional protein environment", "the Four Sisters traditional food environment", "fish, animals and fruits traditional food environment" and "limited access to traditional food environment" based on the likelihood of food type intake within these classes. The "robust" and "limited access" classes differed significantly in their degrees of access to nearly all traditional food categories. In terms of the range of the latent classes, previous studies have also found classes with a similar range ("robust" to "limited access") within their Indigenous participants' food environments. The study by Jock et. al found three Native American communities' food environments to be comprised of 2 classes, "higher" and "lower household food access" (Jock et al., 2020). Using latent profile analysis, a similar study among the 1176 Inuit participants of The Qanuilirpitaa? 2017 Nunavik Health Survey (Q2017) found 4 dietary classes ranging from "Market food dominant" to "Country food dominant" (Aker et al., 2024). Similar to this work, the other 2 discovered patterns were "Diverse consumption" and "Low consumption" (Aker et al., 2024). These findings are aligned with reports on the diets of First Nations living on and off-reserve, highlighting patterns of market and traditional food consumption (L. Chan et al., 2021; First Nations Information Governance Centre (FNIGC), 2018).

The bivariate analyses found that the "robust" class had significantly higher age and household size than the "lowest access class", and was more likely to have full-time employment and different main sources of income. They also participated significantly more in traditional food activities, except collecting seafood, and had higher self-reported physical activity levels. Moreover, despite having significantly lower food security, these participants had a significantly better self-reported health, when compared to the "limited access" class. Years of education and highest attained degree, BMI and BMI categories, % of smokers and type 2 diabetes did not significantly vary between the 2 classes.

The results confirm parts of our initial hypothesis, expecting that there would be demographic differences comparing groups but that robust traditional food environments would be more physically active, have higher self-rated health, have lower BMI, lower prevalence of diabetes, higher food security. We also hypothesized that older populations would have better traditional food access and larger household size would be associated with improved traditional food access. Previous studies have also found that traditional foods play a more important role in older generations of Indigenous peoples' diet (McCartan et al., 2020). The higher average age of more traditional food consumers could be rooted back to the intergenerational teachings and ties to Indigenous knowledge in older adults. The role of elders in knowledge dissemination has been previously recognized in the literature (Domingo, Charles, et al., 2021; Flanagan et al., 2021), with some studies pointing to the strong preference by First Nations to have more traditional foods in their diet (Batal, Chan, Fediuk, Ing, et al., 2021b).

Some studies highlight that households with an elder or active hunter are more likely to secure traditional foods, especially when compared to the rising number of single men or women households (Collings et al., 2016). Moreover, aside from education, traditional food activities require significant support, equipment, and resources (Collings et al., 2016; Domingo, Charles, et al., 2021; Lougheed, 2010), making them more accessible to wage-dependent individuals and larger households with stronger social networks. As a result, many Indigenous Peoples report relying on food-sharing, as opposed to taking part in traditional food activities (Walch et al., 2019).

Beyond nutritional benefits, traditional food practices also promote physical activity (Kuhnlein & Receveur, 1996), which may explain the elevated levels observed in the "robust traditional food environment" class. The key role of traditional foods in Indigenous Peoples' health has been shown in numerous studies (Compher, 2006; Kuhnlein & Receveur, 1996).

Moreover, previous literature has recognized the complexity of the nutritional status of Indigenous Peoples, underlining how their health is also influenced by market foods, decreased physical activity and an array of economic pressures (Kuhnlein & Receveur, 1996), perhaps explaining the non-significant differences in BMI and type 2 diabetes between the two groups. However, these findings are not consistent with a ten-year study among a First Nations community in Ontario, where 492 participants who were not diagnosed with type 2 diabetes were monitored based on their dietary patterns (Reeds et al., 2016). This study concluded that the "beef and processed foods" was significantly associated with type 2 diabetes, whereas the same relationship did not exist among "traditional foods" and "balanced market foods" patterns (Reeds et al., 2016). Previous studies on dietary patterns of Indigenous Peoples have also found no significant association between traditional food dietary patterns and BMI (Jock et al., 2020). Nonetheless, the positive impact of Indigenous food sovereignty on the dietary patterns of communities has previously been recognized (Maudrie et al., 2021).

The similar percentage of smokers in these classes could be further tied down to broader social determinants in Indigenous communities. Reading recognizes tobacco use as a "strong historical, ceremonial and spiritual and medicinal" practice for some Indigenous Peoples (Reading & Nowgesic, 2002). He further argues that smoking is a means of "coping with life in healthy ways" (Reading et al., 2007), and is therefore more common among Indigenous populations who are dealing with socioeconomic pressures (Maddox et al., 2019). Despite the similar prevalence of type 2 diabetes, BMI and percentage of smokers across these 2 classes, participants in the "robust traditional food" class reported better perceived health. This discrepancy may be attributed to First Nations' wholistic understanding of health, which considers emotional, mental, and spiritual well-being as important concepts alongside physical health (Auger et al., 2016; Katz et al., 2017; Reese

et al., 2024), which constitutes the core of health in the Western knowledge system. This multidimensional perspective is closely linked to connections with individuals, families, communities, land, culture, and spirit (Ullrich, 2019)—a guiding conceptual framework of this research.

The lack of food security in both market and traditional foods among Indigenous Peoples has previously been discussed (Shafiee et al., 2022). The higher food insecurity in the robust traditional food groups could be attributed to the misalignment between Indigenous perspectives on food security and the means of measurement in this study. The FNFNES questionnaire addressed food security by asking participants questions regarding their fear of not being able to afford food (L. Chan et al., 2021), whereas Indigenous food systems are based on relational approaches that highlight interdependence with nature and reciprocating with the environments and not "fearing" the lack of food (Delormier et al., 2024). Although such assessments remain valuable, future food security measures should be adapted to reflect diverse cultural understandings.

Lastly, despite the lower number of people in the robust class, future policy should focus on supporting the on-going efforts in revitalizing Indigenous food sovereignty (Kamal et al., 2015; Morrison, 2011) and language revitalizations especially given the cultural significance of traditional foods and the on-going impacts of residential schools (Mosby, 2013). The importance of Indigenous food sovereignty in enhancing nutritional security and health of Indigenous Peoples has previously been established (Sarkar et al., 2020).

Strengths

There is a number of important strengths to this study: First, this study uses the single largest and most recent dataset of First Nations in Canada (FNFNES), which includes a random sample of First Nations adults residing on reserves across 11 ecozones, to ensure representativeness among First Nations south of the 60th parallel. This provides the most up-to-

date and unique assessment of their food environments and supports the generalizability of this study's findings. Second, the FNFNES dataset is the most comprehensive dataset on First Nations in Canada, including the most detailed region-specific list of traditional foods. Third, the use of LCA helps ensure a robust analysis by not relying on a single variable, allowing for a more wholistic understanding of the food environment. Fourth, this research was informed by in-depth knowledge from a Kanien'keha:ka researcher and a Kanien'keha (Mohawk) language expert, this culturally appropriate approach supports the meaningful integration of Indigenous knowledge in such analyses. While the use of Ohén:ton Karihwatéhkwen is not intended to broadly 'pan-Indigenize,' rather a strength is that it is grounded in a cultural knowledge system from the Haudenosaunee peoples. Its principles are adaptable and could be generalized to other groups, highlighting its strength as a versatile framework. While other Indigenous frameworks were not explored in this research, we found OK to be fitting well within both our dataset and concepts, with only a few items fitting precisely within a single group.

Limitations

Although we aimed to minimize the barriers to our analysis, several limitations still existed, which we addressed using various methods throughout the study, or were there for good measure. First, although communities were mostly selected with a randomization process, this study also involved purposefully selected communities to ensure that the FNFNES dataset would be representative, such as Nuxalk Nation, due to a lack of previously published data. Second, this study also did not include First Nations living on Canadian territories in Yukon, Nunavut and Northwest territories because previous research had examined north of the 60th parallel. However, this study provides the most recent and comprehensive data of First Nations adults living on-reserves south of the 60th parallel. Third, while questions on gardening were included as a means of both engaging with the traditional food environments and traditional food consumption, other means of engagement with the traditional food environment such as hunting and fishing were only

addressed by asking whether individuals participated in these activities. However, a variety of traditional food intake variables were included to capture a broader spectrum of consumption. Future studies should aim to incorporate all forms of interaction with traditional food environments and consumption for a more comprehensive analysis. Fourth, we acknowledge that dietary intake is a difficult concept to measure accurately. However, to improve accuracy, the study survey divided the FFQ by season to capture the variations across the year. Fifth, although water is an important aspect of traditional food environments, it could not be incorporated in this analysis due to a lack of related variables from the parent study, FNFNES. Future research should consider incorporation of other aspects of water access into assessments of traditional food environments.

Significance

This research is the first to characterize traditional food environments of the First Nations in Canada using a person-centred approach (LCA) within a community-based participatory research project in eight Assembly of First Nations regions, addressing one of the key aspects of First Nations nutrition. Previously, authors have underlined the necessity establishing appropriate assessments for a variety of food environments (Downs et al., 2020), an approach supported by the use of latent class analysis to wholistically describe First Nations' complex traditional food environments. Furthermore, this work supports and emphasizes the importance of integrating Indigenous knowledge to fully understand their relationship with the land—an approach often overlooked in Western frameworks. The study includes traditional foods without restricting sources to on-reserve areas, ensuring it represents First Nations populations both on and off-reserve. This research could inform future interventions to support Indigenous food sovereignty and point to opportunities for intervention and support more intakes of traditional foods, addressing First Nations' preference to higher traditional food consumption: Given the nutritional and economic benefits as well as cultural significance of Traditional Foods (Batal, Chan, Fediuk, Ing, et al., 2021b; Willows, 2005), FNFNES highlights that many First Nations peoples exhibit a strong

preference for consuming these foods more frequently and in larger quantities (Batal, Chan, Fediuk, Ing, et al., 2021b). This preference is supported by findings from the First Nations Regional Health Survey, which indicates that 70-76% of First Nations peoples regularly consume Traditional Foods (First Nations Information Governance Centre (FNIGC), 2018). However, 77% of FNFNES participants indicated barriers to traditional food consumption, including limited availability and a lack of knowledge in harvesting (Batal, Chan, Fediuk, Ing, et al., 2021b). This research could serve as an example to guide future wholistic research on both market and traditional food environments of Indigenous Peoples both in Canada and other countries.

Conclusions

This is the first study to employ latent class analysis to wholistically characterize First Nations' traditional food environments across Canada. This project demonstrates the utility of latent class analysis in characterizing First Nations' traditional food environments and could be used as an example for studying food environments of Indigenous and non-Indigenous populations. Through latent class analysis, we found 5 traditional food environment subgroups/classes, based on First Nations participants' traditional food item consumption as indicators. These 5 distinct but homogenous classes were "robust traditional food environment", "rich traditional protein environment", "The Four Sisters traditional food environment", "fish, animals and fruits traditional food environment", and "limited access to traditional food environment". When comparing the "robust" and the "limited access" classes, the "robust" class was consisted of participants with a significantly higher average age, household size, full-time jobs and reliance on salary, wages or self-employment. They also participated significantly more in traditional food practices and had higher self-reported physical activity levels. However, they had significantly lower food security and significantly better self-reported health. The classes were similar in terms of years of education and highest attained degree, BMI and BMI categories. This research could inform future interventions to support Indigenous food sovereignty and opportunities for intervention and support more intake of traditional foods, addressing First Nations' preference to higher traditional food consumption.

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