A psychometric evaluation and application of

a measure of food literacy among young adults

by

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AUTHOR'S DECLARATION

This thesis consists of material I authored or co-authored. See the Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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STATEMENT OF CONTRIBUTIONS

This thesis consists of three manuscripts that have been prepared for publication. Exceptions to sole authorship include:

Chapter 5: Martin Holmes, Mona Qutub, Sanaa Hussain, Elsie Azevedo Perry, Heather Thomas, Lauren Kennedy, H. Ruby Samra, Shannon Edmonstone, Edward A. Frongillo, Heather H. Keller, Helen A. Vidgen, Sharon I. Kirkpatrick. Construct validity of a multi-dimensional food literacy (FLit) measure among post-secondary students in Ontario, Canada.

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As lead author of these three chapters, I conceptualized the study designs, developed study materials, led data collection and measure selection, conducted the data analysis, and drafted the manuscripts. My coauthors provided guidance during each step of the research and provided feedback on draft manuscripts, with significant editorial contributions from my advisor, Dr. Sharon Kirkpatrick.

Under Dr. Sharon Kirkpatrick’s supervision, the papers prepared in this thesis are intended to be submitted for publication.

ABSTRACT

Background: Food literacy is an emerging study area encompassing the knowledge, skills, and attitudes required to navigate dynamic food systems. Food literacy has been suggested as a potential leverage point for improving diet quality and health outcomes. The emerging adult population, facing unique dietary and life transitions, is highlighted as an important group in public health research. Following calls for standard and well-evaluated measures of food literacy, a collaborative working group of public health nutrition practitioners in Ontario, Canada, led the development of a comprehensive food literacy measure, the FLit50, for use with young adults. To support the broad use of the measure in public health practice, assessment of the construct validity of the FLit50 and the development of a shortened version were desired by the public health nutrition practitioners.

Objectives: The objectives of this dissertation were to: (1) evaluate the construct validity of the FLit50 measure among post-secondary students (**Chapter 5**); (2) analyze the characteristics of the FLit50 items to facilitate the development and evaluation of a shortened measure (**Chapter 6**); and (3) explore the demographic, income adequacy, studentship, and health correlates of food literacy among post-secondary students (**Chapter 7**). This work was undertaken in collaboration with the public health nutrition practitioners.

Methods and results: The first study (**Chapter 5**) drew upon data from 457 post-secondary students in Ontario, Canada, to evaluate the measure's construct validity by assessing whether it could differentiate between groups hypothesized to have differences in food literacy. The FLit50 showed adequate construct validity, evidenced by higher median food literacy scores among students in food and nutrition programs (KW $\chi2$) = 108, $p < 0.001$), women (KW $\chi2$= 49.2, $p < 0.001$), those with adequate health literacy (KW $\chi2$ = 20.6, $p < 0.001$), those with higher general health (KW $\chi2$ = 49.5, $p < 0.001$), those with higher mental health (KW $\chi2$ = 17.4, $p < 0.001$), and those experiencing food security in the past 12 months (KW $\chi2$ = 21.9, $p < 0.001$), as hypothesized. No differences were observed by age (KW $\chi2$ = 5.24, $p = 0.63$) or perceived income adequacy (KW $\chi2$ = 4.21, $p = 0.38$). Differences in group means were observed as hypothesized for scores on items reflecting the underlying domains of food and nutrition knowledge and self-efficacy and confidence, but not food skills or ecological factors.

The second study (**Chapter 6**) involved the application of the 2-parameter Item Response Theory, using data from postsecondary students (n=457) along with data collected from young adults across Canada during the initial development of the measure (n=351). Item difficulty (mean= -1.72 SD from the sample's average food literacy ability level, range: -3.64 to 3.05 SD) and item discrimination (mean= 1.78, range: 0.33 to 8.43) characteristics were estimated for items on the FLit50. The parameters informed discussions with the public health nutrition practitioner partners to select sixteen items for inclusion in the shortened measure, the FLit16. The correlation coefficient between scores on the FLit50 and the FLit16 was estimated, and whether the FLit16 could differentiate among groups hypothesized to have different levels of food literacy, as per study 1, was examined. Scores from the two versions of the measure were strongly and positively correlated (Rho = 0.87, $p < 0.01$) and the short measure was able to differentiate among groups, consistent with the full measure.

The third study (**Chapter 7**) drew upon data from the sample of postsecondary students to explore associations between demographic, income, studentship, and health characteristics, identified *a priori* based on the emerging food literacy literature, and food literacy scores using multiple linear regression analysis. Data from 413 students were included in these analyses after accounting for missing data on the characteristics of interest. Food literacy was assessed using the FLit50 measure, with a mean score of 42 of 49 points. Adjusting for other characteristics, food literacy was higher among women compared to men ($\beta = 2.509$, $p < 0.001$) and those who reported positive or neutral general health ($\beta = 1.743$, $p < 0.001$). Food literacy was lower among individuals identifying as East/Southeast Asian ($\beta = -2.036$, $p < 0.001$), South Asian ($\beta = -2.409$, $p < 0.001$), and other racial/ethnic identities ($\beta = -1.568$, $p = 0.005$) compared to those identifying as White. Food literacy was also lower among those who lived on-campus ($\beta = -1.457$, $p = 0.073$) and those experiencing food insecurity ($\beta = -1.274$, $p = 0.004$). Food literacy scores did not differ by age, income adequacy, domestic or international studentship, whether students attended college or university, household composition, or self-reported mental health status. The regression analysis yielded an R_2 of 0.403, indicating that 40% of the variance in food literacy scores was explained by this model, with an overall significance of F(15, 396 DF) = 17.79, $p < 0.001$.

Conclusions: This dissertation continues the work of the collaboration of public health nutritionists by furthering two of its main aims: establishing the construct validity of the FLit50 and developing a shortened measure that demonstrates construct validity. The availability of two well-evaluated measures presents opportunities to better understand and monitor food literacy in emerging adults and assess associations with factors such as diet quality.

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I acknowledge the sacred land where my academic journey unfolded. I recognize that my institution, the University of Waterloo, exists on the traditional territory of the Neutral, Anishinaabeg, and Haudenosaunee peoples and is situated on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River. My studies and research extended to North Bay, Ontario, on the land protected by the Robinson Huron Treaty of 1850. This area is the traditional territory of the Anishinabek Nation, now home to the people of Nipissing First Nation and Dokis First Nation. I am deeply grateful for the opportunity to study and work in these territories and strive to respect and honour these communities' traditions and ongoing relationship with their land. I hope that my academic, professional, and personal endeavours during this journey have contributed positively to these communities and that my work continues to respect and uplift the connection between these nations and their traditional lands.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASA24-Canada	Automated Self-Administered 24-hour Dietary Recall for Canada
BBNNI	Bentler-Bonett Non-normed Index
CAD	Canadian dollars
CAT	Computerized Adaptive Testing
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence intervals
CTT	Classical Test Theory
DAG	Directed Acyclic Graph
DIF	Differential Item Functioning
EFA	Exploratory Factor Analysis
FLit	Food literacy
FLit16	16-item food literacy measure
FLit50	50-item food literacy measure
HFSSM	Household Food Security Survey Module
ICC	Item characteristic curve
iKT	Integrated knowledge translation
IP	Internet Protocol
IQR	Interquartile range
IRF	Item Response Function
IRT	Item Response Theory
KW	Kruskal-Wallis
LDCP	Locally Driven Community Program
MDD	Minimum Detectable Difference
NCDs	Non-communicable diseases
NVS / NVS-C	Newest Vital Signs© / Newest Vital Signs© - Canada

RMSEA	Root mean square error of approximation
SARS-COV2	Severe acute respiratory syndrome coronavirus 2
SD	Standard deviation
SES	Socioeconomic Status
SRMSR	Standardized root mean square
TIF	Test Information Function
TLI	Tucker Lewis Index
TLS	Transport Layer Security
USDA	US Department of Agriculture
VIF	Variance Inflation Factor

CHAPTER 1: INTRODUCTION

1.1 Overview and Scope

The study of food literacy is an emerging area of interest[1]. Food literacy is a term accepted to encompass the interconnected skills, behaviour, and knowledge needed by individuals to navigate the food environment and meet their nutrition and health needs and is steadily gaining momentum as an important area of inquiry[1]. Food literacy is a multidimensional construct comprising several attributes relating to individual dimensions (e.g., food preparation skills and experience, organizational skills, knowledge, psychosocial factors) and external determinants (e.g., learning environment, sociocultural environment, food availability and facilities, living conditions)[2].

Food literacy is linked with public health, given its potential influence on individual dietary quality[3]. This is an important area of interest in public health, especially because dietary risk factors are among the top contributors to morbidity and mortality[4]. The relationship between food, dietary intake, and health is complex and multifaceted, with certain patterns of consumption being closely linked to the development of non-communicable chronic diseases (NCDs)[5,6]. These conditions tend to be long-lasting and result from a combination of genetic, physiological, environmental, and behavioural factors, including cardiovascular diseases, type 2 diabetes, cancer, obesity, osteoporosis, and chronic respiratory diseases[5,6]. Understanding the interactions between food literacy, dietary practices, and health outcomes may contribute to strategies to reduce the prevalence and impact of NCDs.

There is also growing attention to food literacy within policy. In Canada, there is a movement to address food literacy in health strategies and guidance. Canada's Dietary Guidelines note that food skills are "an essential part of strategies aimed at supporting life-long healthy eating habits"[7]. Provincially, Ontario legislators have supported new legislation to deliver food literacy-focused curricula throughout public education[8].

In particular, there is growing interest in food literacy among emerging adults[9,10]. Emerging adulthood is the stage of development between 19 and 25 years of age, thought to capture the unique transition between adolescence and young adulthood. It is an often-overlooked period for research on food and diet-related health[9]. Emerging adulthood is an essential developmental stage as it is a time of navigating new eating independence, establishing identity, and building lifelong health-related habits[3,11]. Research suggests a decline in diet quality during late adolescence and early adulthood[12], a period when individuals face unique challenges, including leaving the familial home, beginning (and often funding) post-secondary education, holding precarious pre-career employment, and managing new and changing social and intimate relationships, all of which contribute to dietary behaviours and patterns[13–15]. It is suggested that behaviours and practices developed during this period persist into adulthood[9,16,17], making it crucial in understanding health behaviours and possible avenues for intervention[15,18]. The distinctive experiences of emerging adulthood necessitate understanding various health constructs within this population, including food literacy.

With the emergence of food literacy as a theme of study, the issue of confidently measuring the construct arises. There has been a recent global movement to conceptualize and develop measures of food literacy. Geographically rooted nuances in the food system have led researchers in countries including Switzerland[19], Italy[20], the Netherlands[21], Norway[22], Turkey[23], Australia[24,25], and the USA[26–30] to create context-specific tools based on varying definitions, including varying domains and attributes conceptualized to be components of food literacy. The lack of a standardized and well-evaluated measure to capture the construct in the Canadian context poses a barrier to our understanding of food literacy, including the domains and attributes that may require the most attention to improve health outcomes. Measures used to assess food literacy must be grounded in a well-conceived conceptual underpinning, be practical for delivery (i.e., not burdensome for practitioners/researchers or respondents), and offer accurate and interpretable data made possible through thorough evaluations of validity[31].

1.2 Study context and research objectives

Over the past several years, the Locally Driven Collaborative Project (LDCP) Healthy Eating Team, consisting of members from 16 health units in Ontario and funded by Public Health Ontario, undertook work to conceptualize and develop a measure of food literacy. After formative work, including qualitative research[2] and a scoping review of the literature to derive key domains and attributes of food literacy[32], the team partnered with researchers from the Dalla Lana School of Public Health at the University of Toronto to develop and conduct preliminary testing of a food literacy measure for groups identified as priority populations in Ontario: 1) youth (16 to 19 years of age) and 2) young parents and young pregnant individuals (16 to 25 years of age)[2]. The outcome of this work was the food literacy measure (FLit50, **Appendix 1**) consisting of 50 questions across ten attributes.

Early in 2020, the LDCP Healthy Eating Team, in consultation with researchers familiar with the development and validation of measures, identified the need to conduct further research to augment the evidence of validity to support appropriate uses of the tool. The first identified priority was to assess the measure's construct validity to establish confidence in its use. In addition, long survey instruments can be taxing for respondents, resulting in more substantial measurement errors, and may render the delivery of a measure infeasible[33]. The second priority was to develop an abbreviated measure of food literacy to expand its use in various public health settings and contexts. An abbreviated measure may also be amenable for use in provincial or national level health surveillance (e.g., through the Canadian Community Health Survey), expanding understanding of food literacy geographically and with additional populations.

This thesis thus aimed to examine the construct validity of the FLit50 and to develop an abbreviated measure. Drawing upon data from the FLit measure, correlates of food literacy were also assessed among post-secondary students. The population of interest includes emerging adults, consistent with the priority populations of the LDCP Healthy Eating Team.

Chapter 2 reviews the literature on food literacy and concepts relevant to developing and validating measures, followed by **Chapter 3**, which outlines the study objectives. **Chapter 4** describes the methods for the three studies in **Chapters 5 to 7**. **Chapter 8** discusses the key findings and implications of the thesis.

CHAPTER 2: LITERATURE REVIEW

Research continues to uncover the links between food consumption and the presence and risk of common diseases, like cancer, type 2 diabetes, coronary heart disease, or stroke[5,6]. A systematic analysis of the global disease burden showed that improvements in diet quality could potentially prevent 1 in 5 deaths[34]. The incidence and magnitude of diet-related health issues across the globe have elevated food and nutrition research as a matter of public health priority in many nations, Canada included. At present, most Canadians do not meet food-based recommendations[35], and suboptimal eating patterns are a significant contributor to poor physical and mental health[36,37], poor academic achievement[38], and other adverse outcomes[39–41]. The total number of chronic disease cases has been increasing over time; this is an "area of concern" for the Public Health Agency of Canada, which has identified dietary intake as an essential mitigator of risk[42]. The link between disease and diet is particularly troublesome as the modern Canadian diet has been characterized by high intake of sugary beverages in addition to high sodium intake and low intake of minimally processed and plant-sourced foods[43].

Changes in our food systems have been cited as primary drivers of modern eating behaviours and practices[44]. North American food systems and environments have experienced a dramatic shift over the last half-century. The types of foods available to consumers have steadily changed, along with shifts in how people engage with, acquire, and consume food[44]. These shifts in food environments and corresponding consumer practices have led to what is dubbed a 'nutrition transition', a marked transformation in the composition of diets[44], with increases in the consumption of processed and ultra-processed foods, low-nutrient and energy-dense foods, and sugar-sweetened beverages[45,46]. In addition to the nutrition transition, a 'culinary transition' has been identified whereupon society is experiencing "fundamental shifts in the patterns and kind of skills required to get food onto tables"[47]. A decade after

Lang and Caraher described changes in cooking and culinary practices[47], Desjardins and Azevedo asserted that not only are practices changing but that the population is being "deskilled"[2].

The overabundance of processed, ready-to-eat foods in the food supply means that individuals no longer need to cook or learn and know how to cook[2]. Societal shifts also factor into both the nutrition and culinary transitions. With women increasingly working outside of the home (along with associated concurrent time and transportation pressures), they were no longer consistently available to acquire food and prepare meals for their families, nor were they on hand to teach their children about food and cooking, severing the generational transfer of knowledge[48]. At the same time, society has experienced a 'devaluing' of traditional home economics in formal education settings[2]. Decreasing access to opportunities to learn about food and practice cooking skills through family, school, or community programming (the top places of food information transfer identified by Desjardins and Azevedo[2]) indicates that we are in a food education transition. The nutrition, culinary, and food education transitions concern health scholars, practitioners, policymakers, and dietary clinicians, as a lack of food and nutrition education has been suggested as a potential factor influencing poor diet-related health outcomes[7,49].

These nutrition, culinary, and food education transitions may lead young adults to consume less healthy food. Analysis of data from the 2016 Canada Food Study has revealed that young people consume a substantial proportion of meals either prepared outside the home or ready-to-eat/boxed food prepared at home and requiring little or no skill[50]. Whether these dietary patterns are related to low food literacy is unknown. They are, however, problematic. Consuming food away from home more frequently is associated with obesity, higher body fatness, and eating more fast-food meals, which are linked to consuming more calories, saturated fat, and sugary soft drinks, and fewer fruits, vegetables, and milk[51,52].

2.1 Food Literacy

The research community has recently rallied around the concept of food literacy and begun to parse out the elements that constitute food literacy[1]. In 2014, in the absence of shared use of the term across disciplines, Vidgen and Gallegos[53] advanced the concept of food literacy by offering a comprehensive definition based on two concurrent qualitative studies with experts and young adults, suggesting that food literacy is "a collection of inter-related knowledge, skills and behaviours required to plan, manage, select, prepare and eat foods to meet needs and determine food intake." The authors also conceptualized food literacy in terms of resilience. They identified food literacy as "the scaffolding that empowers individuals, households, communities or nations to protect diet quality through change and support dietary resilience over time[53]."

Along with defining food literacy, eleven key attributes within four food behaviour domains were identified by Vidgen and Gallegos[53], forming an early food literacy framework and, thus, establishing food literacy as a higher-order construct (**Figure 1**). Their conceptualization includes a general food literacy construct and several subconstructs (domains) that capture different, more concrete attributes of food literacy. Using this foundational definition and framework, public health professionals were able to advance the conceptualization of food literacy, suggest alternate frameworks, develop measurement tools, and test intervention strategies, resulting in a surge of food literacy-related publications in the literature[1].

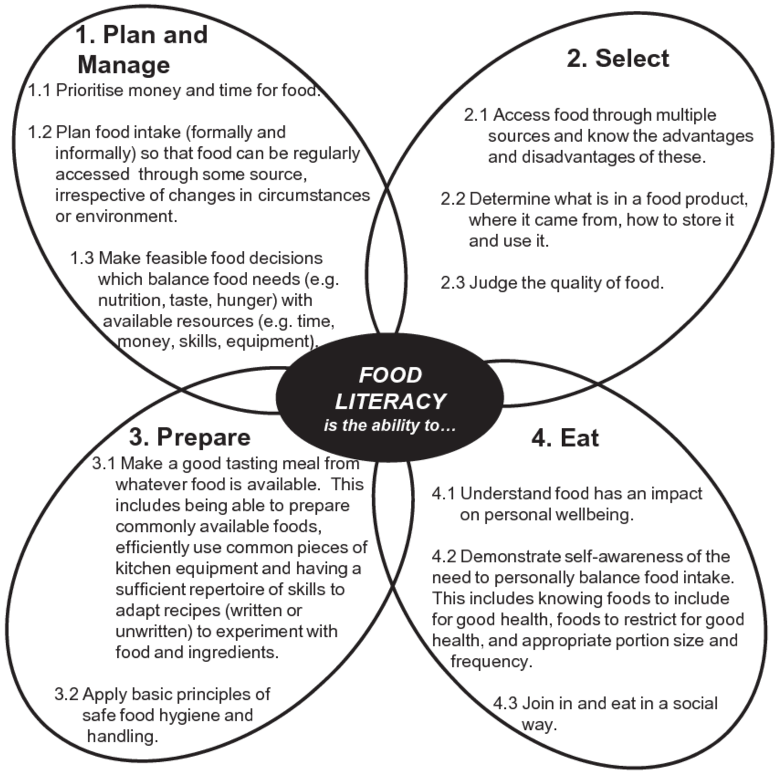

Figure 1: The eleven components of food literacy derived from the Expert and Young People's Studies. Reprinted from Appetite, Vidgen HA, Gallegos D. Defining food literacy and its components. Appetite. 2014 May 1;76:50-9, with permission from Elsevier.

Following the introduction of Vidgen et al.'s model[53], which primarily focuses on the practical aspects of food literacy, such as planning, selecting, preparing, and eating food, there has been a growing recognition of additional food literacy competencies. As such, conceptualizations of food literacy have evolved to encompass both these practical aspects along with food-related knowledge, attitudes, and skills. Efforts to capture this expanded conceptualization were driven by members of the Locally Driven Collaborative Project (LDCP) Healthy Eating team, comprised of public health nutritionists working to develop a unique framework of food literacy in their pursuit of developing a measure of food literacy for use in Canadian contexts. Their work builds upon and expands the foundation set by Vidgen and Gallegos[53] by integrating additional components such as self-efficacy and confidence, and ecological factors[32]. These elements highlight not only the individual's ability to manage food-related tasks but also the influence of external factors such as food environments, cultural norms, and socioeconomic conditions. This broader scope underscores the importance of addressing both individual competencies and the societal context in which food choices are made, suggesting a more comprehensive approach to food literacy.

2.1.1 Positioning Food Literacy Within the Socioecological Framework

Food literacy is a multidimensional construct[54] spanning individual and external determinants and can be positioned within the social-ecological framework[55]. The socioecological framework (**Figure 2**) is a multi-level approach to understanding how individual behaviour and health are influenced by multiple, inter-related layers including at the individual-, interpersonal-, institutional-, community-, and public policy-level. The social-ecological framework[56,57] has been widely applied in public health research and practice through considering the impacts of policy design, implementation, and evaluation on health outcomes[58,59].

Figure 2: Simplified socioecological model, adapted from "An ecological perspective on health promotion" by McLeroy et al.[57] and Institute of Medicine[60] licensed under CC BY-NC-ND 3.0.

At the individual level, food literacy is shaped by individual knowledge, skills, and self-efficacy, as well as attitudes and perceptions about food[54]. These elements influence one's understanding of nutritional information, proficiency in cooking techniques, and knowledge of food safety practices. The development of these aspects typically occurs through direct education and hands-on experience. While sociodemographic factors such as age, education, and income influence food literacy[61], broader societal levels may have a more substantial impact on its development and application.

At the interpersonal level, food literacy is shaped by family and peers[62–64]. In family settings, food norms and the food literacy of parents play pivotal roles[65,66]. How food is discussed, prioritized, and handled within the family influences young adults' attitudes and behaviours towards food that continue when they gain independence[65]. Relevant interpersonal factors include parental practices around food consumption, preparation, and restrictions, which are often mirrored by children and persist beyond cohabitation[67,68]. Peers also impact food literacy among adolescents and young adults. Interpersonal interactions extend to shared experiences such as meal preparation and eating together. These activities are not only practical but serve as conduits for transmitting and establishing traditions and cultural food practices, thereby enriching an individual's understanding and engagement with food[69]. Peer interactions can include conversations about food, collective food-related activities, and the establishment of social norms around eating behaviours[70]. These peer influences can sometimes contradict public health messages about nutrition and introduce pressures that shape individual food perceptions and practices[71,72].

Institutions and communities play a crucial role in shaping food literacy through the establishment of social and cultural norms related to food[73–75]. These norms influence the availability, accessibility, and affordability of food and food education, and extend to the design of built environments that support or hinder attainment of food literacy[76,77]. Organizational influences extend across various settings, including schools, workplaces, healthcare facilities, and non-profit organizations. For example, schools are a primary deliverer of structured educational programs and curriculum that may teach students about nutrition and health[78], while workplaces may offer healthy eating options through cafeterias and wellness programs[79]. Healthcare settings are critical in providing nutritional guidance, especially for diet-related health conditions[80]. At the community level, the local environment may significantly affect food literacy. Access to local markets, community gardens, and food cooperatives enables individuals to learn about and engage with local and sustainable food sources[81–83]. Community-based educational programs and workshops, often led by nutrition practitioners through public health units in Ontario, further support this learning by focusing on food production, preparation, and nutrition[3,11]. Traditional and social media may also shape food literacy by disseminating information, however accurate, and can influence perceptions about food and health[84,85]. Through efforts across various sectors, these entities potentially have the capacity to foster a well-informed public capable of making healthier food choices, contributing to the broader goal of improved public health outcomes.

At the policy level, a variety of actions across levels of government, ranging from municipal, to provincial, national, and beyond to the global context, all play a role in forming an individual's understanding of food systems and food literacy[86]. Key policy initiatives include restrictions on marketing unhealthy foods to children[87], regulations around marketing[88], and zoning enhancements to improve accessibility to food[89]. Government policies also influence educational content within schools[90], dictate food product standards[91], and ensure the availability of healthy food options[92], particularly in underserved communities. These policy levers are essential in providing widespread access to food education and resources, supporting both community and individual efforts to enhance food literacy. Governments also influence ecological factors such as minimum wage and social assistance rates as well as employment standards that may shape opportunities to develop and practice food literacy.

The socioecological model serves as a powerful tool for understanding the factors that may shape food literacy, including for conceptualizing research to better understand which factors are the most important leverage points for supporting food literacy, including among emerging adults.

2.1.2 Food Literacy and Dietary Quality

Research seeking to link food literacy to eating patterns is limited to date. While studies increasingly include broader conceptualizations of food literacy, previous research often failed to capture the totality of food literacy by focusing on select elements of the construct, such as cooking ability or nutrition knowledge, potentially obscuring the relevance of food literacy more holistically to dietary intake[53]. For example, cooking ability (a specific domain present in different conceptualizations of food literacy[20,93–96]) among adolescents has been associated with higher consumption of fruits and vegetables[97,98], a preference for healthy food[99,100], smaller serving sizes, and lower frequency of consumption of packaged or processed snacks[100,101]. Among a US sample aged 18 to 23 years, high levels of self-perceived food skills have been linked with a greater frequency of food preparation and more complex preparation steps, which are linked to higher diet quality[102]. In contrast, low food literacy is associated with known barriers to healthy dietary behaviours, including a lack of food skills related to planning, acquiring, and confidence in food preparation[103–105]. For example, Knol and colleagues found that emerging adults with low levels of cooking skills and efficacy, including confidence in their cooking skills, the ability to follow a recipe, cooking a meal in a short period of time, and cooking a nutritious, affordable meal, were also those who were experiencing food insecurity, both of which had an impact on their dietary quality[106].

2.1.3 Food Literacy and Emerging Adulthood

Various findings have emerged from research in which individuals close to emerging adulthood (i.e., late adolescence) have been studied in relation to some attributes of food literacy, mainly focusing on knowledge, skills, and action. They are succinctly described in a review by Vaitkeviciute, Ball, and Harris[3]. Due to the relative newness of the field and a tendency to overlook emerging adults as a unique cohort distinct from adolescents and adults, few quantitative studies have been conducted to gain a complete understanding of food literacy in this age range using a comprehensive measure.

Focusing on food literacy among emerging adults is important due to the unique transitional phase they experience[17]. Emerging adulthood is marked by significant life changes, such as leaving the parental home, beginning higher education or entering the workforce, and establishing independent living arrangements[16]. These transitions often introduce new responsibilities related to food acquisition, preparation, and consumption, which differ markedly from previous experiences within the family home[107]. This shift can significantly impact dietary behaviours and overall health as young adults typically have growing independence in navigating these tasks[108]. Additionally, emerging adults are faced with a contemporary food environment that is more complex and challenging than that faced by previous generations. The modern food environment is characterized by the corporatization of many elements of the food system, pervasive availability of highly processed foods, advances in food marketing, messaging, and media, and the prevalence of fast food options, which complicate efforts to maintain a healthy diet[109]. Food literacy may be a crucial factor in managing these new challenges.

The development of food literacy is not a static process but one that continues to evolve over the lifespan. However, several challenges can hinder this development. Traditionally, food literacy is developed through caretaker influence and participation in food-related activities during youth. The food literacy one gains during youth is heavily reliant on the food literacy of their caretakers, typically a parent[110,111], and influenced by the social and economic constraints faced in the household[53]. Additionally, there is a notable gap in comprehensive food education within school curricula and public health initiatives[112], leaving many young adults inexperienced and lacking guidance from nutrition professionals. The emerging adult years can also be a period of limited financial resources, which can restrict the ability to 'practice' food literacy through direct experiences like cooking and grocery shopping[113]. The 'starving student' phenomenon, whereby consuming inexpensive and often unhealthy foods is perceived as a rite of passage, can negatively impact both academic performance[114,115] and the development of healthy eating habits[51,52,116]. For those entering the workforce, poor food literacy may contribute to suboptimal dietary patterns that impair workplace performance[117].These immediate impacts can be consequential for the young adults themselves, and as these individuals transition to parenthood, their food literacy will influence the health and well-being of their offspring through dietary provision and inter-generation translation of food literacy[65,66].

The measurement of food literacy is vitally important for understanding how best to foster long-term healthy eating patterns. Systematic surveillance and monitoring of food literacy during this developmental stage using well-conceived and evaluated measures are necessary to understand the evolving needs of young adults to tailor interventions and policies to ensure they are relevant and impactful.

2.2 Measuring Food Literacy

In the years since food literacy was formally defined, many researchers and teams have devised measures of food literacy to suit their needs and conceptualize it in their setting[32,118–121]. However, the lack of well-evaluated and standardized measurement tools to confidently capture the domains and attributes of food literacy has been identified[24, 2]. Given the uniqueness of food systems, cultural practices, and policy environments, measures developed in one context may not be suitable for use in other locales, suggesting the need for a measure that is specifically tailored to the Ontario and Canadian contexts—one that is psychometrically robust and sufficiently comprehensive to accurately assess food literacy in this setting.

The lack of an evidence-based and well-evaluated measure of food literacy has significant ramifications for public health practice [2,24]. Primarily, it affects the ability to assess and monitor food literacy at the population level and impedes the ability to tailor, target, and evaluate interventions based on the elements of food literacy that are lacking. Having a well-tested food literacy measure is also helpful in directing advocacy efforts for policy to reduce systemic inequities thought to shape food literacy and eating patterns[122].

Much of the development of food literacy measures to date follows the traditional process outlined in Boateng et al.'s scale development guidance[123], such as the use of Delphi techniques with subject matter experts to narrow down domains and items/questions, cognitive and pilot testing, and evaluation of the measure using exploratory and confirmatory factor analysis[123]. Different research groups (and consulting experts) agree that food literacy is a construct comprised of multiple sub-domains of interest (e.g., food skills, knowledge, attitude, beliefs) but have come to different conclusions on what domains, attributes, and indicators to include in their conceptualizations and therefore, measures[24].

Food literacy is increasingly recognized as a multidimensional construct, encompassing a range of competencies and knowledge areas. A scoping review by Azevedo Perry et al.[32] examining how food literacy was conceptualized in the literature in the post-definition period (2014-2017) found fifteen attributes of food literacy used, with different domains than those promoted by Vidgen and Gallegos[53]. In another review, Truman et al.[118] found six domain themes related to food literacy that have emerged as the literature advances: skills and behaviours, food/health choices, culture, knowledge, emotions, and food systems. Truman et al.[118] acknowledged that in most measures, an inconsistent selection of these is used. Due to the variation in the measures used to assess food literacy, generalization and comparisons of results across studies have proven to be particularly difficult[1].

The field of psychometrics, an area of study dedicated to the theory and technique of measurement, plays a pivotal role in assessing the quality and utility of measurement tools[124]. These assessments are critical in determining a measure's validity—the extent to which a tool accurately captures the construct it purports to measure. Validity is not just a metric of measurement accuracy; it is essential for ensuring that the inferences made from resultant scores are sound and actionable[125]. Without evidence of validity, the practical applications of research findings to areas like educational programs, public policy, and individual assessments could be fundamentally flawed[126]. Methods used to assess validity range from examining the content and structure of the measure to correlating its scores with external criteria known to be indicators of the construct.

2.2.1 FLit Measure

In 2012, a group of registered dietitians and other health professionals from eight Ontario public health units were funded to carry out a project on food skills through Public Health Ontario's LDCP program. The project aimed to set a target priority population for further work to understand and conceptualize food skills and to conduct ethnographic interviews to explore the meanings of the term "food skills" and develop a working definition. Through the interviews, the researchers sought to identify the barriers and facilitators to acquiring and implementing food skills and use the findings to inform programs and policies that could improve healthy food preparation among the priority population in Ontario. A literature review was carried out, and two priority groups were identified: adolescents (age 16 to 19 years) and pregnant individuals and parents (age 16 to 25 years) with at least one social determinant of health risk factor for poor health outcomes[2]. Interviews with those belonging to the two priority groups (n=85) revealed that the meanings and practices that the participants ascribed to food skills encompassed knowledge and technical ability but also psychological factors, including confidence, social connectedness, and resilience, that impacted food behaviours[2]. As a result, the researchers recognized that "food skills" was too narrow of a conceptualization and that food literacy, which was emerging in the literature, was a more appropriate term. Two conceptual models were generated, capturing the individual dimensions and external determinants[2].

In 2016, the LDCP Healthy Eating Team, having expanded to members from 16 health units, was again funded through the LDCP program to focus on food literacy. This project aimed to create a food literacy measure for use with the two priority populations and begin preliminary testing of the measure[127]. **Figure 3** outlines the timeline and phases of the project. A scoping review was conducted to derive key attributes of food literacy from the literature, which were then prioritized for inclusion in a measure using the Delphi method[128]. Eleven attributes were identified for inclusion in a food literacy measure[127].

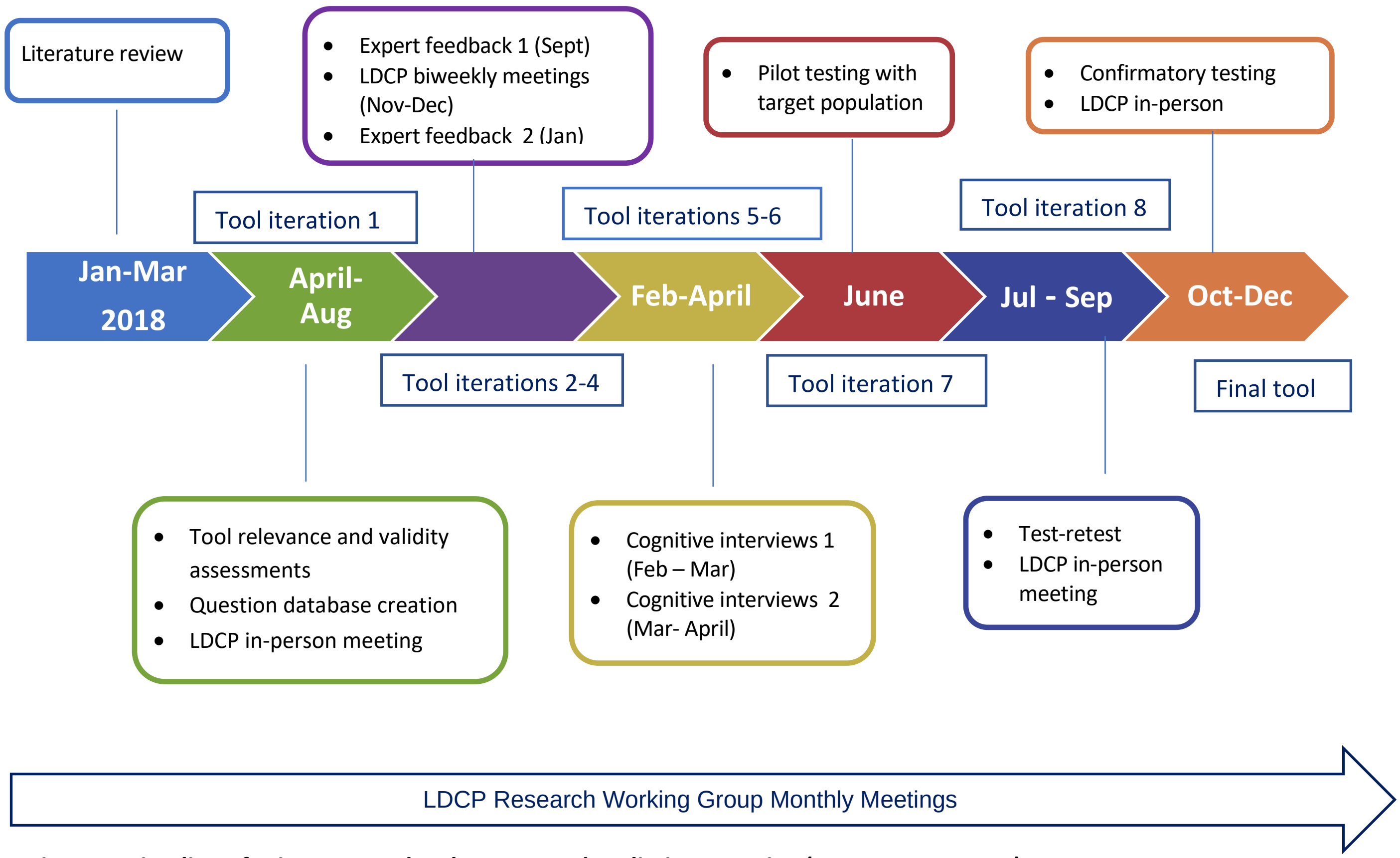

Figure 3: Timeline of FLit measure development and preliminary testing (Jan 2018-Dec 2019).

The LDCP team then partnered with researchers from the Dalla Lana School of Public Health at the University of Toronto to develop and conduct preliminary testing of a measure. The team prepared a database of items used in other measures relating to the identified food literacy attributes, resulting in approximately 30 to 60 questions for each attribute. After reviewing the item list, the researchers concluded that most questions were inappropriate for the purpose. These included items that were potentially culturally dependent and irrelevant in Canada, items that were not aligned with current evidence, items that were meant to be administered in clinical settings, and items that did not fit the identified attributes[127]. The decision was made to alter existing items or develop new items to better align with the attributes of interest. A revised set of items was designed, resulting in the first iteration of the tool consisting of 126 items.

The second iteration of the tool consisted of 139 items after incorporating feedback received from four (of six invited) international experts. The LDCP Healthy Eating Team met to critically appraise the items, resulting in a third iteration of the measure, which consisted of 77 items across 12 attributes[127]. Three experts (of six invited) and one registered dietitian (of three invited) were involved in a second expert review panel, providing feedback on the measure's third iteration, which resulted in a fourth iteration containing 68 items across 12 attributes[127]. This fourth iteration of the food literacy measure was used in preliminary testing. The tool was tested with the groups identified as priority populations in Ontario: 1) youth (16 to 19 years of age) and 2) young parents and young pregnant individuals (16 to 25 years of age)[127].

Cognitive testing was performed (n=25), and nine items were removed[127]. Seven participants from the priority populations participated in the pilot testing of an online administration of the food literacy measure and the broader survey tool used in its evaluation. They provided feedback on ease of completion and ideas to improve the measure. Overall, the feedback from the pilot testing was positive, though satisfaction with the length of the measure was mixed. Three items were altered, and one was added in this seventh iteration of the tool[127]. Test-retest reliability and exploratory and confirmatory factor analysis were conducted in the final testing phase. Exploratory Factor Analysis (EFA) was conducted with 255 participants recruited from across Canada to reduce the measure to a smaller, more parsimonious set of questions[127]. Scree plots and the Kaiser Guttman criterion were applied to the data, following a Promax oblique rotation to allow for correlated factors[127]. The tool was re-administered to 147 participants in a retest phase[127]. Test-retest reliability was assessed via percent agreement, Cohen's Kappa for nominal questions, and weighted Kappa for ordinal, Likert scale questions[127]. Finally, 226 new participants were recruited for the confirmatory testing phase to test how well the factors suggested by EFA fit under a new sample[127]. Confirmatory Factor Analysis (CFA) was used to assess model fit, the quality of the general factor structure, and relationships among items.

Using an eigenvalue cut-off of 1 and a visual examination of a Scree plot, EFA extracted 14 factors[127]. For seven factors, measure items were grouped as expected by attribute. Two pairs of items were grouped as one factor, two factors consisted of items from various attributes, and two factors loaded single items[127]. Cronbach's alpha was used to assess the internal consistency of the items, measuring how closely they inter-relate with the underlying factors[129]. Alpha was calculated for each attribute as they were designed and for the factors that resulted from the EFA. In each case, the factors suggested by EFA improved Cronbach's alpha. Three sets of items corresponding to the factors had a Cronbach's alpha greater than 0.7 (cooking self efficacy = 0.85, food attitude/dietary behaviour = 0.84, and sociocultural/social determinants = 0.80[127], which suggests acceptable internal reliability[130]. Two sets of items had a Cronbach's alpha between 0.6 and 0.7 (food systems = 0.69, nutrition literacy = 0.65[127]. Food skills items did not load to a factor together and had a low Cronbach's alpha (0.29). Items belonging to the remaining three factors, food knowledge, nutrition knowledge, and food and nutrition language, had lower Cronbach's alpha but improved over the original attribute Cronbach's alpha (Food knowledge: Attribute Cronbach's alpha = 0.289, Factor Cronbach's alpha = 0.424. Nutrition knowledge: Attribute Cronbach's alpha = 0.405, Factor Cronbach's alpha = 0.538. Food and nutrition language: Attribute Cronbach's alpha =0.454, Factor Cronbach's alpha = 0.526)[127]. Guided by a priori criteria set by the project team, five items were removed, and two were modified as they did not load with any items from the same attribute. One item was removed and one modified as they loaded onto a factor with less than three other items, and one item was removed as it loaded onto more than two factors[127].

Percent agreement from test to retest ranged from 64% to 97%[127]. Most items had fair (0.21-0.40) to moderate (0.41-0.60) kappa[127], a statistic used to measure the reliability of categorical variables that accounts for chance agreement. Two questions had lower Kappa (0-0.20) but a very high percent agreement. Based on the percent agreement and kappa statistics, it was concluded that the food literacy measure has relatively stable reliability over time[127]. Confirmatory factor analysis was used to test the hypothesized factor model extracted by EFA using several model fit indices. The final model consisting of 11 factors had adequate values for the root mean square error of approximation (RMSEA Estimate = 0.044), the Bentler Comparative Fit Index (CFI = 0.854), and the Bentler-Bonett Non-normed Index (BBNNI = 0.838[127] as ascribed by Schrieber[131].

In a final meeting between the researchers and the LDCP Healthy Eating Team, the FLit measure was finalized. One attribute from the EFA and CFA, dietary behaviour, was judged as potentially being an outcome of food literacy and/or other factors and was removed from the measure[127]. The questions designed for the dietary behaviour attribute were replaced with questions that assessed an individual's understanding of the relationship between behaviour and health and were eventually included as part of food attitudes[127]. This decision was made because individuals could demonstrate their understanding of the relationship between dietary behaviour and health but may not follow certain dietary practices due to socioeconomic status or the availability of food. It was acknowledged that dietary practices could be measured separately using standardized measures of dietary intake (e.g., 24-hour recall) alongside the FLit measure rather than being included in the measure itself[127].

The outcome of this work is a food literacy measure (FLit50, **Appendix 1**) consisting of 50 items spanning 10 attributes that make up four domains[127] (**Table 1**). Nineteen items are multiple-choice questions reflecting food knowledge, nutrition knowledge, food and nutrition language, food skills, and nutrition literacy. Fifteen items reflecting the attributes of nutrition self-efficacy and cooking self-efficacy present Likert scale response options requiring an indication of the level of confidence across four response options (not confident to very confident), and 16 items assessing the attributes of food attitude and dietary behaviours, food systems, and sociocultural and social determinants of health use a five-point agreement Likert scale (strongly disagree to strongly agree, with a neutral response option). Different scoring approaches were evaluated by the researchers during the development of the measure[127], and a scheme was settled upon whereby one point is assigned for a correct answer to the knowledge-based questions and one point given for an affirmative Likert scale response (i.e., responses that indicated agreement and confidence; disagreement or neutrality with the statement were awarded no points). A sum-scoring approach is used with scores at the attribute level summing to produce a score for their respective domain score, and domain scores summing to a total food literacy score out of 50 points[127].

Table 1: LDCP Healthy Eating Team final food literacy domains, attributes, and descriptions.

Domain	Attribute	Description
FOOD & NUTRITION KNOWLEDGE	FOOD KNOWLEDGE	To know the variety of foods within all food groups. To know where food comes from and what is in it. To make an informed decision on food choices, including what is available locally.
	NUTRITION KNOWLEDGE	To understand the nutrients in food and how these can affect health and well-being.
	FOOD AND NUTRITION LANGUAGE	To understand commonly used words to describe characteristics of nutrition in food (e.g., high fibre, low sodium) and preparation of food (e.g., sauté, fold).
FOOD SKILLS	FOOD SKILLS	To be able to prepare meals throughout the life span using basic skills like chopping, measuring, reading recipes, and being food safe.
SELF EFFICACY & CONFIDENCE	NUTRITION LITERACY	To be able to distinguish between credible and false nutrition information. Knowing how to find reliable nutrition information and how to make sense of it (e.g., reading a food label).
	FOOD AND NUTRITION SELF-EFFICACY	To believe in one's ability to apply food and nutrition-related knowledge to make healthy choices in a complex food environment.
	COOKING SELF-EFFICACY	To have confidence in one's ability to use cooking equipment and prepare tasty meals with available food.
	FOOD ATTITUDE	To understand one's attitude towards food and trying new foods. Having the desire to choose and prepare healthy and safe food to enjoy at all times
ECOLOGIC FACTORS (External)	FOOD AND OTHER SYSTEMS	To have an understanding of how the broader food system and society as a whole impacts an individual's decisions about food and how an individual's food choices impact the broader food system (e.g., buying local food and the impact on the local farms or food industry).

	SOCIAL DETERMINANTS OF HEALTH	To understand the social and environmental conditions (e.g., inadequate income and education) that can result in inequities in health status (e.g., adequate income), which can impact the capacity to make decisions about food and cooking.

From a measurement perspective, the conceptualization of food literacy in this context is a higher-order latent construct. The food literacy (FLit) construct in this conceptualization consists of three layers of abstraction. In particular, this characterization of food literacy is a third-order construct measured by a composite of second-order variables (referred to as the domains of food literacy (n=4)), of which three are made up of first-order attributes reflective of their respective question items. One domain, food skills, does not have an associated first-order dimension. This conceptualization is considered a 'complex measurement model' according to the description by Hair et al.[132], due to the inclusion of both reflective and formative constructs. The conceptual structure of food literacy used in this research is described as a complex, reflective-formative-formative, third-order measurement model.

The team desired further evaluation of construct validity to allow confident use of the FLit measure, along with the recommendation that it be shortened to reduce the burden for practitioners/researchers and respondents and to make it more practical for broad use in public health contexts. Modern testing theories and techniques can be combined with traditional approaches to measurement evaluation to satisfy these needs[133,134]. The following section will provide background on psychometric evaluation, centering on the methods and techniques used in this research.

2.3 Evaluating Measurement Tools

Science involving latent constructs, like food literacy, depends on using measures to collect data that show high validity in reflecting the construct of interest. Confidence in the validity of a measure is obtained through specifically designed studies that determine the extent to which measures reflect (and at what strength) the phenomena of interest[135]. Psychometrics is the field of study concerned with the evaluation of measurement and offers many theories and techniques to assess the validity of a measure.

Overall, the goals of psychometric studies are to provide convincing evidence that the scope of the measure's items (i.e., questions) corresponds to the scope of the phenomenon of interest and to demonstrate that the scores yielded by a measure take on values that are consistent with the understanding of how the phenomenon of interest varies in the real world[136].

There are three major types of validity: content, criterion, and construct validity. Content validity examines whether the instrument adequately covers all the content that it should with respect to the variable and is often assessed by experts in the field[137]. Criterion validity reflects how well a measure correlates with an established standard of comparison (if one exists) in a convergent, divergent, or predictive way[137]. Construct validity refers to whether inferences can be made about scores of a measure related to the concept being studied and is usually demonstrated through tests of homogeneity (the instrument measures one construct) or factorial validity (dimensionality exists for constructs believed to be multi-dimensional), convergence (the measure is in alignment with other similar constructs), and nomological validity (the measure behaves as expected relative to theoretical propositions or in alignment with previous research findings)[138,139].

Psychometric techniques are used to determine the validity of a measurement tool and fall within two main approaches: classical test theory (CTT) and item response theory (IRT). Both CTT and IRT are frameworks for modelling measurement data. Both approaches offer various techniques to calculate the statistical properties of a measure, its items, and the respondent[140]. For example, CTT and IRT allow for the examination of person statistics, item difficulty, and item discrimination. While some studies have found that different statistics of common measurement properties produced through each approach can be similar[141,142], how they are arrived at differs considerably. For example, there are some commonly identified issues in CTT around calibration of item difficulty, sample dependence, and estimates of measurement error that can be addressed by IRT[143]. Despite traction in measurement analysis toward modern theories of IRT, CTT techniques are more familiar in the literature and often employed in validation studies[144].

CTT is a conventional quantitative approach to testing the validity of a measure[145]. CTT is comprised of a set of principles that allow for the determination of how successful the proxy indicators are at estimating the unobservable construct using observable information, such as the sum of scores on questionnaire items in a given sample[136]. CTT assumes that each observed score on a measure is a combination of a true underlying ability level and unsystematic (i.e., random) error[145]. To CTT belongs several popular statistical techniques used to evaluate a measure at the item and scale levels, like factor analysis, coefficient alpha for internal consistency, and correlations for convergence validity testing[136]. These types of analysis, along with face, content, and criterion validity, provide vital evidence to deem a measure acceptable for use for a given purpose[136].

CTT approaches bring several advantages. One is familiarity with its basic concepts; researchers exposed to measurement theory are likely to have encountered CTT through training or its near-ubiquitous use in the literature. Another advantage is that methods and techniques are widely available through common computing software programs. Methods derived through these theories work particularly well when measures are designed with items that roughly contribute an equal amount of information to the underlying construct[136]. The CTT approach has some notable disadvantages. CTT-based methods rely on the full measure being delivered in its entirety for each implementation, and deviations from the protocol that has been previously tested for validity can introduce uncertainty with respect to error[136]. Another disadvantage is that estimates of a construct under CTT depend on the sample of individuals studied. Different samples with different variances will make comparisons across populations difficult. With some of these disadvantages in mind, psychometricians have developed new mathematical approaches to evaluating measures in IRT.

IRT, often termed 'modern' test theory due to its more recent emergence, offers unique benefits to the research community. IRT is commonly used for its ability to estimate parameters at the item level by modeling a person's responses to the items in a measure from their underlying level of the construct, termed 'ability'[146,147]. Item difficulty, the parameter describing the probability of endorsing (or scoring on) an item along the ability scale, can then be calculated for each item[148]. IRT also makes it possible to examine the expected degree of measurement error at levels of the construct on an item-by-item basis, rather than relying on one global standard error of measurement, as is the case with CTT. Another benefit of IRT is that it allows for extrapolating estimates of the construct for individuals outside the range studied in the standardization sample[149], making it an attractive method for expanding the use of a measure.

IRT is a particularly useful approach when the research objective is shortening an existing measure that may have benefited from more items included in the early development phase. Based on several statistical and graphical outputs (e.g., item characteristic curves, item information curves, and differential item functioning), test items can be selected to minimize measurement error and maximize information gained at a particular targeted level of ability[149]. This approach is helpful as it ensures that items included in a final or abbreviated version are the combination of questions that provide the most value in assessing the construct while reducing the burden on respondents by eliminating questions that provide less value. IRT can also add value when the objective is to update or expand a measure since the item statistics are sample invariant and it has shown value in the development of item banks and computerized adaptive testing[150,151].

Different models exist within the IRT family based on the number of parameters estimated for each. The Rasch model holds its place as the least complex, modeling ability with item difficulty[152], making it a favourable choice for many researchers[153,154]. The 2-parameter model adds the extra element of item discrimination to the model, a statistic related to how well an item distinguishes among individuals who are at different levels of ability[155]. Other models include a parameter to account for the possibility of a respondent guessing the correct response in multiple-choice questions, and different treatments can be used for items with polytomous responses, usually in the form of Likert scale response options. As the popularity of evaluating measures using IRT increases, understanding is growing, and new models are being developed to account for more complex measures[156].

As interest in food literacy continues to be explored as a determinant of dietary quality and health, the need for a measure that captures the construct at a high level of validity is critical. The use of CTT approaches allows researchers to demonstrate aspects of construct validity of a developed measure statistically. IRT gives researchers the ability to analyze a measure, its factors, and individual items, providing depth to understanding of the mechanics of a measure. Incorporating distinct psychometric approaches to the evaluation of the FLit provides a broad and robust understanding of the measure, informing its future use and providing research value to the collaborative partnership with the LDCP Healthy Eating Team.

2.4 Integrated Knowledge Translation

Collaboration with and inclusion of knowledge users in research is a valued approach and is considered a bridging solution to the underutilization of research outcomes by those in positions to implement change. Integrated knowledge translation (iKT) is defined as “a model of collaborative research, where researchers work with knowledge users who identify a problem and have the authority to implement the research recommendations”[157]. iKT encourages researchers to integrate knowledge users throughout the stages of the research process, such as its execution, interpretation, as well as the use and dissemination of its products[158,159]. Proponents of co-produced research describe synergies evolving from the collaboration that result in better science, more relevant and actionable research findings, increased use of the findings in policy or practice, and mutual learning[157]. Recognizing the impact that iKT can have, Canadian health research funding agencies are promoting and prioritizing the funding of research partnerships, which have identified iKT as a component[160].

Adopting an iKT approach in research can bring multiple benefits to both the researchers and knowledge users. At its core, iKT focuses on researchers and knowledge users appreciating each other's points of view and entering the research space as experts in their own right[161]. Working together, those making up the partnership can benefit from a newly created shared perspective. In addition, an intangible capacity can be built among the group, which has been interpreted as tacit knowledge and social capital or relational capital[162], and can sustain and drive future collaborations, research based or otherwise[163]. Some evidence suggests that researchers may gain more benefit through the collaborative process by expanding their knowledge base to include the individual and collective context of the knowledge users[160,164].

The incorporation of iKT can introduce challenges to the research process, particularly in establishing and maintaining the value in the partnership. Effective health research collaborations demand that researchers have specific knowledge and skills for working in partnership with knowledge users[165]. Unfortunately, many researchers are not afforded the opportunity to learn how to build collaborative relationships, and training in research partnerships is not offered in most graduate programs[166]. This can lead to ineffective behaviour and affect the development of positive, mutually beneficial research partnerships[166].

iKT can be implemented in a research project through many different activities and strategies. Different tactics can be used to strengthen the community within the partnership and others directed towards generating research outcomes and decisions. Integrating knowledge users within the research activities is not a simple process and thoughtful consideration must be given to the range of interactions. Different stages of the research project will necessitate varying degrees of intensity, complexity, and level of engagement from some or all members of the collaborative. Care must also be made in communicating scientific concepts by considering the level of exposure and interest of the partnership group toward the research.

With momentum growing around the topic of food literacy and measurement of food literacy in Ontario and Canada, iKT is a viable approach for the research described in this thesis. The LDCP Healthy Eating Team represents a collective of knowledge users and an established community of practice in the field of food literacy. The Team has led various research projects related to food literacy, including the conceptualization and development of the FLit50 measure and directing the next steps of the psychometric assessment of the FLit measure, conducted as part of this dissertation.

Health research is conducted with the expectation that it advances knowledge and eventually translates into improved health systems and population health[167]. Incorporating knowledge users in the research process through approaches like iKT provides the opportunity to generate greater and faster societal impact than if the research was undertaken as a strictly academic pursuit[167]. With the concise objectives charted by the LDCP Healthy Eating Team, this research has the potential to generate outcomes to be used in the application of the measure and improve the understanding of food literacy among emerging adults.

CHAPTER 3: RESEARCH OBJECTIVES

With growing momentum related to food literacy in Ontario, including concerning emerging adults, having a well-developed and evaluated measure is necessary. Such a measure can help identify those with lower food literacy and specify which food literacy domains and attributes may require attention. Data from the measure will also allow for the consideration of how various factors are associated with food literacy levels, informing future research and action to support food literacy.

The specific objectives of this dissertation were to:

1. evaluate the construct validity of the FLit50 measure among post-secondary students;
2. analyze the characteristics of the FLit50 items to facilitate the development and evaluation of a shortened measure; and
3. explore the demographic, economic, studentship, and health correlates of food literacy among post-secondary students.

This thesis is manuscript-based. Studies based on the above objectives form the basis of three manuscripts (**Chapters 5 to 7**) to be submitted for publication.

CHAPTER 4: GENERAL METHODS

4.1 Design

The primary quantitative data used in this dissertation were acquired through a non-randomized, cross-sectional methodology, implemented via an online survey platform between March and May 2022, focusing on a cohort of post-secondary students. These data were used exclusively in **Chapters 5 and 7**. In **Chapter 6**, the student data were combined with data collected in July/August and October 2019 through non-randomized, cross-sectional study phases by researchers at the Dalla Lana School of Public Health at the University of Toronto who partnered with the LDCP Healthy Eating team to develop the 50-item food literacy measure (FLit50) and evaluate aspects of its validity and reliability.

4.2 Participant Recruitment

The primary sample (referred to as the student sample) included persons aged 18 to 25 years, currently enrolled in post-secondary education at an Ontario institution, in their second year or above of studies, who could complete a survey in English and had access to an internet-capable digital device to complete the online survey. This age range was selected as a subset of the population for which the FLit50 measure was developed (16 to 25 years of age). The FLit50 measure was developed for use in Ontario, creating the target sample's spatial bounds. Most academic programs start with survey courses that broadly cover topics and typically have more flexible requirements in the first year. Additionally, first-year students often live in residence and have campus-offered meal plans. Therefore, we recruited students in their second year and above to better evaluate potential differences in food literacy scores between two known groups—students in food and nutrition-related programs versus students in other programs, as explored in **Chapters 5 and 6**—as part of the assessment of construct validity. The survey was designed and delivered in English, necessitating familiarity with the language to participate; translation of the FLit50 measure to French or other languages has not been undertaken. Lastly, the screening questionnaire and survey modules were delivered and completed online. Access to a device and internet connection capable of completing each was assumed based on completing the online screening questionnaire.

The student data were collected from March 14 to May 12 of 2022. A selection of Ontario-based post-secondary institutions was initially targeted based on offering food- and nutrition-related programs and the potential capacity to develop partnerships with researchers and staff for recruitment. After March 28, 2022, the recruitment strategy was expanded to include students from any university or college in Ontario to meet the target sample size. Advertisements about the study and invitations to the screening questionnaire were delivered to potential participants by social media (on platforms including Facebook, Twitter, LinkedIn, and Reddit) and emails to administrative, faculty, and student partners at target institutions for forwarding to listservs and sharing amongst private networks (e.g., campus organizations and student clubs). More targeted recruitment adverts, explicitly designed for students in food- and nutrition-related programs, were delivered via the same social media sites and through outreach made to student organizations for distribution through their listservs. The recruitment materials are included in **Appendix 2**.

4.2.1 Sample Size

Sample size statistics (a priori) were calculated using GPower 3.1 (Dusseldorf, Netherlands)[168]. A priori calculations were centred on detecting a difference between groups considered to have different food literacy (students in food and nutrition programs vs. those enrolled in other programs), a comparison used in evaluating another food literacy measure[169]. Using a one-tailed t-test, a minimum sample of 176 respondents was needed (relative effect size d = 0.5, alpha error probability = 0.05, power = 0.95). Using a relative effect size of 0.5 SD in the sample size calculation is more suitable than an absolute effect size, as it ensures the ability to detect differences that are scaled to the variability of the data rather than fixed point differences, making the analysis more adaptable to the distribution of food literacy scores in the population[170]. Relaxation of the allocation ratio target was made as students studying in food and nutrition-related academic programs are fewer and may be harder to reach. Measurement evaluation using Item Response Theory (IRT) (**Chapter 6**) suggests including between five and 10 participants per item in the measure[171], translating to between 250 and 500 participants for the 50-item measure. In consultation with the LDCP Healthy Eating Team and considering budget availability for remuneration, it was determined that a suitable sample target size would be 500 participants with the aim of at least 100 participants in the food and nutrition program students, with the remaining students in non-food and nutrition programs. This target sample satisfies the requirements for analytical methods used in **Chapters 5** and **6** and is appropriate for the analysis described in **Chapter 7.**

Post-hoc power analyses were conducted after data collection to assess whether the sample size was sufficient for the intended group comparisons. For the variables of enrollment in food and nutrition related academic program and gender, which were dichotomized, power was calculated using a one-tailed t-test with an effect size of $d = 0.5$, an alpha level of 0.05, and a desired power of 0.95. For variables with more than two groups, Cohen's f ($f = 0.5$, $\alpha = 0.05$) was used to assess the effect size across group comparisons. Given the unequal distribution of sample sizes across the groups, the harmonic mean was employed to adjust the sample size, accounting for the unbalanced group sizes and ensuring the power analysis was reflective of the ability to detect significant differences with the data. Most group analyses demonstrated power levels greater than 0.99, though caution is required in interpreting results from smaller subgroups with fewer participants.

4.3 Data Collection Procedures

4.3.1 Eligibility Screening

Potential participants were directed to an online eligibility screening questionnaire hosted on the Qualtrics (Qualtrics, Provo, UT) survey platform[172]. The eligibility screening questionnaire (**Appendix 3**) provided potential participants with information about the study and questions designed to ascertain the eligibility criteria and target sample demographics through questions related to age, post-secondary enrollment, whether respondents were in their second year of study or above, and whether they were in a food- and nutrition-related academic program or not (used for quota sampling). Potential participants were presented with a reCAPTCHA question to mitigate issues around bots. In addition, potential participants were asked to provide a post-secondary institution-issued email address to confirm student status. The email address allowed for the monitoring of repeat participation attempts and was used as the method of communication between the researchers and the participants. All interested participants who completed the eligibility screening questionnaire were shown a thank you message indicating that their responses would be reviewed and those meeting the eligibility criteria would be contacted to complete the survey.

Screening questionnaire responses were analyzed to determine adherence to the eligibility criteria. Those meeting the target characteristics and who provided a post-secondary institution-issued email address were invited to participate in the study. Individuals failing to satisfy the eligibility criteria—for instance, those identifying as first-year students or providing an email address unaffiliated with a post-secondary educational establishment—were excluded from participation and did not receive further contact from the research team. Of the 1226 respondents who completed the initial screening questionnaire, 548 were deemed eligible and invited to participate in the study (**Figure 4**).

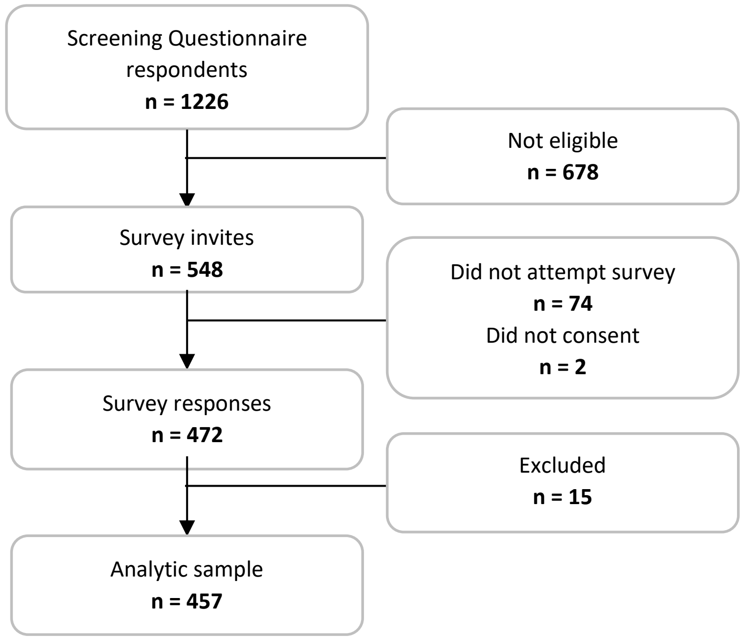

Figure 4: Summary of the overall participant flow from the collection of student data.

4.3.2 Survey

Invitations to complete the survey were emailed, each containing an individualized link for Qualtrics. To avoid fraudulent survey completions, including by bots, eligible participants were sent personalized links to the Qualtrics survey platform[172]. Once potential participants accessed the site, they were presented with the study information letter (**Appendix 4**) and a question eliciting agreement to consent to participate in the study. Participants declining to consent (n=2) were shown an end-of-survey message. A reminder was issued to encourage survey completion approximately one week after the initial invitation for those who had not begun or concluded the survey. The individualized links were designed without an expiry date, allowing participants the flexibility to respond at their convenience until the closure of the survey. Before concluding the data collection period on May 12, 2022, reminders were sent on April 24 and May 3 to invitees who had not yet completed the survey. Of the eligible individuals invited to complete the survey, 472 consented and provided responses (**Figure 4**).

In addition to the FLit measure, consenting participants were asked questions about demographic characteristics, living situation, food acquisition and preparation practices, income adequacy, and general and mental health status. The survey also included a measure of health literacy using the Newest Vital Sign - Canada (NVS-C)[173] and experiences with food insecurity via the adult-referenced questions from the Household Food Security Survey Module (HFSSM)[174], modified to assess individual food insecurity over the past 12 months. Five attention verification questions doubling as bot traps were interspersed throughout the survey to ensure the integrity and quality of the responses, aligning with best practices for online surveys as delineated by Storozuk et al.[175] All questions presented to participants in the study survey are documented in **Appendix 5**.

Data collected from the survey were checked for quality based on time to completion and answering at least three of the five attention check/bot trap questions correctly. A time threshold of over seven minutes was set based on one-third of the average time to complete the items in the initial test phase of a test-retest analysis (11.2 minutes) of the FLit50 measure[127] plus an additional allotment of time to complete the additional questions. Participants' IP addresses were also reviewed for duplicates; however, some participants may have shared the same IP address if they were roommates or shared an internet router. Fifteen records were removed from the analytic sample due to incomplete surveys (**Figure 4**), resulting in a sample of 457. The final samples used in the analyses are described in **Chapters 5 to 7**.

4.3.3 Dietary Intake Data

Dietary intake data were also collected. Within one to three days of completing the survey, participants were invited via email to complete one 24-hour dietary recall using the Canadian version of the online Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24-Canada) (https://epi.grants.cancer.gov/asa24/respondent/asa24-canada-2018.html)[176]. The invitations to complete ASA24-Canada were purposefully distributed across weekdays and days of the weekend to account for the impact of day-of-the-week on consumption patterns[177]. ASA24-Canada was used to collect information about all foods and beverages consumed the previous day. The dietary data were not used for any analysis in this dissertation. Future research will examine the cross-sectional association between food literacy and dietary quality.

4.3.4 Remuneration

Participants were remunerated $10 CAD for their participation in the food literacy survey (an additional $10 CAD was provided to those who completed the dietary recall). Those who were unfinished but completed more than one-third of the survey received $10 CAD. Those who failed to complete one-third of the survey (i.e., quit) were sent a reminder to participate near the end of the data collection period. These respondents were not remunerated if they failed to reach the one-third threshold after the reminder. Participants who completed the survey but did not meet the data quality criteria (e.g., time to complete was too short, did not meet the attention/bot check criteria) were remunerated for their time with $10 CAD, following the approved ethics protocol. All honoraria were sent via e-transfer. An e-transfer password was required for most participants (unless their email address was registered for auto-deposit with their banking institution). The password was sent to participants in a follow-up email with a final thank you message. In instances in which the honoraria were sent but not accepted by the participant, two follow-up e-transfers were sent one month apart. In total, eight participants did not accept their honoraria.

4.3.5 Study Tracking

A database to track study communications and survey completion was constructed according to the three study phases (the screening questionnaire, the survey including the FLit measure, and the ASA24-Canada dietary recall). Individual records were identified with a participant ID, with each ID assigned a personalized survey link to the Qualtrics survey and a pre-defined username and password for use in ASA24-Canada. As participants completed the screening questionnaire, their email addresses and identification as food and nutrition students or not were entered into the database. Upon invitation to the survey, the date of communication and the research team member sending the communication were recorded. Qualtrics was checked daily for completed surveys, and data were extracted and tracked, including the time to complete, the number of attention check/bot check questions attained, IP address, whether they identified as a student in a food and nutrition program, and the name of their academic program. Records of any reminder invitations and which end-of-study communication was sent were logged. The database was also used to track information related to the honoraria payments. Only investigators associated with the project and included in the ethics application had access to the database, which was stored on a secure drive at the University of Waterloo.

4.3.6 Instrumentation

The survey used to collect data for the studies that make up this dissertation included the Flit50 measure, the NVS-C measure of health literacy[173], the ten adult-referenced items from the HFSSM[174,178] and questions on sociodemographic characteristics (**Appendix 5**). These are described briefly below and in detail within the chapters describing each of the studies (**Chapters 5 to 7**).

Food Literacy Measure

The FLit50 is a 50-question food literacy measure designed for use with groups identified as priority populations: 1) youth (16 to 19 years of age) and 2) young parents and young pregnant individuals (16 to 25 years of age)[127]. The FLit50 is designed on a framework of food literacy conceptualized as a higher-order, multidimensional construct. Within the measure, the items reflect ten food literacy attributes. Scores on the items at the food literacy attribute level combine to form four domains of similarly themed attributes. Scores at the domain level combine to make up the total food literacy score. The FLit50 is characterized by an unbalanced design, with the underlying attributes represented by varying numbers of items. The conceptual structure of the food literacy measurement model is presented graphically in **Figure 5**.

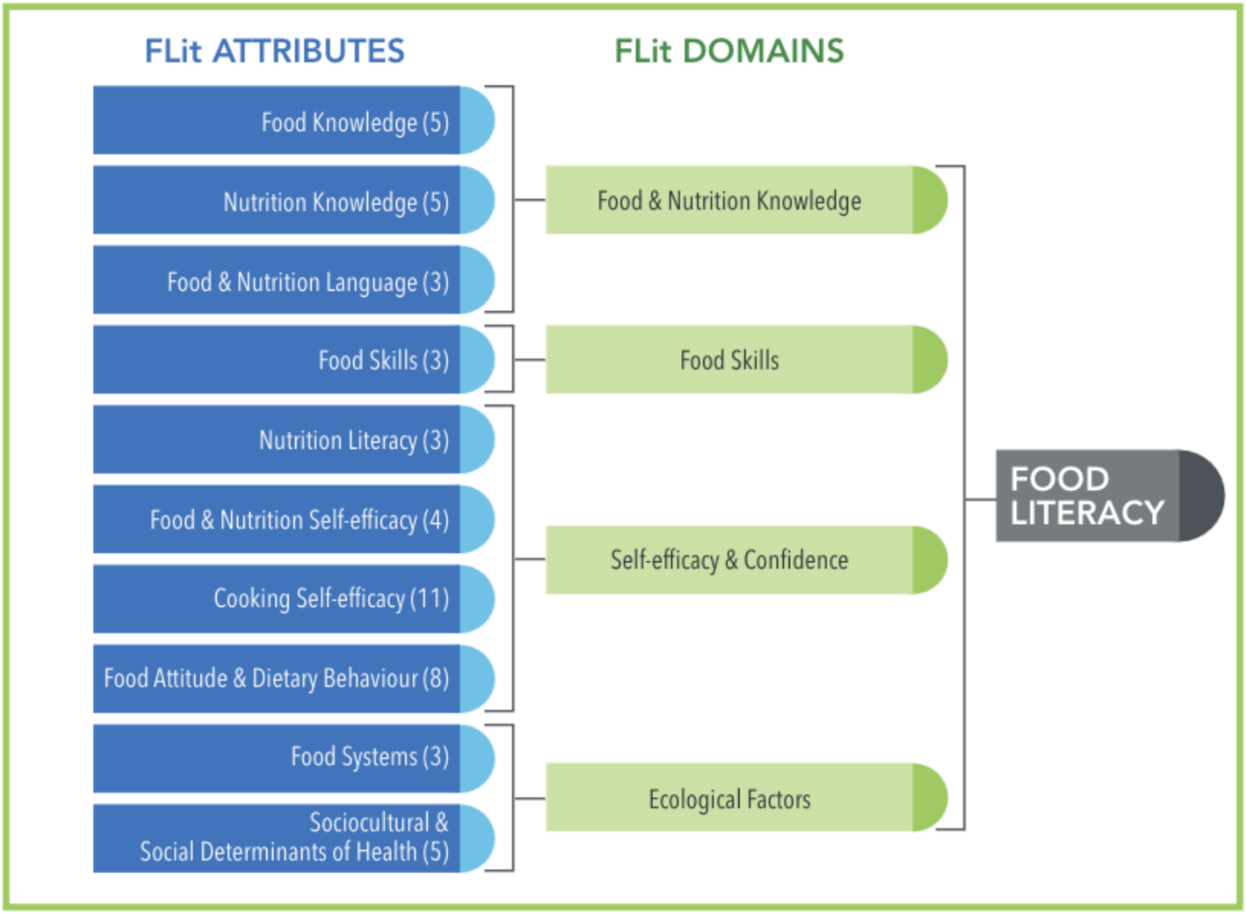

Figure 5: Conceptual model underlying the food literacy measure. Values in parentheses represent the number of items on the food literacy measure related to each reflective attribute and formative domains. Drawn from the Food Literacy (FLit) Measures Guide (Appendix 7).

Items reflecting food knowledge, nutrition knowledge, food and nutrition language, food skills, and nutrition literacy (19 items) are designed as multiple-choice questions. Items reflecting nutrition self-efficacy and cooking self-efficacy (15 items) require an indication of the level of confidence using a four-point Likert response scale ranging from not at all confident to very confident. The 16 items for the food attitude and dietary behaviours, food system, and sociocultural and social determinants of health attributes use a five-point scale ranging from strongly disagree to strongly agree. Various psychometric properties of the FLit measure were evaluated during development and are described in the related publication[127].

One item related to the attribute food attitude and dietary behaviours was mistakenly omitted from the FLit measure. The overlooked item reads: “It is important for my health to make most meals or snacks using basic ingredients (e.g., pasta, vegetables, meat)”, with the response options of strongly disagree, disagree, neutral, agree, strongly agree.

Scoring for the FLit50 was consistent with the preliminary evaluation of the measure[127], with one point assigned for a correct answer to the knowledge-based questions and one point given for an affirmative Likert scale response (i.e., responses that indicated agreement and confidence; disagreement or neutrality with the statement were awarded no points). The total food literacy scores and domain scores were treated as continuous variables in the studies presented in Chapters 5 to 7.

The structure of the FLit50 measure, with varying numbers of items across attributes, impacts how scores are produced and interpreted. Since some attributes have more items than others, these attributes disproportionately influence the overall food literacy score and the domain scores. For instance, an attribute with 12 items contributes more heavily to the total score than an attribute with only three items. This uneven weighting means that certain aspects of food literacy, such as knowledge, skills, or confidence, might dominate the score, potentially reflecting a biased representation of an individual's food literacy, emphasizing some components over others. This imbalance can lead to misinterpretation of the results, such that higher scores might be incorrectly attributed to overall food literacy rather than specific strengths in overrepresented attributes. When interpreting the scores derived from the use of the FLit50, it is important to be mindful of this unbalanced aspect to ensure a comprehensive and accurate understanding of an individual's food literacy.

Health Literacy

Health literacy, the ability to read, understand, and act upon health information[179], was assessed using the NVS-C. The Newest Vital Sign© was developed in the United States to measure patient health literacy in clinical settings and has since been adapted for use in Canada and digitized for computer-based applications[173].The NVS-C has been used to measure health literacy in Canada[173] and the original form has been used to evaluate the convergent validity of other food literacy measures[180,181].

The NVS-C is based on the ability of a respondent to answer questions related to a Nutrition Facts Table. Study participants were shown a Nutrition Facts Table for ice cream and asked five questions relating to the content and interpretation, with a sixth question presented to participants who provided a specific response to the fifth question. Participants received one point for each of the six questions answered correctly and 0 points for each incorrect answer (including those unanswered). The categorization of the scoring followed that recommended by the NVS, with 0-1 suggesting a high likelihood of limited literacy, a score of 2-3 indicating the possibility of limited literacy, and a score of 4-6 almost always indicating adequate literacy[173].

In its original form, the NVS-C was read aloud to participants who indicated their responses using paper and pencil administration[173]. In the digital adaptation, the questions were recorded, and an audio file was played concurrently with the question shown. For the current research, through consultation with collaborators, the recording of questions was deemed unnecessary and questions were presented in text form in the survey.

Food Security Status

Food security status over the past 12 months was assessed using the ten adult-referenced items from the HFSSM. The HFSSM asks respondents several statements based on experiences of uncertain, insufficient, or inadequate food access due to financial constraints in the previous 12 months[196]. The survey module has shown validity through several psychometric studies[182] and has been applied in the Canadian/Ontario context[183–187]. Affirmative responses to items on the HFSSM are used to categorize households as experiencing food security or marginal, moderate, or severe food insecurity[188]. Small changes were made to the wording of survey questions. The original question text was edited to remove reference to “other household members” and “other adults in the household” as individual rather than household food security status was the focus. The question text used in this study can be found in **Appendix 5**.

Responses to the HFSSM can be operationalized as a continuous variable or categorized into groups. Analyses in **Chapters 5 and 6** treat scores as categorized dependent variables, whereas in **Chapter 7**, scores were dichotomized with no experiences of food insecurity being classified as food secure and any experience representing food insecurity. In cases with missing responses to the HFSSM items, no imputation was conducted.

To reduce respondent burden, the module is designed in a staged manner such that affirmative responses trigger further questions. Any affirmative responses to the three initial questions result in the display of a second set of five follow-up questions. Of those five questions, two (AD1 and AD5) are designed to display a question eliciting the frequency of the coping mechanism. An error was made in the logic flow related to the HFSSM in the administration of the survey. Question AD5, which reads, "In the last 12 months, did you ever not eat for a whole day because there wasn't enough money for food?" is meant to be presented to participants who indicate a 'yes' response to *any* of the questions AD1 – AD4. AD5 was erroneously presented only to participants who responded 'yes' to *all* questions AD1 – AD4 in the survey. An affirmative response to question AD5 prompts a sub-question querying the frequency of not eating due to insufficient money for food. This affected the HFSSM scores of 66 individuals, who would have had the opportunity to identify further experiences of food insecurity. Of those 66, 48 respondents would have remained in their classification regardless of their responses to the AD5 and AD5b. The other 18 respondents had the potential to be reclassified from experiencing moderate food insecurity to experiencing severe food insecurity, depending on their responses. These 18 respondents remained in their current categorization for the analyses described in **Chapters 5 and 6**. The error did not affect the dichotomized categorization of whether individuals experienced food security or not, as used in **Chapter 7**.

Demographic, Studentship, Economic, and Health Characteristics

In addition to the FLit50 measure, the NVS-C, and the HFSSM, variables related to demographic, education, income adequacy, and health characteristics were collected. Altogether, 22 primary variables were gathered, with additional variables derived based on survey responses. Detailed descriptions and applications of the variables used for analysis are provided in **Chapters 5 to 7**.

4.3.7 Supplementary Data Used in Chapter 6

A secondary dataset was combined with the student data for the study presented in **Chapter 6**. Youths between 16 and 19 years of age and pregnant or young parents between 16 and 25 years of age living in Canada were invited to complete the online food literacy measure to assess aspects of validity, reliability, and feasibility through three phases: 1) test 2) retest; and 3) confirmatory test. These data were collected by a research team from the Dalla Lana School of Public Health at the University of Toronto, contracted by the LDCP Healthy Eating Team.

In July and August 2019, participants were recruited for the test-retest phases using paid advertisements on Instagram and Facebook and through community/public health programs and services[127]. Two hundred and fifty-five (n=255) respondents completed the measure as part of the test phase, including 126 youth and 129 young people who identified as a parent or being pregnant. Within two weeks of the initial administration of the survey, a refined version of the measure was completed by 147 participants in the retest phase. Because the measure used in the retest phase was more similar to the final 50-item measure versus that used in the test phase, only the data from this phase was used in the analyses. Finally, using the same social media recruitment strategy, 226 new participants completed the food literacy measure in the confirmatory test phase in October 2019[127]. The confirmatory test phase used a further refined version of the measure, with some items removed as part of the ongoing measurement development process. The eligibility criteria for this phase were individuals who lived in

Canada, were 16 to 25 years old, and did not participate in the test-retest phases. As with the data collection with postsecondary students, procedures and checks were used to prevent the inclusion of data submitted by bots. A flowchart outlining the analytic sample of the supplementary data used in combination with the primary student data is presented in **Figure 6**.

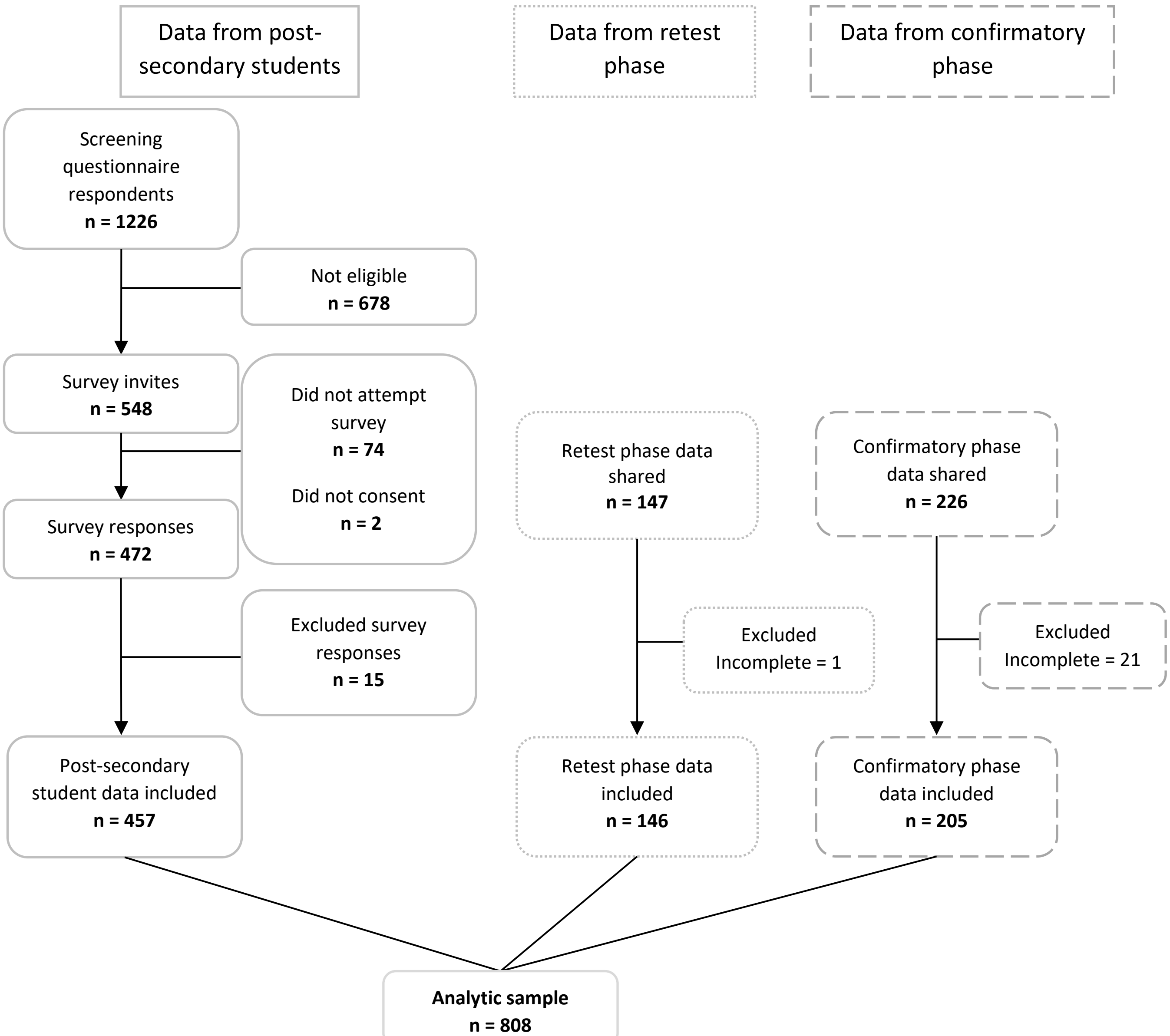

Figure 6: Summary of the overall participant flow used in Chapter 6, including primary data collected from students and supplemental data from retest and confirmatory phases.

In both the retest and confirmatory phases, demographic characteristics queried included age, gender, racial/ethnic identity, pregnancy/parental status, geographic location, and socioeconomic status (SES). SES was queried using an adapted version of the MacArthur Scale of Subjective Social Status,[189] which consisted of a 10-point ladder question, with 1 representing the least access to life opportunities (e.g., education, jobs) and 10 representing the most access to life opportunities.

Participants received a $10 e-gift card for each survey completed.

4.4 Procedures

4.4.1 Data Preparation, Manipulation, and Management

Primary (Student) Data

At the end of the collection period, data from the survey were exported from Qualtrics survey software as a .csv file type and saved for retention as the raw dataset. The raw data were copied and imported into Microsoft Excel (Redmond, Washington)[190], a program suitable for data preparation and cleaning[191]. Within Excel, food literacy scores were computed and derived categorical variables were created for measures including the NVS-C and HFSSM. Demographic questions related to gender identity, living situation, and income source contained open-text response options if needed; open-text responses were reviewed and coded.

The resulting database was reviewed to identify records for exclusion. A stepwise process was used to exclude records based on respondent's progress in the survey module. Fifteen surveys were identified as not being complete and were excluded, as noted above. Missing data was also a focus of the data cleaning and preparation. Twenty-four variables had missing values. Ten of the 24 variables with missing data had more than one participant who provided no response. An item from the cooking self-efficacy attribute, CSE1_8, had the highest number of missing values (n=6). Overall, there was no discernable pattern in missing responses. Responses related to the question relating to studying in a food program had two missing values, and forty responded with "Prefer not to answer." The response in the screening questionnaire was used to substitute values. Due to the capability of the different statistical tests used in the analyses to handle missing data, decisions on how to address the missing values were made for each study and are presented in **Chapters 5 to 7**.

A final database containing the coded demographic variables, scoring, and derived categorical responses was saved for analysis.

Secondary (Development) Data

The secondary (development) data collected by researchers from the Dalla Lana School of Public Health at the University of Toronto who had previously worked with the LDCP team to develop the measure underwent thorough preparation prior to analysis. Initially, the shared databases were reviewed against the provided data dictionary to understand the information they contained. The retest data (from the test-retest study) were identified and copied to another datasheet (n=147). Only responses to the final 50-item version were retained. One record in the retest dataset was identified as incomplete and was removed, resulting in 146 records being included in the analysis from the retest phase (**Figure 6**). A similar process was used for the data from the confirmatory factor analysis phase of the previous study (n=226). Twenty-one incomplete records were excluded, leaving 205 records that were included in the combined analytic sample. The retest and confirmatory phase data were merged into a single datasheet for review before integration with the primary student data. Scores were calculated for attributes, domains, and food literacy overall. Alignment and consistency across question headers between the three data sets were checked, and items that were not part of the final FLit50 measure were deleted. This dataset was then combined with the student data resulting in an analytic sample of 808 for the study presented in **Chapter 6**.

4.4.2 Privacy and Data Storage

Completed survey data were downloaded from Qualtrics and stored on a secure server at the University of Waterloo. These data can only be accessed through password-protected folders and are available only to the investigators on the ethics application. Following the guidance for minimum data retention periods outlined via the University of Waterloo's Human Research Guidelines and Policies, data collected for this study will be stored for a minimum of seven years. Once obtained, the data collected from the University of Toronto were stored in the same location. The project tracking database contained the only identifying information (email addresses) collected in the study and was destroyed once data collection was completed.

As Qualtrics cannot determine the nature of the information in its custody, all information is treated as confidential and is secured through encrypted servers using TLS (Transport Layer Security), including for data at rest, and remains the customer's property (i.e., researcher). Survey information is only available to the survey author and those granted access by the author.

Any files used in third-party analysis software (described below) did not include participant-identifying information.

4.4.3 Statistical Software

The data were cleaned in Microsoft Excel[190] and imported into R Studio (Boston, Massachusetts, USA) for analysis[192]. R Studio is a free software that relies on the open-source R language.

4.5 Statistical Analysis

The primary analytic samples and statistical procedures used in each study are briefly presented below. Any further exclusions of data and expansions of procedures are detailed further in the methods sections of **Chapters 5 to 7**.

4.5.2 Chapter 5: The evaluation of construct validity of the FLit50 measure

The analysis in **Chapter 5** used tests based on Classical Test Theory (CTT) to evaluate the construct validity of the FLit50 measure. Kruskal-Wallis Analysis of Variance was used to assess differences in median scores among groups and group levels using a selection of variables collected. Specifically, known-group validity was evaluated to determine whether a difference existed between those who study in food and nutrition programs and those who do not, following the approach used in validating other measures of food literacy[21,169]. Kruskal-Wallis Analysis of Variance was used to assess construct validity through hypothesis testing derived from published literature[193,194] and theoretical assumptions. Several hypotheses were created a priori. The results were used to determine whether there was evidence that food literacy scores were different among levels of categorical variables. For variables with three or more group levels and for which the results from the Kruskal-Wallis analysis indicated differences in medians, pairwise comparisons were used to determine whether the differences in mean scores were patterned in the hypothesized directions. The same evaluations were made across the four food literacy domain scores to assess whether the items belonging to each domain demonstrated construct validity and could potentially be used as independent measurement modules.

4.5.3 Chapter 6: The development of a shortened measure and evaluation of construct validity

In **Chapter 6**, analytical methods based in IRT were used to evaluate the FLit50 measure items to inform the selection of items for inclusion in a shortened measure. Regular meetings between the research team and LDCP Healthy Eating Team were used to elicit insights into the goals, potential use cases, and requirements of and preferences for the short measure, including an appropriate length and the importance of the balance of the retained items across attributes. Two-parameter item response functions (IRF) were used to evaluate item characteristics with data from the two datasets (n=808). Item difficulty and discrimination parameters were returned, numerically and graphically, modelled on the scores attained at the attribute level[195]. Decisions about item inclusion in the shortened measure were made with consideration of both statistical indicators (i.e., IRT parameters) and the practical relevance of each item within its attribute through discussions with the LDCP Healthy Eating Team. The analyses were also performed at the domain and food literacy levels to ensure the items identified for discussion were suitable across all levels of the conceptual framework. The outcome of these discussions and decisions were 16 items selected to be included in the 16-item shortened measure (FLit16). Three methods of evaluating the FLit16 were used: the Spearman's rank correlation test to assess the direction and strength of the association between scores on the full and shortened measure using the combined dataset, Kruskal Wallis ANOVA with examination of pairwise comparisons following the hypotheses used to evaluate the validity of the full measure outlined in **Chapter 5** and using the student data only, and an IRT analysis of item characteristics and model fit using the combined dataset.

4.5.4 Chapter 7: Examination of student correlates of food literacy

In **Chapter 7** of this dissertation, regression analysis was used to explore associations between food literacy scores (measured using the FLit50) and student characteristics. Independent variables were selected to span demographic (age, gender identity, racial and ethnic identity), studentship (institution type, academic program, student and enrollment status), income adequacy, general and mental health status, and individual food security status. Before conducting the regression modeling, assumptions were systematically tested to validate the analytic techniques' appropriateness and inform adjustments. Inferences were based on the effect sizes and p-values, providing insights into correlates of food literacy within this sample of emerging adults.

4.6 Ethics Clearance

This study, including using the data from the University of Toronto, has been reviewed and received ethics clearance through the University of Waterloo Office of Research Ethics (ORE#43057). A copy of the ethics approval certificate can be found in **Appendix 6**.

4.7 Integrated Knowledge Translation

Collaboration with the LDCP Healthy Eating Team to share the results and implications of the research described in this thesis is ongoing. In addition to their co-authorship of the manuscripts prepared for submission and presented in **Chapters 5 to 7**, the Team has provided feedback on posters presented at national and international conferences, and the student researcher has supported the team in their dissemination, including presentations and posters. The student researcher is also participating in the planning of end-of-study knowledge translation, including webinars designed to reach public health practitioners from across the province.

A user guide (**Appendix 7**) for the measure was developed collaboratively for dissemination to public health researchers and practitioners. This guide details the history of the project, how the Flit50 and the 16-item shortened measure (FLit16) were developed, and the validation processes. The guide then advises on using the measures within public health practice and interpreting the results.

CHAPTER 5: CONSTRUCT VALIDITY OF A MULTI-DIMENSIONAL FOOD LITERACY MEASURE AMONG POST-SECONDARY STUDENTS IN ONTARIO, CANADA

Target Journal: Journal of the Academy of Nutrition and Dietetics

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M.H. and S.I.K. and the LDCP Healthy Eating Team designed the study and formulated the research questions. S.I.K. secured the funding through the LDCP Healthy Eating Team. M.H., M.Q., S.H., and S.I.K. coordinated data collection. M.H. prepared the dataset, conducted the analyses, and led the drafting of the manuscript. All authors provided critical feedback on the manuscript.

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Conflict of interest: none

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5.1 Overview

Background

The lack of a common and standardized measure of food literacy—the knowledge, skills, and self-efficacy to navigate food environments—has posed a barrier to understanding food literacy in Canadian public health contexts. Public health nutrition practitioners in Ontario, Canada developed a multidimensional measure of food literacy (Flit50) for use with young adults, with initial evaluation suggesting face and content validity, test-retest reliability, and factorial validity confirming underlying food literacy dimensions (i.e., domains). To be confident in using the measure to assess food literacy and guide public health practice, an evaluation of the construct validity of the measure was required.

Objective

The study evaluated the construct validity of a food literacy measure, including the domain scales, among postsecondary students through the assessment of differences in scores by enrollment in food and nutrition programs or not, gender identity, age, health literacy, income adequacy, general and mental health, and food security status.

Design

Cross-sectional food literacy and sociodemographic data were collected from a sample of post-secondary students.

Participants/setting

From March to May 2022, 457 students enrolled in university and college programs in Ontario, Canada, 116 of whom were students in food and nutrition programs, completed an online survey that included sociodemographic questions, the Flit50, the Newest Vital Signs-Canada (NVS-C) measure of health literacy, and the ten adult-referenced items from the Household Food Security Survey Module (HFSSM) modified to assess individual food security status over the past 12 months.

Statistical analyses

Kruskal-Wallis Analysis of Variance was used to assess differences in group median scores under hypotheses that higher food literacy scores would be found among those in food-related academic programs, those of higher age, women, those with higher health literacy, those with higher perceived income adequacy, those with higher self-rated general and mental health, and those who were food secure. Pairwise comparisons assessed differences in group means to determine the directionality of the differences. These analyses were conducted at the levels of the full FLit50 and the domains.

Results

The mean Flit50 score was 42 (SD=4.8) of 49 possible points, ranging from 25 (min) to 49 (max). Differences in median scores were observed between those in food and nutrition programs (n=116) vs. those who were not (n=341) ($p<0.001$) and gender identity ($p < 0.001$), as hypothesized. Differences in median scores were also observed by health literacy ($p < 0.001$), self-rated general ($p < 0.001$) and mental health ($p < 0.001$), and food security status ($p < 0.001$), and pairwise comparisons showed the differences were in the hypothesized directions. Differences in median scores were not observed by age ($p = 0.63$) or income adequacy ($p = 0.379$). Similar patterns were found for the items reflecting the food and nutrition knowledge and self-efficacy and confidence domains but not for the domains of food skills or ecological factors.

Conclusions

These findings suggest construct validity of the food literacy measure and the domains of food and nutrition knowledge and self-efficacy and confidence, and support the use of the measure with postsecondary students. Future work can investigate the measure's applicability across diverse populations and settings and develop and evaluate a shorter form of the food literacy measure to enable broader use.

Keywords: Food literacy, Measurement, Emerging adults, Validity, Public health nutrition

5.2 Introduction

Societal shifts related to the types of foods available to consumers[1], the abilities needed to get food onto tables[2], and opportunities to learn about food and practice cooking skills[3] are recognized as modern food system transitions. Over recent years, increasing attention has been paid to food literacy as a potential influence on food consumption and food-related practices[4]. Food literacy is a multi-dimensional construct encompassing the interconnected knowledge, skills, behaviour, and beliefs to navigate the food environment and meet nutrition and health needs[5].

Emerging adults, characterized as those 19 to 25 years of age[6], have been identified as a subgroup of interest concerning food literacy due to a decline in diet quality during late adolescence and early adulthood[7–9]. It is suggested that health practices developed at this age persist into adulthood[6,7,10], making it an ideal cohort for intervention[11,12]. Specific domains conceptualized as being part of food literacy, such as nutrition literacy[13–15], cooking skills[16–20], and confidence with food[21,22], are associated with food consumption patterns at this life stage. For example, greater cooking ability among adolescents has been associated with higher consumption of fruits and vegetables[23,24], preference for healthy food[25,26], and lower frequency of consumption of packaged or processed snacks[26,27]. Food skills and efficacy, referring to an individual's belief in their ability to successfully perform tasks related to food[28], have been linked with more frequent food preparation and more complex preparation steps, which have been associated with higher diet quality [21,22].

Despite growing interest, the lack of a standardized and well-evaluated measure to capture food literacy hampers understanding of its potential role in improving dietary practices and health[29]. Noted issues with assessments of food literacy are the variety of conceptualizations[30] and methods of measurement[31]. A review of tools used to measure food literacy published in 2018 noted the inconsistency in the constructs targeted, such as a focus on nutrition-related elements or food-related skills, the items included in the measure, and the lack of reported psychometric properties[31]. Similar findings were noted by Amouzandeh et al.[32], whose 2019 review of food literacy measures used in research focusing on adults revealed barriers to assessment of food literacy and the synthesis of findings due to the variety of conceptualizations underpinning food literacy, the measures used and items included, and the psychometric efforts to evaluate measures[32]. The variation in measures has highlighted the need for a conceptually strong and thoroughly evaluated tool to advance understanding of food literacy.

Based on qualitative research with young adults[3], a scoping review[33], and a Delphi study, a conceptual model (**Figure 7**) of food literacy was developed by a team of public health nutrition practitioners in Ontario, Canada[34]. A corresponding 50-item, multi-dimensional measure, called the FLit50, integrates items to capture ten attributes of food literacy. The measure is intended for use with youth (16 to 19 years of age) and young parents and young pregnant individuals (16 to 25 years of age), priority populations with respect to food literacy[3] and Public Health Ontario's Population Health Assessment and Surveillance Protocol (2018)[35]. The FLit50 is based on a conceptualization that is considered hierarchical. Food literacy is conceptualized as including ten specific attributes. Similar attributes form four domains (food and nutrition knowledge, food skills, self-efficacy and confidence, and ecological factors), presenting a more cohesive, interpretable, and practical framework for understanding different facets of food literacy than the ten attributes. At the top of this hierarchy, the domains combine to describe the overarching construct of food literacy. This tiered model recognizes the interconnected and multifaceted nature of food literacy and can facilitate a nuanced understanding of food literacy.

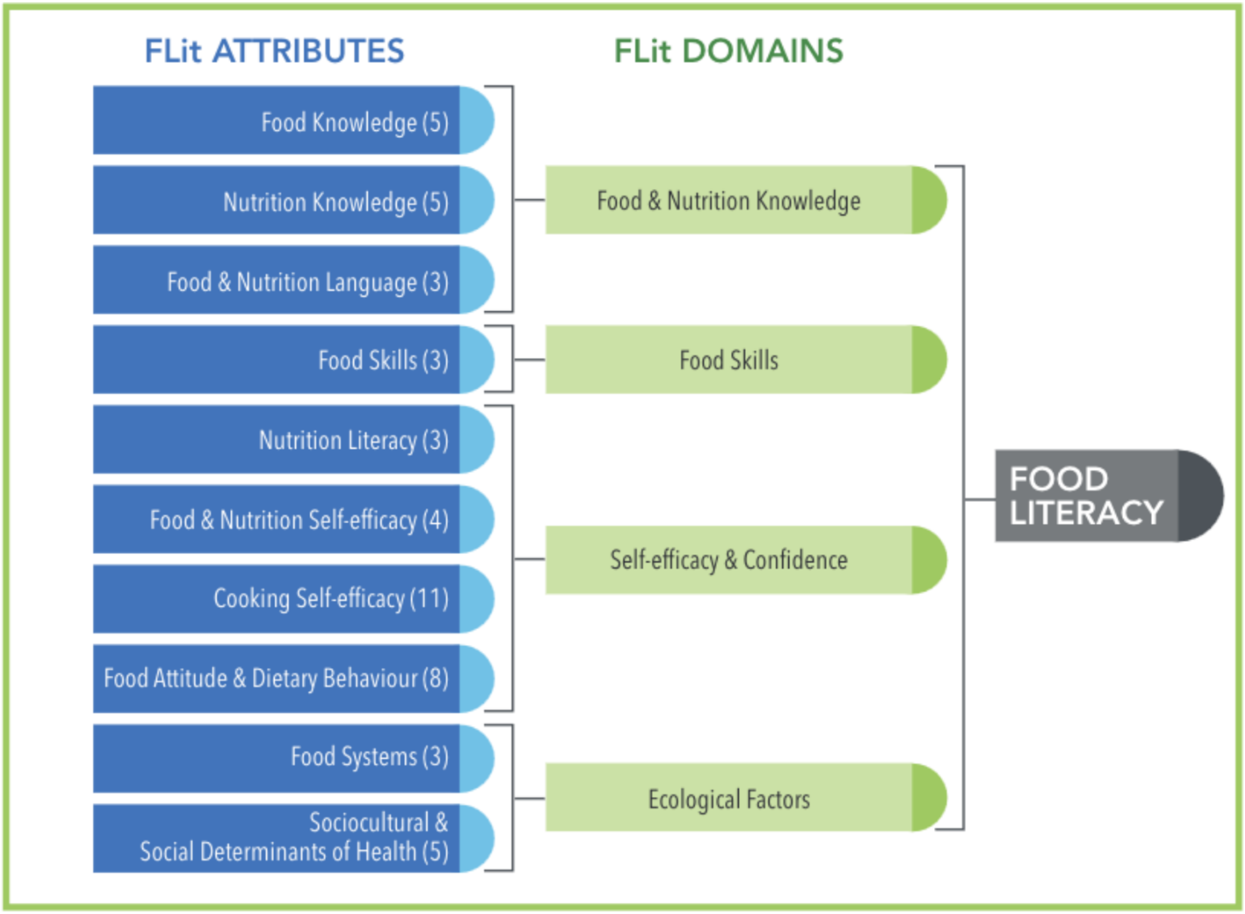


Figure 7: Conceptual model underlying the food literacy measure. Values in parentheses represent the number of items on the food literacy measure related to each reflective attribute and formative domains. Drawn from the Food Literacy (FLit) Measures Guide (Appendix 7).

Preliminary evaluations of the FLit50 measure among a sample of adults aged 16 to 25 years suggested satisfactory face, criterion, and content validity, along with test-retest reliability[34], with factor analysis confirming the presence of the attributes (i.e., factors) in the measure's design[34]. To further inform the use of the measure with young adults, an assessment of construct validity—the extent to which items in a measure reflect, and at what strength, the phenomena of interest[36]—is needed. There was also interest in determining whether the items reflecting the four domains can be used as stand-alone measures. This study aimed to evaluate the construct validity of the measure at the food literacy and domain levels among post-secondary students in Ontario, Canada.

5.3 Methods

Cross-sectional data were collected from a sample of post-secondary students from March to May 2022. Eligible participants were aged 18 to 25 years old and in their second year of study or above in a university or college in Ontario, Canada, and had a post-secondary institute-affiliated email address and an internet-enabled device to complete the survey. The study was reviewed and approved by the University of Waterloo Office of Research Ethics (ORE # 43057).

Sample Size Calculation

Sample size statistics (a priori) were calculated using GPower 3.1 (Dusseldorf, Netherlands)[37]. A priori calculations were centred on detecting a difference between groups considered to have different food literacy (students in food and nutrition programs vs. those enrolled in other programs), a comparison used in evaluating another food literacy measure[38]. Using a one-tailed t-test, a minimum sample of 176 respondents was needed (standardized (relative) effect size d = 0.5, alpha error probability = 0.05, power = 0.95). Available resources and the intention to use the data for additional analyses (e.g., assessing construct validity using other variables and evaluating items using Item Response Theory (IRT)) led to a target sample of 500 participants, aiming to recruit at least 100 students in food and nutrition programs. The final sample was 457 participants with 116 respondents in food- and nutrition-related programs.

Following data collection, post-hoc power analyses were conducted to assess the adequacy of the sample size for additional group comparisons. For the enrollment in food- and nutrition-related academic programs and gender variables (which were dichotomized for the analysis), the power of the sample was calculated with the specifications of a one-tailed t-test, and a standardized effect size d = 0.5, alpha error probability = 0.05, power = 0.95. For the multi-group variables, power calculations were conducted using Cohen's f (f = 0.5, $\alpha = 0.05$) to assess the effect size for comparisons across multiple groups. Due to the unequal group sizes in the collected data, the harmonic mean of the group sizes was used to provide an adjusted sample size that accounts for the unbalanced nature of the data and ensured that the power calculations more accurately reflected the ability to detect meaningful differences across the various categories. Overall, most group analyses were sufficiently powered, with power levels generally exceeding 0.99. However, certain subgroups had limited sample sizes that require cautious interpretation of results. Despite this, the overall analyses remain robust and reliable across most variables. Oversampling ensured a dataset that met the initial conservative estimates for detecting differences, particularly by mitigating issues related to small cell counts within certain subgroups and providing flexibility and enhanced power for subsequent analyses.

Sampling and Data Collection

Quota sampling was used to recruit students in food- or nutrition-related academic programs and those in non-food- or nutrition-related programs (e.g., business, engineering, mathematics). Participants were recruited via postings to social media platforms, including Twitter, Facebook, LinkedIn, and Reddit, with careful checks to prevent bogus participants (e.g., bots). Social media recruitment was supplemented by emails to administrators/faculty/student networks at some institutions requesting that they forward study information and invitation details via listservs. Interested participants were directed to a screening questionnaire to assess their eligibility and were required to provide an email address associated with a post-secondary institution. To avoid fraudulent survey completions, including by bots, eligible participants were sent personalized links to Qualtrics survey platform[39], where they were presented with the information letter and asked to consent before proceeding to the survey. The survey included sociodemographic questions, the Flit50, the Newest Vital Signs-Canada (NVS-C) measure of health literacy[40], and the ten adult-referenced items from the Household Food Security Survey Module (HFSSM)[41,42], modified to assess individual food security status over the past 12 months. Five attention check/data integrity questions were dispersed throughout the survey[43]. Participants received a $10 Interac transfer in appreciation for their time.

There were a total of 1226 completions or attempts of the screening questionnaire (**Figure 8**). Five hundred and forty-eight respondents met the study criteria and were invited to participate in the survey via their institutional email address. Two did not consent and were presented with an end-of-survey message. Four hundred and seventy-four individuals attempted the survey, reflecting a response conversion rate of 86%. Data from 15 participants were excluded due to incomplete data for the food literacy measure, completion times of less than seven minutes (based on one-third of the time to complete the FLit50 items in the test-phase from a previous evaluation of the measure of 11.2 mins[119] plus time to complete sociodemographic and additional survey questions), or incorrect responses to three or more of the five attention check/data integrity questions. In total, data from 457 participants were included in the analytic sample.

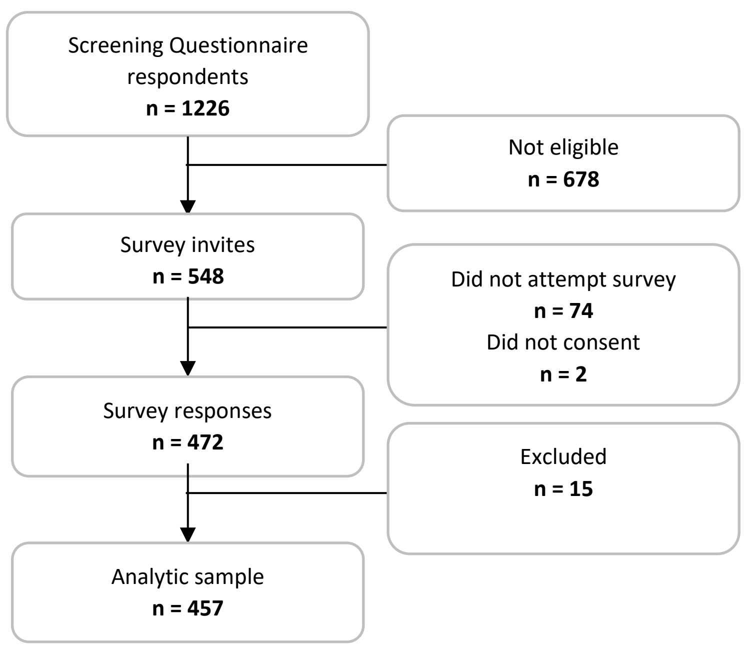


Figure 8: Chart showing overall participant flow to the analytic sample for a study to assess the construct validity of the FLit50 food literacy measure.

Variables

The FLit50 measure includes 19 multiple-choice questions reflecting the attributes of food knowledge, nutrition knowledge, food and nutrition language, food skills, and nutrition literacy. Fifteen items reflecting the attributes of nutrition self-efficacy and cooking self-efficacy require an indication of the level of confidence across four Likert scale response options (not confident to very confident), and 16 items assess the attributes of food attitude and dietary behaviours, food systems, and sociocultural and social determinants of health using a five-point agreement Likert scale (strongly disagree to strongly agree, with a neutral response option). While digitizing the survey into the Qualtrics platform, one item from the measure was unintentionally omitted, resulting in 49 items overall and seven rather than eight items within the food attitude and dietary behaviours attribute. The domains formed from the attributes are depicted in **Figure 7**, and the items making up the measure by attribute and domain are presented in **Appendix 1**.

Scoring for the FLit was in accordance with how the measure was designed[34], with one point assigned for a correct answer to the knowledge-based questions and one point given for an affirmative Likert scale response (i.e., responses that indicated agreement and confidence; disagreement or neutrality with the statement were awarded no points). The total food literacy score (score out of 49) and domain scores for food and nutrition knowledge (score out of 13), food skills (score out of 3), confidence and self-efficacy (score out of 25), and ecological factors (score out of 8) were treated as continuous variables for analyses. Analysis at the attribute level was avoided because the few items pertaining to each attribute limit capacity to categorize respondents precisely along a continuum of ability.

A question related to the academic program of study was used to categorize participants as belonging to a food- or nutrition-related program or not. Participants could select from common food and nutrition-related program names available in Ontario or type their program names in an open text box. These open-text responses were reviewed for accurate categorization of the food- or nutrition-related programs or not. In cases in which individuals indicated "prefer not to answer" to this question in the survey, their responses about whether they were in a food- or nutrition-related program ("yes", "no") on the eligibility screener were used.

Health literacy broadly encompasses the knowledge, skills, and confidence needed to make informed health-related decisions[44]. It includes understanding health information, navigating healthcare systems, and managing personal health[44]. Food literacy can be conceptualized as a sub-domain of health literacy. Both constructs involve skills such as critical thinking, decision-making, and the ability to apply knowledge in everyday life[45]. Individuals with higher health literacy may have higher food literacy as well. The Newest Vital Sign© (NVS) measure of health literacy has been used in evaluating the validity of other food literacy measures[46,47]. This study employed the Canadian adaptation, the NVS-C, which includes six items referencing a nutrition label[40]. The original NVS tool demonstrated criterion validity and reliability[48], and the Canadian adaptation demonstrated face validity with Health Canada experts[40]. Each question was scored as correct (1) or incorrect (0), and categorization of total scores was made in alignment with NVS guidance with a score of 0-1 suggesting a high likelihood (50% or more) of limited literacy, a score of 2-3 indicating the possibility of limited literacy, and a score of 4-6 almost always indicating adequate health literacy[40].

Sociodemographic characteristics of interest were based on associations with food literacy observed in other studies. There is evidence that higher age corresponds with higher food literacy levels[49]. As age increases, individuals will have had more opportunity and life experience to develop food literacy through the management of food-related tasks and are expected to have a higher food literacy score. Eight participants who did not report their age were not considered in relevant analyses.

There is also evidence of differences in food literacy in relation to gender identity, with women showing higher levels of food literacy[49,50]. These differences may be attributed to societal norms and expectations that position women as primary food preparers within households, increasing their exposure to food-related tasks and knowledge[51,52]. In contrast, men are generally less engaged with food literacy activities, particularly in younger age groups, and may rely more on convenience foods and be less likely to engage in cooking[53]. These assertions are supported by research showing that women report higher confidence in food planning, budgeting, and cooking skills[54]. It was therefore hypothesized that women would score higher on the food literacy measure compared to men. Individuals were asked, “What is your current gender identity?”. Trans-men and trans-women were grouped with men and women, respectively[55]. Eight respondents identifying as genderqueer/non-conforming were excluded from models using this variable as the cell size was too small for reliable analysis. Three who did not report their gender identity were also excluded from the relevant analyses.

Income adequacy has been suggested as a factor associated with food literacy[56,57]. Prohibitive income may not afford individuals opportunities to practice food literacy by purchasing food to meet health recommendations (acting on nutrition knowledge) or performing culinary exploration (developing skills and efficacy)[56]. Perceived income adequacy was assessed by asking participants, “Thinking about your total monthly income, how difficult is it for you to make ends meet?” with response options including very difficult, difficult, neither easy nor difficult, easy, very easy, don't know and prefer not to answer[58]. Nine respondents who indicated they did not know their income adequacy and thirteen who did not respond to this question were excluded from analyses using the perceived income adequacy variable.

Some research has suggested that those with lower food literacy experience higher food insecurity[59–61], though other studies examining associations between food insecurity and food and nutrition knowledge[62,63], skills[64], or efficacy[65] have not observed these associations[66]. Food security status over the past 12 months was assessed using the ten adult-referenced items from the Household Food Security Survey Module[67], developed by the US Department of Agriculture (USDA) to monitor food security within the US[42] and adopted by Health Canada for population surveillance[67]. Question text was altered to query individual experiences of food insecurity among adults over the previous 12 months[67].

Respondents were classified as food secure, marginally food insecure, moderately food insecure, and severely food insecure using cut-points from Health Canada[41].

The HFSSM is designed in a staged manner such that affirmative responses to some questions trigger further questions. Question AD5, which reads, “In the last 12 months, did you ever not eat for a whole day because there wasn't enough money for food?” is meant to be presented to participants who indicate a ‘yes’ response to *any* of the questions AD1 – AD4. AD5 was erroneously presented only to participants who responded ‘yes’ to *all* questions AD1 – AD4 in the survey. An affirmative response to question AD5 prompts a sub-question querying the frequency of not eating due to insufficient money for food. This affected the HFSSM scores of 66 of the 457 responses, who would have had the opportunity to identify further experiences of food insecurity if applicable. Of those 66, 48 respondents would have remained in their classification regardless of their responses to the AD5 and AD5b. The other 18 respondents had the potential to be reclassified from their current status as experiencing moderate food insecurity to severe food insecurity, depending on their responses. No adjustments were made to the classifications for the current analyses.

Qualitative research has suggested a positive association between food literacy and general and mental health[68,69]. To ascertain participants’ general health, a question asking, “In general, would you say your physical health is...?”, (five response options: poor to excellent)[70] was used. A similar question related to mental health was asked using the same response options[71]. Three respondents did not report their general health, and one did not report their mental health. These participants were excluded from analyses incorporating these health variables.

Statistical Analyses

The data were exported from Qualtrics survey software (Provo, Utah) to Microsoft Excel (Redmond, Washington)[72] for data cleaning and preparation before being imported to R Studio (Boston, Massachusetts)[73] for analyses. Descriptive statistics were generated to describe the sample and measures of central tendency and variability for food literacy and domain scores were calculated.

Construct validity of the full measure and domain scales was assessed by examining whether there were differences in FLit50 scores among sample sub-groups hypothesized to have differing levels of food literacy (i.e., known-group validity)[74] by comparing scores among students enrolled in food and nutrition programs vs. those not. Additional assessments of construct validity examined whether patterns of food literacy scores conformed with established theoretical predictions or documented findings from existing research literature[75]. Here, food literacy scores were hypothesized to be higher by categorical levels of specific demographic characteristics, self-reported health, health literacy, and food insecurity (**Table 2**).

Table 2: Hypotheses evaluated at the food literacy and domain levels using Kruskal-Wallis Analysis of Variance (ANOVA).

Variable	Hypothesis
Food program	Food and nutrition students will score higher in food literacy and domain scores than non-food and nutrition students.
Age	With higher age, food literacy and domain scores will be higher.
Gender identity	Individuals identifying as women will score higher on the full food literacy measure and for the domains than men.
Health literacy	Individuals with higher scores in food literacy and domain scores will have higher health literacy scores.
Income adequacy	Individuals with adequate financial resources will have higher food literacy and domain scores.
Food security status	Individuals experiencing food security will have higher food literacy and domain scores.
General health	Individuals with better self-rated general health will have higher food literacy and domain scores.
Mental health	Individuals with better self-rated mental health status will have higher food literacy and domain scores.

Tests of the data distribution indicated that the food literacy scores were not distributed normally (Shapiro-Wilk $W = 0.952$, $p < 0.01$) and were highly negatively skewed (skewness = -0.79) (**Figure 9**). Consequently, the Kruskal-Wallis Analysis of Variance (ANOVA), a non-parametric test, was employed to assess differences in median scores across various group levels of sociodemographic characteristics, self-reported health status, health literacy, and food security status.

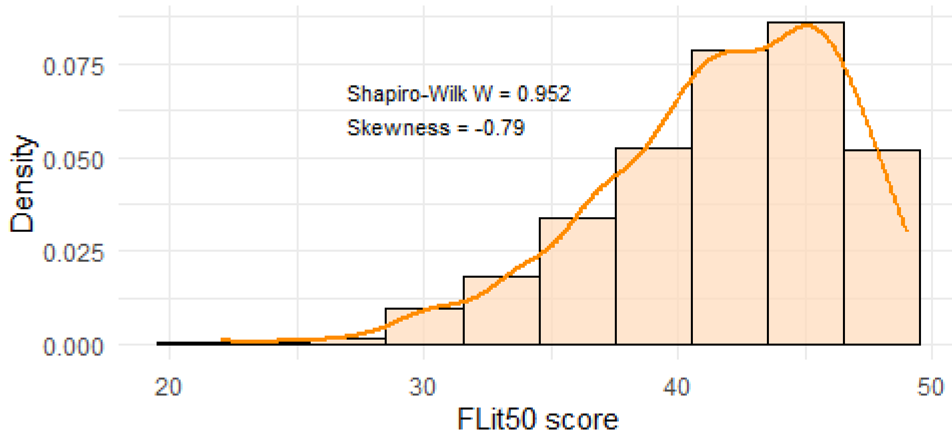


Figure 9: Distribution of food literacy scores using the FLit50 with density overlay.

While the Kruskal-Wallis ANOVA provided an initial assessment of differences in medians, subsequent pairwise comparisons were conducted using Dunn's test, with Bonferroni adjustments to correct for multiple comparisons. The tests were focused on evaluating the differences in mean scores among groups. This approach was chosen instead of linear regression to capture nuanced insights into group differences, which might be overlooked with a strictly monotonic analysis.

To address concerns about varying sample sizes of groups potentially affecting results (e.g., n=103 and n=343 for men and women, respectively), examinations included calculating Minimum Detectable Differences (MDD), confidence intervals, and relative effect sizes of standard deviation. MDD calculations used a power level of 0.80, ensuring an 80% probability of detecting true effects, and a 95% confidence level to provide high certainty in estimating differences. This multi-step process allowed for assessments of the hypotheses, highlighting the directionality and magnitude of differences in the data.

At the domain level, similar patterns of non-normality were observed (**Figure 10**), and the same statistical procedures were applied to scores of each domain.

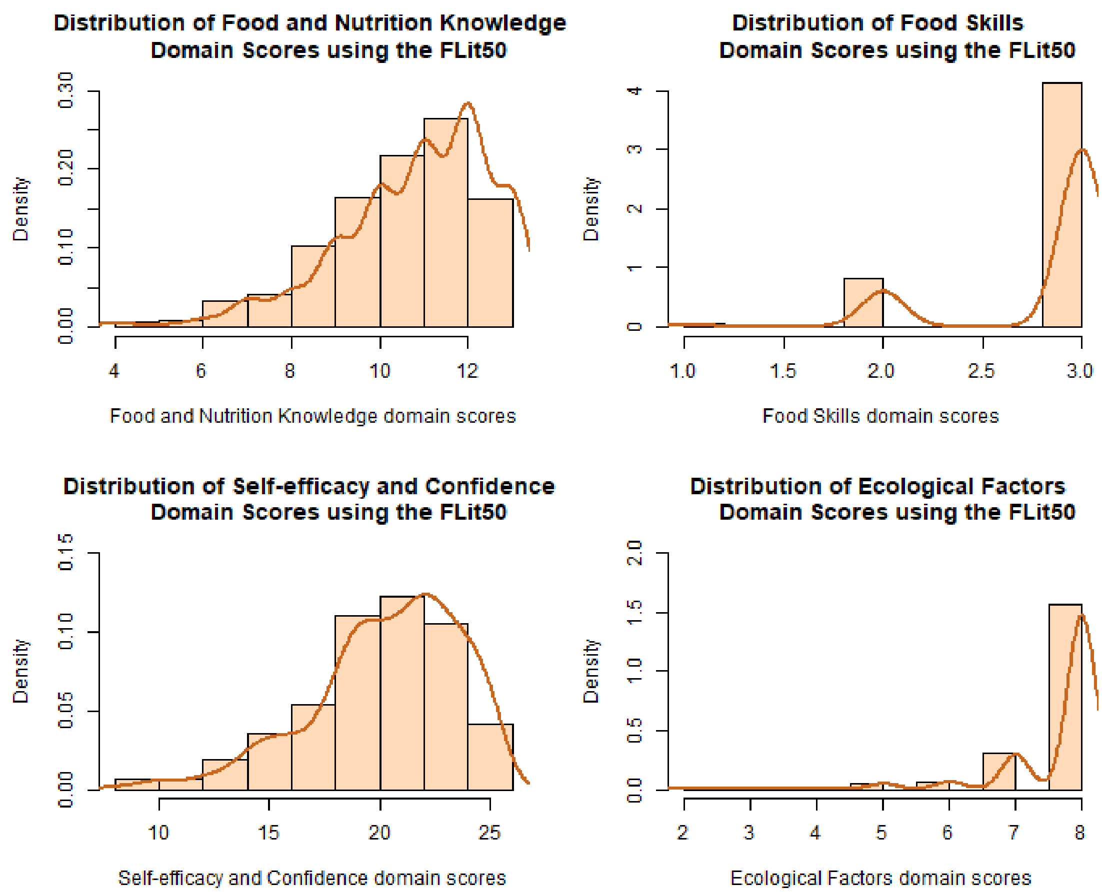


Figure 10: Distribution of food literacy domain scores with density overlays.

5.4 Results

The median age of participants was 21 years (SD = 1.75) (**Table 3**). Twenty-five percent of respondents (n=116) were enrolled in food and nutrition-related programs, and 75% (n=341) were enrolled in other academic programs. Seventy-five percent identified as women/trans women, and 23% identified as men/trans men. Forty percent of participants identified as White (European descent), 24% as East/Southeast Asian, and 20% as South Asian. Eighty-eight percent had adequate health literacy. For perceived income adequacy, 37% of respondents reported that it was very difficult or difficult to make ends meet each month (16% and 21%, respectively), and 44% reported it was neither easy nor difficult. The highest proportion of respondents self-reported their general health as good (38%), with very good

(26%) and fair (25%) being the next most reported. Twenty-one percent of individuals rated their mental health as poor, 30% as fair, 33% as good, and 14% as very good. Sixty percent of respondents were categorized as being food secure.

Table 3: Sociodemographic and health-related characteristics of post-secondary students in Ontario, Canada (n=457) who participated in a study to assess the construct validity of a food literacy measure.

Sample characteristic	Total sample (n=457)		Food & Nutrition Students (n=116)		Other Students (n=341)
	n (%)		n (%)		n (%)
Gender identity					
Man	103 (23%)		12 (10%)		91 (27%)
Women	343 (75)		104 (90)		239 (70)
Gender queer/gender non-conforming	8 (2)		0 (0)		8 (2)
Different identity	3 (1)		0 (0)		3 (1)
Age					
18	5 (1%)		1 (1%)		4 (1%)
19	76 (17)		18 (16)		58 (17)
20	96 (21)		20 (17)		76 (22)
21	110 (24)		34 (29)		76 (22)
22	64 (14)		21 (18)		43 (13)
23	46 (10)		11 (9)		35 (10)
24	18 (4)		3 (3)		15 (4)
25	34 (7)		6 (5)		28 (8)
Age not reported	8 (2)		2 (2)		6 (2)
Racial/Ethnic Identity					

Black (African, Afro-Caribbean, African-Canadian descent)	14 (3%)		2 (2%)		12 (4%)
East/Southeast Asian (Chinese, Korean, Japanese, Taiwanese descent; Filipino, Vietnamese, Cambodian, Thai, Indonesian, other Southeast Asian descent)	110 (24)		20 (17)		90 (26)
Indigenous (First Nations, Métis, Inuit descent)	1 (0)		1 (1)		0 (0)
Latino (Latin American, Hispanic descent)	5 (1)		0 (0)		5 (1)
Middle Eastern (Arab, Persian, West Asian descent, e.g., Afghan, Egyptian, Iranian, Lebanese, Turkish, Kurdish, etc.)	21 (5)		6 (5)		15 (4)
South Asian (South Asian descent, e.g., East Indian, Pakistani, Bangladeshi, Sri Lankan, Indo-Caribbean etc.)	93 (20)		12 (10)		81 (24)
White (European descent)	181 (40)		69 (59)		112 (33)
Other	4 (1)		0 (0)		4 (1)
Mixed racial/ethnic identity	27 (6)		6 (5)		21 (6)
Health literacy					
High likelihood of limited literacy	5 (1%)		1 (1%)		4 (1%)
Possibility of limited literacy	51 (11)		9 (8)		42 (12)
Adequate health literacy	401 (88)		106 (91)		295 (87)
Perceived income adequacy					
Very difficult	71 (16%)		19 (16%)		52 (15%)
Difficult	95 (21)		21 (18)		74 (22)
Neither easy nor difficult	200 (44)		50 (43)		150 (44)
Easy	58 (13)		18 (16)		40 (12)
Very easy	11 (2)		2 (2)		9 (3)

Don't know	9 (4)		4 (3)		5 (1)
Prefer not to say	13 (3)		2 (2)		11 (11)
Self-reported physical health					
Poor	23 (5%)		1 (1%)		22 (6%)
Fair	116 (25)		18 (16)		98 (29)
Good	172 (38)		49 (42)		123 (36)
Very good	121 (26)		41 (35)		80 (23)
Excellent	22 (5)		6 (5)		16 (5)
Don't Know	3 (1)		1 (1)		2 (1)
Self-reported mental health					
Poor	94 (21%)		22 (19%)		72 (21%)
Fair	139 (30)		27 (23)		112 (33)
Good	149 (33)		52 (45)		97 (28)
Very good	64 (14)		12 (10)		52 (15)
Excellent	10 (2)		3 (3)		7 (2)
Don't Know	1 (0)		0 (0)		1 (0)
Food security status					
Food secure	273 (60%)		82 (71%)		191 (56%)
Marginal food insecurity	67 (15)		8 (7)		59 (17)
Moderate food insecurity	71 (16)		14 (12)		57 (17)
Severe food insecurity	46 (10)		12 (10)		34 (10)

The mean and median food literacy score was 42 (SD = 4.8, interquartile range (IQR) = 6), and scores ranged from 22 to 49. There was evidence of higher median food literacy scores among students in food and nutrition programs (median = 46, IQR = 3) versus those in other programs (median = 41, IQR = 6) (Kruskal-Wallis χ^2 = 108, p < 0.001) (**Table 4**). The median score was higher among women (median = 43, IQR = 6) compared to men (median = 39, IQR = 6) (Kruskal-Wallis χ^2 = 49.2, p < 0.001).

Table 4: **Comparative analysis of mean and median food literacy scores among different demographic groups using the Kruskal-Wallis Test.**

Characteristic	n (%)	Mean FLit50 Score (SD)	Median Flit50 score (IQR)	df	KW statistic	p values[1]
Food Program	**457**	**42 (4.8)**	**42 (6)**	**1**	**108**	**< 0.001**
Yes	116 (25%)	45.1 (4.0)	46 (3)			
No	341 (75)	40.5 (4.4)	41 (6)			
Gender[2]	**446**	**42 (4.8)**	**42 (6)**	**1**	**49.2**	**< 0.001**
Man	103 (23%)	39 (4.6)	39 (6)			
Women	343 (75)	42.6 (4.5)	43 (6)			
Age[3]	**449**	**42 (4.8)**	**42 (6)**	**7**	**5.24**	**0.63**
18	5 (1%)	43.4 (6.1)	45 (2)			
19	76 (17)	41.3 (5.2)	42 (6.25)			
20	96 (21)	41 (4.9)	42 (6)			
21	110 (24)	42.2 (4.6)	42 (7)			
22	64 (14)	42.1 (4.8)	43 (7)			
23	46 (10)	41.7 (4.7)	42 (6.75)			
24	18 (4)	41.4 (4.0)	42 (6)			
25	34 (7)	42 (4.8)	43 (4.75)			
Health literacy	**457**	**42 (4.8)**	**42 (6)**	**2**	**20.6**	**< 0.001**
High likelihood of limited literacy	5 (1%)	38 (1.6)	38 (2)			
Possibility of limited literacy	51 (11)	38.9 (5.6)	40 (9)			
Adequate health literacy	401 (88)	42.1 (4.6)	43 (7)			
Perceived income adequacy[4]	**435**	**42 (4.8)**	**42 (6)**	**4**	**4.21**	**0.379**
Very difficult	71 (16%)	42.6 (4.4)	43 (6)			
Difficult	95 (21)	41.3 (4.8)	42 (7)			
Neither easy nor difficult	200 (44)	41.7 (4.7)	42 (6)			
Easy	58 (13)	41.4 (5.2)	41 (6)			
Very easy	11 (2)	40 (6.2)	42 (7.5)			
General health[5]	**454**	**42 (4.7)**	**42 (6)**	**4**	**49.5**	**< 0.001**
Poor	23 (5%)	38 (5.52)	38 (7.5)			
Fair	116 (25)	39.9 (4.8)	40 (6.25)			

Good	172 (38)	42.2 (4.4)	43 (5)			
Very good	121 (26)	43.3 (4.0)	44 (5)			
Excellent	22 (5)	44.2 (3.5)	44.5 (6)			
Mental health[6]	**456**	**42 (4.8)**	**42 (6)**	**4**	**17.4**	**< 0.001**
Poor	94 (21%)	40.8 (5.2)	41 (8)			
Fair	139 (30)	40.9 (4.7)	42 (5.5)			
Good	149 (33)	42.8 (4.6)	44 (6)			
Very good	64 (14)	42.4 (4.3)	43 (6)			
Excellent	10 (2)	42.6 (4.1)	42 (6.25)			
Food security level	**457**	**42 (4.8)**	**42 (6)**	**3**	**21.9**	**< 0.001**
Food secure	273 (60%)	42.5 (4.4)	43 (6)			
Marginal food insecurity	67 (15)	41 (4.5)	42 (6)			
Moderate food insecurity	71 (16)	39.8 (5.5)	41 (8)			
Severe food insecurity	46 (10)	40.9 (5.0)	42 (6.75)			

1 - P values were derived using one-way Kruskal-Wallis Analysis of Variance (ANOVA) after the Shapiro-Wilk normality test provided evidence of non-parametricity in the data
2 - Eight individuals were not included because they identified as genderqueer/gender non-conforming, and three were not included as they did not report their gender identity
3 - Eight individuals were not included because they preferred not to report their age
4 - In response to the question, "How difficult is it for you to make ends meet?" nine individuals were not included because they did not know income adequacy, and thirteen did not report
5 - Three individuals were not included because they did not report general health status.
6 - One individual was not included because they did not report mental health status.

The analysis indicates that differences in health literacy scores are associated with food literacy scores, supporting the hypothesis. Specifically, individuals with adequate health literacy have a significantly higher median food literacy score (43, IQR = 7) compared to those with the possibility of limited health literacy (40, IQR = 5). The mean food literacy score for individuals with adequate health literacy was 42.1 (SD = 4.6), while it was 40.2 (SD = 3.6) for those with the possibility of limited health literacy (Dunn's test statistic = 2.83, *p.adj* = 0.01), with a difference in means of -1.9 (MDD = 1.26, CI = [-3.39, -0.62], $\varepsilon^2 = 0.004$)(**Appendix 8, Supplemental Table 1**). These findings are consistent with the literature on health literacy, suggesting that individuals with lower health literacy are more likely to have lower food literacy as well. Although individuals with a high likelihood of limited health literacy also had lower food literacy scores (median = 38, IQR = 2), the small sample size in this group (n=5) may limit the precision of this finding. Nonetheless, the direction of the difference aligns with expectations.

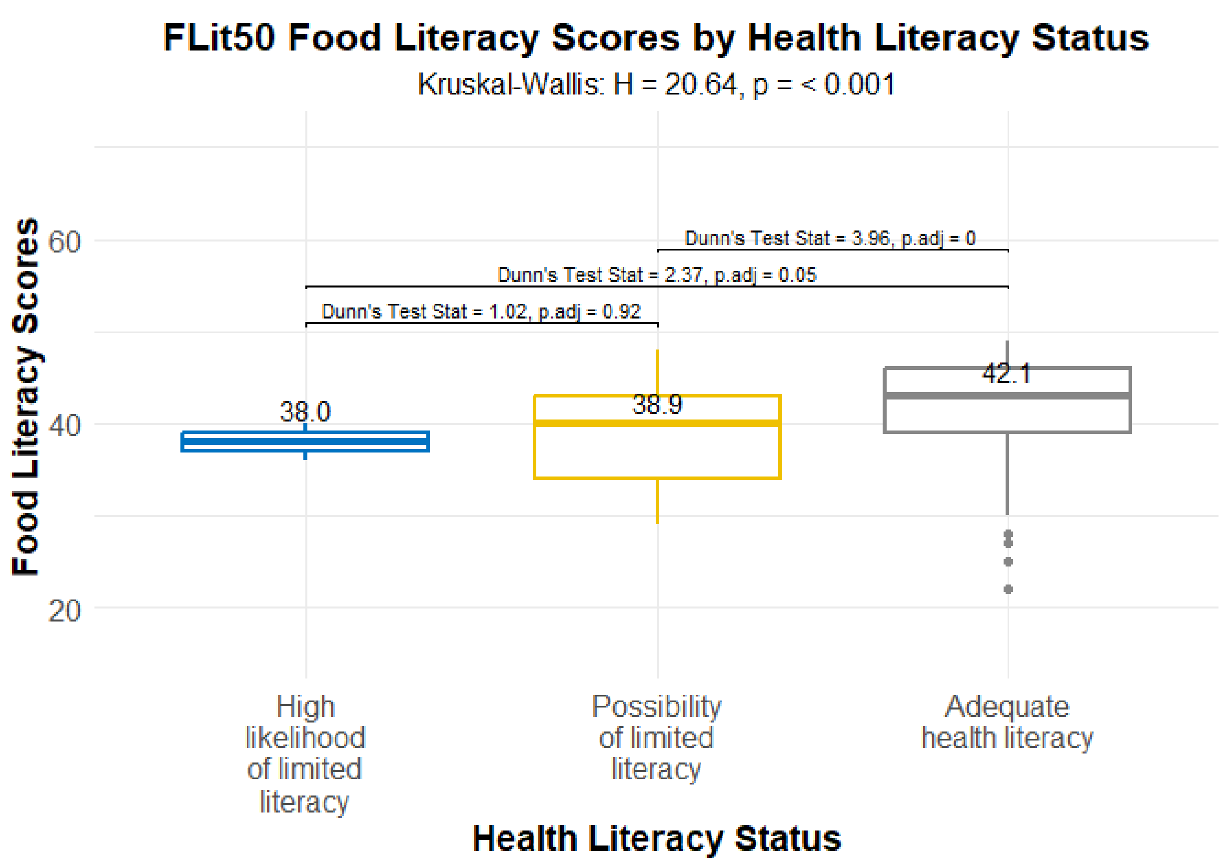
Differences in food literacy scores were observed across general health categories, with trends in the hypothesized direction. Specifically, individuals reporting fair health had lower food literacy scores (median = 40, IQR = 6.25, mean = 39.9, SD = 4.8) compared to those reporting good health (median = 43, IQR = 5, mean = 42.2, SD = 4.4) (Dunn's test statistic = 4.01, *p.adj* < 0.001, MDD = 1.09, CI = [-3.33, -1.14], $\varepsilon^2 = 0.014$). Similarly, those reporting good health had lower scores than those reporting very good health (median = 44, IQR = 5, mean = 43.3, SD = 4.0) (Dunn's test statistic = 2.0, *p.adj* = 0.45, MDD = 0.97, CI = [-2.04, -0.1], $\varepsilon^2 = 0.007$). Although individuals reporting poor health had lower food literacy scores (median = 38, IQR = 7.5, mean = 38, SD = 5.2) and those reporting excellent health had higher scores (median = 44.5, IQR = 6, mean = 44.2, SD = 3.5), the small sample sizes in these groups limits the precision in describing differences between these and other groups. Nevertheless, the overall trend supports the hypothesis that better general health is associated with higher food literacy scores.

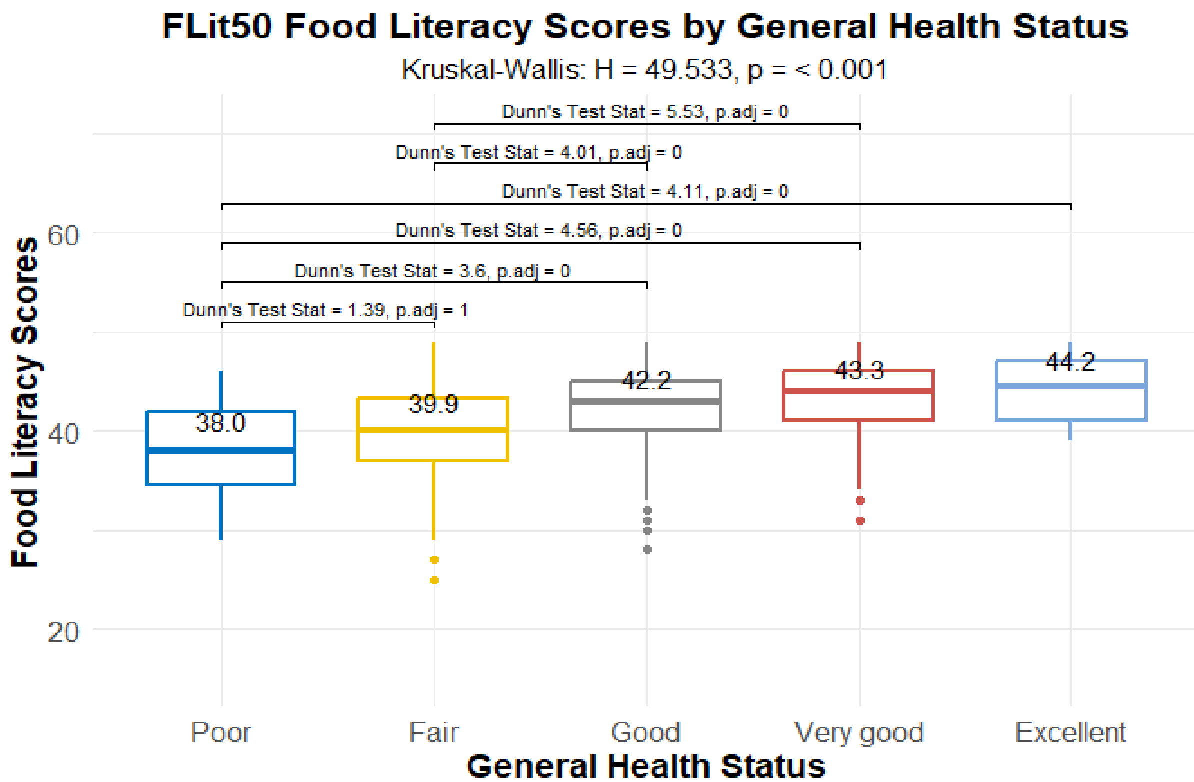
Differences in median food literacy scores were observed in relation to self-reported mental health (Kruskal-Wallis $\chi^2 = 17.4$, $p < 0.001$), with median scores ranging from 41 (IQR = 8) among those indicating poor mental health to 44 (IQR = 6) among those reporting good mental health. The mean food literacy score for individuals reporting good mental health was 42.8 (SD = 4.6), while it was 40.8 (SD = 5.2) for those reporting poor mental health (Dunn's test = 3.1, *p.adj* = 0.013) for a difference of 2.0 (MDD = 1.28, CI = [-3.26, -0.71], $\varepsilon^2 = 0.013$). However, this pattern did not continue at higher levels of mental health status, with mean scores of 42.4 (SD = 4.3) and 42.6 (SD = 4.1) for very good and excellent. It should be noted that the group reporting excellent mental health had a considerably smaller sample size (n=10) than the other groups, which may limit the reliability of findings for this category.

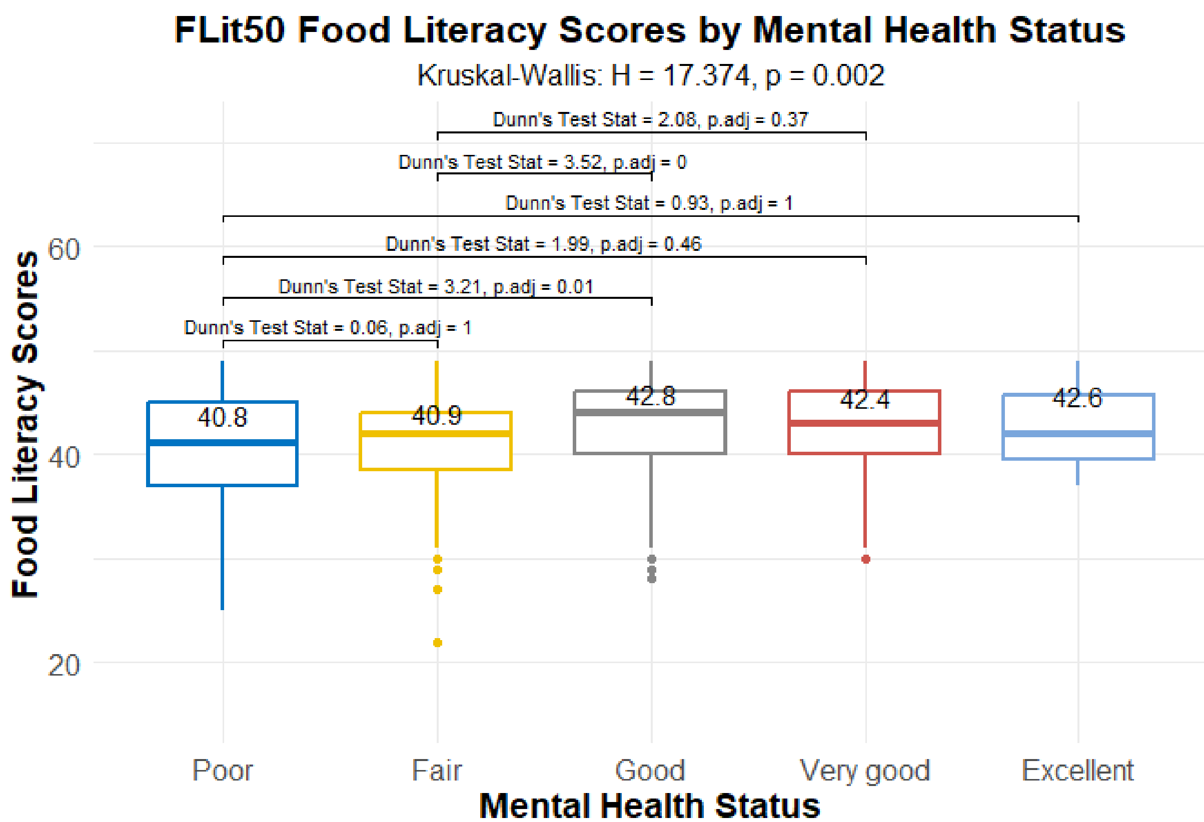
Individuals experiencing food security over the past 12 months had higher food literacy scores compared to those experiencing marginal and moderate food insecurity. The median food literacy score for food-secure individuals was 43 (IQR = 6), while it was 41 (IQR = 8) for those experiencing moderate food insecurity. The mean scores were 42.5 (SD = 4.4) and 39.8 (SD = 5.5), respectively (Dunn's test = -4.07, *p.adj* < 0.001). The calculated difference in means was 2.77 (MDD = 1.38, CI = [1.39, 4.16]), with small differences and effect sizes (ε^2 = -0.012).

No differences in food literacy scores were observed by age (KW $\chi 2$ = 5.24, *p* = 0.63) or perceived income adequacy (KW $\chi 2$ = 4.21, *p* = 0.38).

The detailed results for the pairwise comparisons can be found in **Appendix 8, Supplemental Table 1**. Graphical representations of the differences for the variables with significant differences at *P*<0.001 and three or more categories—health literacy, general health, mental health, and food security status—are displayed in **Figure 11**.




FLit50 Food Literacy Scores by General Health Status
Kruskal-Wallis: H = 49.533, p = < 0.001
Dunn's Test Stat = 5.53, p.adj = 0
Dunn's Test Stat = 4.01, p.adj = 0
Dunn's Test Stat = 4.11, p.adj = 0
Dunn's Test Stat = 4.56, p.adj = 0
Dunn's Test Stat = 3.6, p.adj = 0
Dunn's Test Stat = 1.39, p.adj = 1
38.0
39.9
42.2
43.3
44.2
Food Literacy Scores
60
40
20
Poor
Fair
Good
Very good
Excellent
General Health Status


FLit50 Food Literacy Scores by Mental Health Status
Kruskal-Wallis: H = 17.374, p = 0.002
Dunn's Test Stat = 2.08, p.adj = 0.37
Dunn's Test Stat = 3.52, p.adj = 0
Dunn's Test Stat = 0.93, p.adj = 1
Dunn's Test Stat = 1.99, p.adj = 0.46
Dunn's Test Stat = 3.21, p.adj = 0.01
Dunn's Test Stat = 0.06, p.adj = 1
40.8
40.9
42.8
42.4
42.6
Food Literacy Scores
60
40
20
Poor
Fair
Good
Very good
Excellent
Mental Health Status

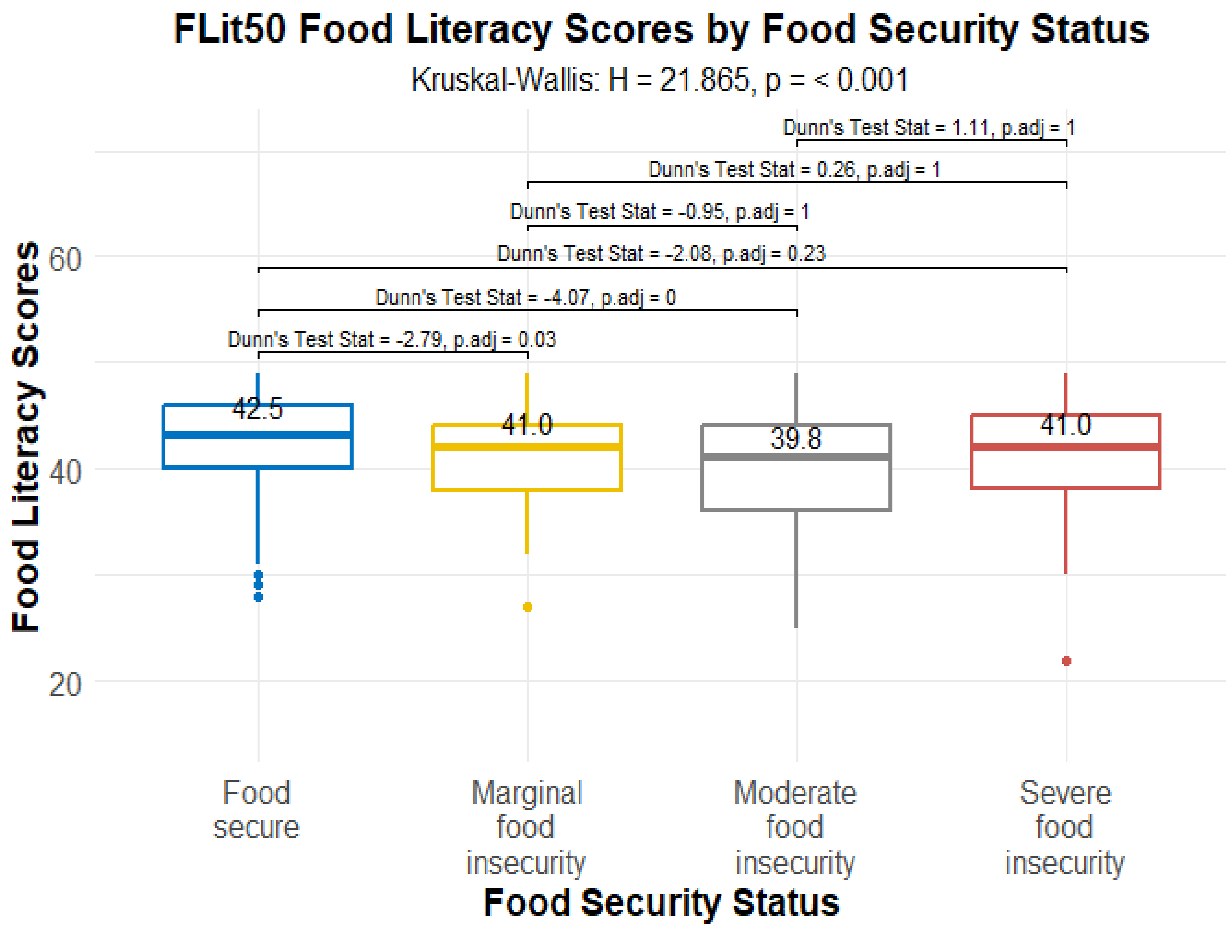


Figure 11: Box plots illustrating pairwise comparisons of food literacy scores using Dunn's test and Bonferroni corrections for variables with significant differences in medians by Kruskal-Wallis ANOVA and three or more group levels.

At the food literacy domain level, scores were highly negatively skewed, with a large proportion of respondents receiving high or maximum points, particularly in the domains of food skills (mean score = 2.8 /3) and ecological factors (mean score = 7.7/8).

Evidence of differences in median scores between students in food and nutrition programs versus those in other programs was found in the domains of food and nutrition knowledge (KW $\chi 2$ = 76.4, $p < 0.001$) and self-efficacy and confidence (KW $\chi 2$ = 100, $p < 0.001$). No significant differences were observed in the domains of food skills (KW $\chi 2$ = 0.143, p = 0.71) and ecological factors (KW $\chi 2$ =

2.04, p = 0.16) (**Appendix 8, Supplemental Table 2**). Women consistently scored higher than men across all domains.

Pairwise comparisons revealed specific differences supporting the hypotheses. In the domain of food and nutrition knowledge, differences were observed for health literacy, with higher scores among individuals with adequate literacy compared to those with the possibility of limited literacy (difference in means = -1.41, MDD = 0.57, CI = [-1.97, -0.84], ε^2= 0.011). For general health, scores were higher for those reporting excellent health compared to poor health (difference in means = -2.15, MDD = 1.06, CI = [-3.21, -1.09], ε^2= 0.084). In terms of food security status, individuals experiencing food security scored higher than those experiencing moderate food insecurity (difference in means = 1.02, MDD = 0.48, CI = [0.54, 1.5], ε^2= -0.012). No differences in scores for the domain of food and nutrition knowledge were found by age, income adequacy, or mental health status.

In the domain of self-efficacy and confidence, similar patterns were observed. Differences were noted by food program (KW $\chi2$ = 0.143, p = 0.71), gender (KW $\chi2$ = 0.143, p = 0.71), and general health status, with the most pronounced difference between those reporting fair and excellent health (difference in means = -3.22, MDD = 1.16, CI = [-4.39, -2.06], ε^2= -0.03). Small differences were found between some groups by mental health status and individual food security status. No differences in scores (median or mean) were observed across any domain by income adequacy levels.

The detailed results for the pairwise comparisons at the food literacy domain level can be found in **Appendix 8, Supplemental Table 3**.

5.5 Discussion

The findings indicate that the FLit50 exhibits construct validity for use among post-secondary students, demonstrated through its ability to differentiate among groups hypothesized to have different levels of food literacy. Two of the four domains—food and nutrition knowledge and self-efficacy and confidence—showed evidence of construct validity, providing confidence for their use as stand-alone modules. This was not the case for the food skills and ecological factors domains.

Food literacy remains an underexplored area, and the diversity in how food literacy is defined and the heterogeneity of study populations in research make it difficult to make comparisons across studies. Nonetheless, there is a growing base of research that provides a framework within which the results of the current study can be situated. A notable finding from this study is the pronounced disparity in food literacy scores based on the academic discipline, particularly when comparing students with academic training in food and nutrition programs to those from other fields. This finding aligns with evaluations of the validity of other emerging food literacy measures using known groups, such as those examining the Eating and Food Literacy Behaviors Questionnaire (EFLBQ)[38] and work by Poelman and colleagues assessing the SPFL[76]. Women were found to score higher in food literacy and in each domain, aligning with our hypothesis. These findings resembled those of other studies that found elements of food literacy, such as food and nutrition knowledge, were higher among women[46,77,78]. Individuals scoring higher in food literacy also had higher levels of health literacy. These findings align with those of other studies that examined associations with health literacy, and in particular, those using the NVS tool to evaluate food literacy measures[79–82].

The relationship between self-reported general and mental health is a rarely studied topic, though Palumbo[69] has encouraged its study. When it has been studied, it has been shown that people with better food literacy were less likely to self-report poor health status[46] and improvement in food literacy post-intervention has led to improvements in self-reported general and mental health[83]. The hypothesis that individuals experiencing food insecurity would have a lower food literacy score was borne out by the analysis. However, the differences in scores were minimal. Several studies have found differences in food literacy between food-secure and food-insecure individuals,[59,60] which informed the hypothesis. However, food insecurity status is acknowledged to stem from financial insecurity[57], making the link between food literacy and food insecurity indirect. It has been suggested that higher food literacy may indirectly mitigate challenges related to inadequate income[56,84], potentially explaining the lack of differences in food literacy scores by income adequacy. Other research suggests that income adequacy is associated with different domains of food literacy, including planning and management, shopping, preparation, and cooking[60]. It is also possible that differences were not observed by perceived income adequacy because the income spread among students is likely relatively small. Differences in food literacy scores by age were not found in this study, contrary to the hypothesis. It is possible that the age range (18 – 25 years old) was not sufficient to detect differences.

The rising interest in food literacy underscores the critical need for reliable and valid tools for its assessment. Two recent reviews of the psychometric properties of available measures have been conducted[31,32], with both highlighting the inconsistency in methodological rigour and the lack of multidimensional, psychometrically validated tools in the field of food literacy. The field faces challenges due to the wide array of definitions, the diversity in measurement approaches, and the variability in approaches to assessing these tools' psychometric strengths[31,32]. Both reviews identified that a minority of papers reported on construct validity[31,32]. Of the reviewed measures, only two were based on an underlying multi-dimensional conceptual framework[68,85]. A strength of this research is the application of suggestions made in these reviews[31,32], such as employing a food literacy measure with a solid conceptual foundation and conducting psychometric evaluation and reporting using standard practices. This study follows previous work by employing common methods for assessing food literacy, such as analyzing differences across known groups related to academic program[38,76], comparisons with health literacy scores[80–82,86], and hypothesis testing involving demographic factors[85,87,88]. The lack of a universally accepted 'gold standard' for measuring food literacy further emphasizes the importance of rigorous evaluations of psychometric properties to advance the field.

By targeting the emerging adult population, this research addresses a key gap in the literature and provides insights that can inform targeted interventions. The focus on students in Ontario ensures that findings are highly relevant to the province's specific cultural and policy environment. These strengths, coupled with the involvement of the LDCP Healthy Eating Team as partners, bolster confidence in the measure's validity and underscores its potential contribution to public health practice.

The results of the analyses provide evidence of the construct validity of the FLit50 measure. However, the effect sizes observed in this study were generally small, as indicated by the epsilon squared (ε^2) values reported. This suggests that while differences were detected among groups, the practical significance of these differences may be limited. The small effect sizes could be attributed to the high median food literacy scores (42 out of 49) and the relatively low standard deviation of scores. In contexts in which the overall scores are high and the variability is low, even small differences can have low p-values without necessarily indicating substantial practical differences[89]. Despite the small effect sizes, the differences provide valuable insights into patterns of food literacy across different demographic and health-related variables. Small effect sizes do not diminish the relevance of the observed differences but rather, highlight the need for nuanced interpretation in the context of high baseline scores[90].

The high scores observed may be explained by the sample composition. The sample population of post-secondary students is a sub-set of young adults, the demographic for whom the measure was developed. It may be that post-secondary students have food-related advantages, such as education level and experiences with food education and independent living, that those with less social positioning may not. Further research with samples beyond post-secondary students may return less skewed data and provide a more accurate depiction of food literacy status among the general population. Sampling bias may have elicited participation from those who are interested in food and who may exhibit high levels of food literacy. The high scores and low variability may also stem from the measure's design. High scores were also observed during the measure's development phases with a pan-Canadian sample indicating that the questions may not be overly challenging[34]. Future efforts to examine item-level characteristics can identify questions that do not offer substantial value to the measure and these can be removed or revised[91]. The scoring scheme may also contribute to the high scores, with any affirmative responses on polytomous scaled items (i.e., agreement or confidence) awarded a point. A different scoring mechanism may produce more variability and lead to more precision in scaling[92].

This research assessed differences in food literacy scores in relation to program of study and other variables using bivariate analysis, without accounting for potential confounding variables. While other methods, such as linear regression, could have been employed, the Kruskal-Wallis test was appropriate for the exploration of group differences. The subsequent pairwise comparisons uncovered detailed patterns of differences between groups, which might have been masked by using monotonic tests. For example, a test for monotonicity would have shown higher food literacy scores with higher mental health status, but the nuanced pattern—whereby food literacy scores were higher until the "good" category and then plateaued in the uppermost categories—would not have been evident. Future studies can explore the inter-relationships of food literacy and intersecting variables, such as socioeconomic status and gender, incorporating more complex analytical methods to account for potential confounders.

The data for this study were collected in 2022 during the SARS-COV-2 pandemic, a time during which post-secondary studies were disrupted and the promotion of improved food intake as a protective factor was emphasized[93], possibly increasing opportunities to engage in food preparation or the acquisition of knowledge and skills. As a result, some students may have increased their food literacy during this time. The sample was recruited using convenience sampling, which can limit the generalizability of the research. In particular, the sample population was predominantly women. There was also a limited number of respondents from different institutions presents a second limitation. In

Ontario, most post-secondary institutes are found in the south of the province and larger urban centres, limiting generalizability to all post-secondary students.

The fact that the FLit50 measure exhibited characteristics of construct validity is promising for future research, including further evaluations of the measure and assessing relationships between food literacy and dietary practices. The group that developed the conceptualization underlying the FLit50 initially focused their qualitative work on young adults. However, the conceptualization drew upon literature more broadly, and it is possible that the measure can be used with other groups. To be confident in its use, additional validity evaluations with different populations (older or younger than 19 – 25 years), populations outside of this geographical range, and more ethnically diverse populations are warranted. Additionally, as other measures of food literacy are developed for the Canadian context, further examinations, including the convergent validity of the FLit50 measure with such measures, can be examined.

At 50 questions in length, the measure may be burdensome for respondents as well as for inclusion in research, including population health surveys. Further evaluation of the FLit measure using IRT can be used to create a shortened measure that can scale respondents adequately in reference to this longer measure[91]. With interest in improving food literacy in public health through policy and programming interventions, additional efforts to evaluate the measure for its capacity to detect change are also necessary. The findings from this study lay the groundwork for further evaluations of the FLit50, which are essential for establishing its reliability and validity across different contexts.

5.6 Conclusion

There is a growing focus on food literacy–the knowledge, skills, and self-efficacy to navigate food environments–as a possible lever to support eating patterns consistent with human and planetary health. The objectives of this study were to evaluate the construct validity of a recently developed food literacy measure among postsecondary students in Ontario, Canada. The results demonstrate that the measure exhibits construct validity through associations with variables in hypothesized directions, and two of the sub-domains, food and nutrition knowledge and self-efficacy and confidence, demonstrated the capacity to act as stand-alone measures.

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CHAPTER 6: THE DEVELOPMENT OF A SHORT FOOD LITERACY MEASURE AND EVALUATION OF ITS CONSTRUCT VALIDITY

Target Journal: Public Health Nutrition

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M.H. and S.I.K. designed the study. S.I.K. secured the funding through the LDCP Healthy Eating Team. M.H., M.Q., S.H., and S.I.K. coordinated data collection and the LDCP Healthy Eating Team facilitated access to the data from from the University of Toronto. M.H., S.I.K., E.A.P, H.T., L.K., H.R.S., and S.E. formulated the research questions. M.H. prepared the dataset, conducted the analyses, and led the drafting of the manuscript. M.H., S.I.K., E.A.P, H.T., L.K., H.R.S., and S.E. were involved in collaborative meetings. All authors provided critical feedback on the manuscript.

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6.1 Overview

Background

Food literacy is steadily gaining momentum as an important area of inquiry, with a focus on developing suitable measures to adequately capture the construct. Recently, a team of public health nutrition practitioners and researchers developed the FLit50, a food literacy measure for use with young adults in Ontario, Canada. However, at fifty items in length, there was interest in a shortened version of the FLit50 to allow for broader use in public health.

Objective

The objectives of this research were to develop a shortened food literacy measure and to evaluate its construct validity.

Design

Cross-sectional data were collected from young adults (n=808) in Canada during three phases of FLit50 development and evaluation.

Participants/setting

Data from one hundred and forty-six (n=146) young adults who completed the measure as part of the retest phase (of a test-retest study) in July and August 2019 were combined with data collected in October 2019 from 205 new participants from across Canada as part of a confirmatory testing phase, and data from students (n=457) enrolled in university and college programs in Ontario, Canada, collected from March to May 2022.

Statistical analyses

Two-parameter IRT was employed to return item difficulty and discrimination characteristics for items in the FLit50. These characteristics and discussions among the research team informed the selection of items for inclusion in a shortened measure. To evaluate the construct validity of the shortened measure, Spearman's rank correlation determined alignment with the scores from the full measure using data from the total combined sample. Using the data from postsecondary students, Kruskal-Wallis ANOVA and pairwise comparisons were employed to evaluate the variance in group scores, testing the hypothesis that higher food literacy scores would be observed among those enrolled in food-related academic programs; those of a higher age; women; those with higher health literacy, perceived income sufficiency, and self-rated general and mental health status; and those who were food secure. Items in the FLit16 were re-analyzed using data from the total sample using 2-parameter IRT to assess characteristics of the new unidimensional measure of food literacy.

Results

Item-level characteristics (mean difficulty = -1.72, mean discrimination = 1.78) informed discussions with the public health nutrition practitioners and led to the selection of 16 questions for inclusion in a shortened measure, the FLit16. FLit16 scores correlated strongly with Flit50 scores (Rho = 0.87, $p < 0.01$) and differences in median FLit16 scores were observed between those in food and nutrition programs vs. those who were not ($p < 0.001$), as hypothesized. Differences in FLit16 scores were also observed in hypothesized directions by gender identity, health literacy, self-rated general and mental health, and food security status (all $p < 0.001$) with small relative effect sizes, though not by age ($p = 0.349$) or income adequacy ($p = 0.401$). Items in the FLit16 demonstrated high item information at the lower end of food literacy ability, a high standard error at the higher end of ability, and adequate model fit, with room for refinement ($X^2 = 241.99$, $p < 0.001$, RMSEA = 0.04).

Conclusions

This study demonstrates the construct validity of a shortened measure of food literacy, the Flit16, for assessing food literacy among young adults. Future research can use the two measures to investigate how food literacy correlates with diet quality and food-related practices in young adults, as well as to continue to refine the FLit50 and FLit16 to support broad use in public health.

Keywords: Food literacy measure, Short Measure, Item Response Theory, IRT, scale reduction

Integrated Knowledge Translation, iKT

6.2 Introduction

Food literacy is steadily gaining momentum as an important area of inquiry[1], public health intervention[2,3], and policy[4,5]. Food literacy describes the interconnected skills, behaviour, and knowledge individuals need to navigate the modern food environment and meet nutrition and health needs[6]. It is conceptualized as a multidimensional latent construct made up of several underlying attributes relating to individual dimensions (e.g., food preparation skills and experience, organizational skills, knowledge, psychosocial factors) and external determinants (e.g., learning environment, sociocultural environment, food availability and facilities, food ecology, living conditions)[7]. Young adults are a particular demographic drawing attention regarding food literacy due to the significant challenges faced as they transition to independent living, driven by sub-optimal food and nutrition education and experience, competing priorities and interests, and complex relationships with food[8].

Food literacy is touted as an influential factor in public health[9,10]. Studies have shown that individuals with higher food literacy are more likely to adhere to dietary recommendations and have healthier eating practices[,11–13]. It has been found that food literacy is positively associated with higher consumption of fruits and vegetables[14]. On the other hand, low food literacy and non-adherence to dietary recommendations are more prevalent in disadvantaged groups, such as those with lower socioeconomic status[11,15]. Improving food literacy among individual, may contribute to better nutrition and overall well-being[12]. There is growing interest in examining food literacy in relation to factors beyond health outcomes, such as the enjoyment of food[16], considerations around sustainability[17], cultural dimensions of food[18,19], and general knowledge of the food system[20,21]. To inform efforts to improve food literacy, it is critical to have a well-designed measure for use in surveillance and monitoring[22].

Despite the interest in exploring food literacy, differing conceptualizations of the construct and the lack of a common and standardized measure designed for use in Canada have hindered a complete understanding of the construct[23,24]. Recently, a team of public health dietitians (the Locally Driven Collaborative Projects (LDCP) Healthy Eating Team) developed a 50-item food literacy measure, the FLit50, for use with young adults in Ontario, Canada. The development of the measure focused on two identified priority target groups: adolescents (age 16 to 19 years) and pregnant individuals and parents (age 16 to 25 years)[7]. The measure was based on a comprehensive conceptualization of food literacy stemming from a scoping review of how food literacy is described in the literature, including domains and attributes used[25], a review of existing measures and their items[25], and a Delphi process with experts to refine the language describing food literacy attributes and to reach consensus on their relevance for public health measurement[26]. The result of this work was a unique multi-dimensional conceptualization of food literacy upon which the measure was based.

Iterative revisions of the measure were informed by consultations with experts in the field, cognitive validity testing with target population members, and factor analysis to confirm the grouping of items into underlying attributes of food literacy[27]. The FLit50 measure contains questions designed to reflect the ten food literacy attributes. Conceptually, these attributes are grouped into four similarly themed domains of food literacy: food and nutrition knowledge, food skills, self-efficacy and confidence, and external factors (**Figure 12**). The scores based on items to measure each of the four domains combine to form a total score from the 50-item measure.

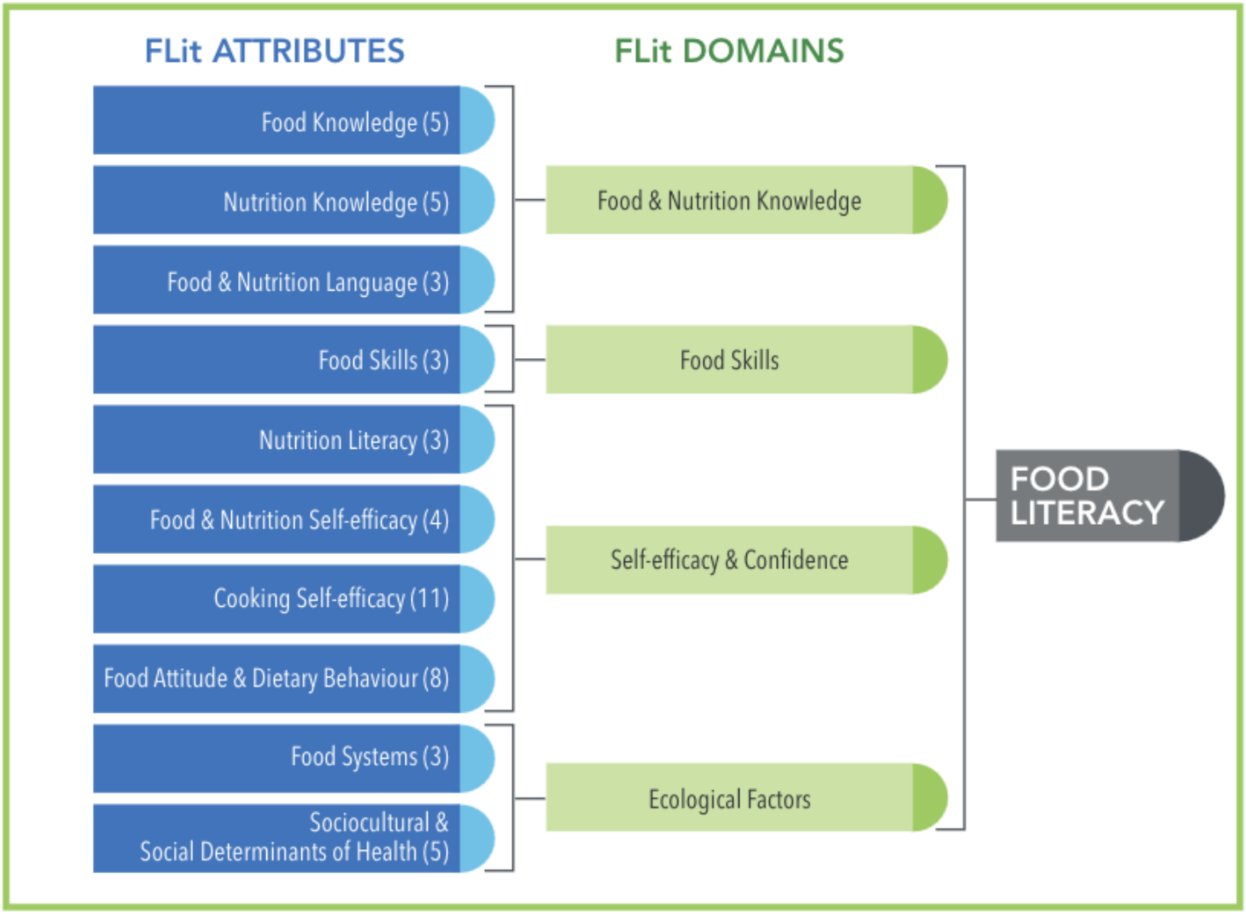

Figure 12: Conceptual model underlying the FLit50 measure. Values in parentheses represent the number of questions related to each attribute. Drawn from the Food Literacy (FLit) Measures Guide (Appendix 7).

An abbreviated version of the food literacy measure was desired to enable widespread adoption in public health settings. Shortened measures, when they accurately represent the construct of interest, are highly beneficial in both research and practical settings[28]. Their use enables more efficient data collection, making it feasible to measure constructs such as food literacy in a wider range of studies, including large-scale surveys. This efficiency can lead to more timely and actionable insights and guide intervention strategies aimed at improving nutritional outcomes and promoting healthier eating across populations.

Item Response Theory (IRT) is one method used to create abbreviated measures from longer measures[29]. IRT is a statistical framework used in psychometrics to analyze the measurement properties of tests and questionnaires[30]. Offering a modern update to Classical Test Theory (CTT), which assesses reliability and validity based on overall test scores while treating the contribution each item makes to the measure uniformly, IRT focuses on item-level data and modelling the relationship between how an item is responded to based on the level of the trait or construct being measured[29]. Through analysis of different item characteristics, IRT provides information for each item for measurement developers to use in decision-making while shortening a measure[29]. Using item-level characteristics allows for the identification and selection of items that provide a balance of difficulty and discrimination across ability levels of a construct, such as food literacy. One can also select items to maintain the underlying conceptual structure of the measure (e.g., select one item from each attribute rather than the best items irrespective of the corresponding attributes) while accounting for the difficulty and discrimination parameters. These features are particularly useful when examining multidimensional constructs, such as food literacy[31].

The objectives of this study were to 1) construct a shortened version of the FLit50 measure, 2) evaluate the shortened version for construct validity, and 3) assess the test- and item-level characteristics of the shortened measure. The LDCP Healthy Eating Team members involved in developing the measure were involved throughout the process of shortening the measure as subject matter experts and future measure users.

6.3 Methods

The cross-sectional data used for this study were generated from three different sources. The data included responses collected from adolescents and young adults in Canada to from the retest phase of an evaluation of test-retest reliability (n=146) and a second independent sample drawn upon to perform a confirmatory factor analysis of the FLit measure (n=205)[27]. These data (referred to as the 'development' data hereafter), collected by researchers at the University of Toronto in collaboration with the LDCP Healthy Eating Team, were combined with data from post-secondary students (n=457) collected to assess the construct validity of the food literacy measure in Ontario, Canada (**Chapter 5**), referred to as the 'student' data. This study, including the use of the measure development data shared by researchers at the University of Toronto, was reviewed and approved by the University of Waterloo Office of Research Ethics (ORE # 43057). Ethics approval for the development studies was obtained from the University of Toronto.

Sample Size Calculation

It is suggested that measurement evaluation using IRT should include between 5 and 10 participants per item in measure[32], translating to between 250 and 500 participants for the current study. The 808 data records satisfy this suggestion. Having more participants per item in IRT analysis is generally beneficial as it can improve the estimation accuracy of item parameters, leading to more stable and reliable results[33]. After the use of IRT analysis to inform the items included in the shortened version of the food literacy measure, evaluation of the construct validity of the measure was performed via assessments of known-group differences, including between students in food and nutrition programs vs. those enrolled in other programs. Sample size statistics for the evaluation of validity were calculated a priori using GPower 3.1 (Dusseldorf, Netherlands)[34]. Calculations were centred on detecting a one-tailed difference between students in food related and non-food related programs, a comparison used in evaluating another food literacy measure[35]. A minimum sample of 176 respondents was required to detect a difference of 0.5 standard deviations (standardized effect size), with an alpha error probability of 0.05 and a power of 0.95. The final sample for the evaluation of construct validity was 457 participants with 116 respondents in food- and nutrition-related programs.

Post-hoc power analysis was conducted to assess whether the sample size was adequate for the intended group comparisons. For binary variables, such as enrollment in food and nutrition related academic programs and gender, power was calculated using a one-tailed t-test, with an effect size target of $d = 0.5$, alpha at 0.05, and power aimed at 0.95. For comparisons of variables involving multiple categories, Cohen's f ($f = 0.5$, $\alpha = 0.05$) was used to determine effect size for each group. To address the variation in group sizes, the harmonic mean was applied to adjust for these differences, ensuring the accuracy of the power calculations. Most analyses demonstrated strong power, with the majority exceeding 0.99. However, smaller subgroups had limited samples, necessitating cautious interpretation of those specific results. Overall, the sample was sufficient to meet the power requirements, instilling confidence in the findings despite the presence of small subgroups.

Sampling and Data Collection

The sampling and data collection methods used in collecting the development and student data have been described elsewhere[27]. Briefly, for the retest and exploratory factor analysis study, participants who lived in Canada were recruited through paid social media advertisements and community/public health programs and services in July and August 2019. Only data from the retest phase of the test-retest procedure were used in the analysis, as the measure used in the retest phase was more similar to the final 50-item measure versus that used in the test phase. After inspection of the shared data (n=147) (**Figure 13**), one record was removed due to incomplete data, resulting in 146 records that were included in the analysis. In October 2019, participants aged 16-25 years who lived in Canada and who were not part of the test-retest study were recruited for the confirmatory testing phase through paid social media advertisements. Data from 226 participants were available in the dataset, and 21 of these participants were excluded from the analysis due to incomplete data, leaving 205 records from this phase that were added to the combined analytical sample. Demographic characteristics, including age, gender, ethnicity, pregnancy/parental status, geographic location, and socioeconomic status (SES), were collected concurrently. SES was queried using an adapted version of the MacArthur Scale of Subjective Social Status[36].

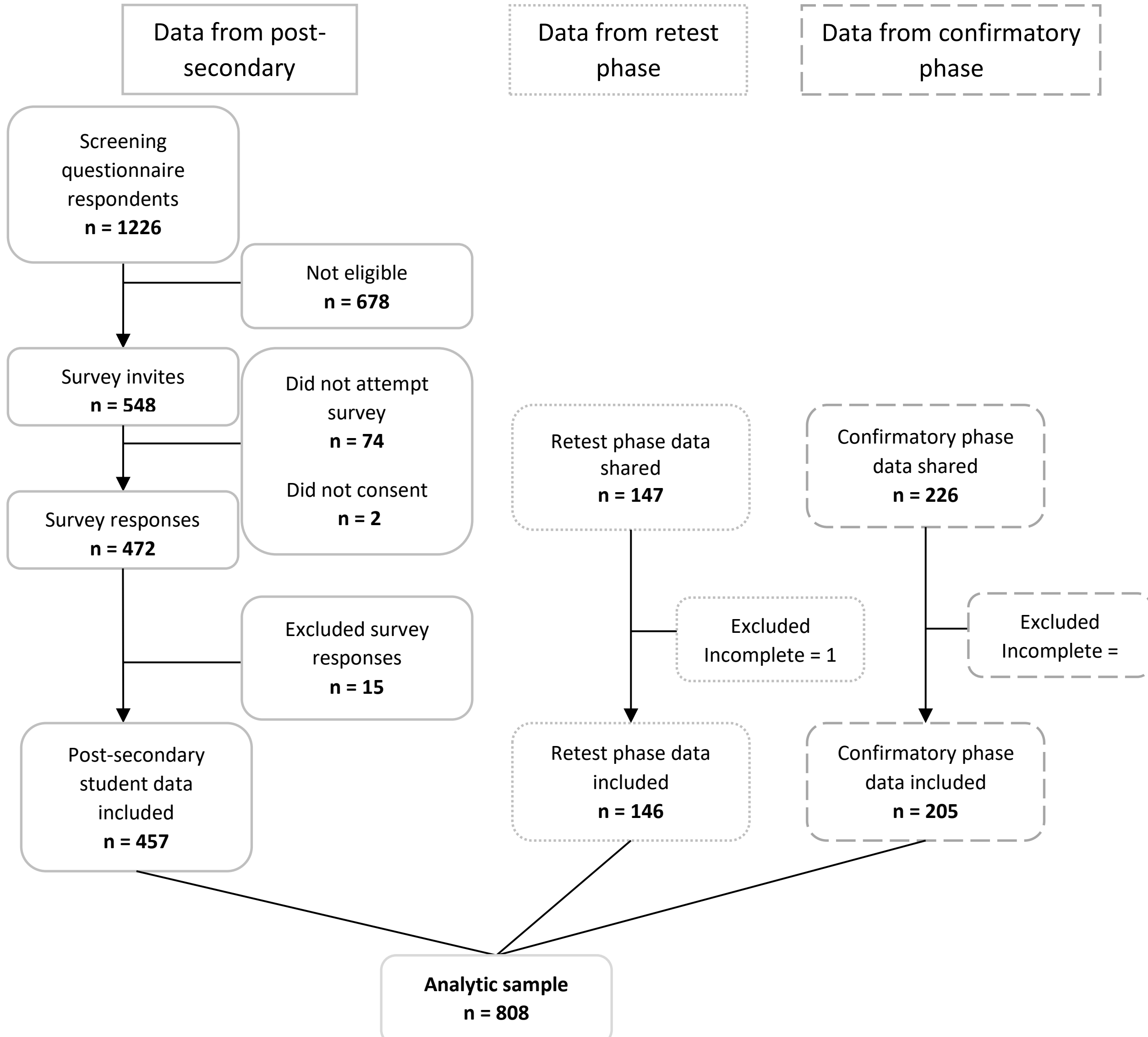

Figure 13: Summary of the overall participant flow, including primary data collected from students and supplemental data from retest and confirmatory phases.

For the student data, individuals aged 18 to 25 years who were in their second year or above at a college or university in Ontario, Canada, were recruited between March to May 2022. Posts on various social media platforms and outreach to post-secondary institutional partners were used to recruit participants. Eligibility criteria included being between the ages of 18 and 25 years old, being an enrolled student in Ontario—confirmed through the provision of a valid email address affiliated with a post-secondary institution—and being in their second year or above of their studies. Quota sampling targeted participants enrolled in food and nutrition programs along with those enrolled in other programs. Potentially interested participants completed a screening survey (n=1226), and eligible respondents (n=548) were sent an individualized link to the study details and survey through Qualtrics survey software (Provo, Utah)[37] where they were presented with the information letter and asked to consent before proceeding to the survey. Four hundred and seventy-two respondents attempted the survey (**Figure 13**). In addition to completing the food literacy measure, participants were queried about their age, gender identity[38], ethnic and racial identity[39], income adequacy[40], and general and mental health[41]. Participants also completed the Newest Vital Signs-Canada (NVS-C) module[42] measure of health literacy and the ten adult-referenced items from the Household Food Security Survey Module (HFSSM)[43], modified to assess individual food security status over the past 12 months as the household level was not the focus. After a review of the survey responses, 15 records were removed due to incomplete surveys, leaving 457 records from this study and data from a total of 808 participants in the combined dataset.

Variables

The FLit50 measure comprises 50 items, with 19 multiple-choice questions focusing on attributes of food knowledge, nutrition knowledge, food and nutrition language, food skills, and nutrition literacy. Additionally, 15 items assess respondents' levels of confidence in nutrition and cooking self-efficacy using a four-point Likert scale ranging from "not confident" to "very confident”. The measure also includes 16 items evaluated on a five-point Likert scale (from "strongly disagree" to "strongly agree”, with a neutral option) to capture food attitudes, dietary behaviours, food systems, and sociocultural and social determinants of health. The FLit50 questions and response options are provided in **Appendix 1**. Scoring follows the methodology established during the instrument's development[27], with one point awarded for each correct response on knowledge questions and for every positive Likert response indicative of agreement or confidence. Responses indicating disagreement or neutrality do not receive points.

The food literacy measure was refined iteratively during its development. Fifty-seven items were administered in the retest phase, and 51 items were included in the confirmatory factor analysis phase. Responses to the items not included in the final FLit50 were removed prior to the current analysis. In the student sample, the inadvertent omission of one item from the food literacy measure led to a total of 49 items, adjusting the number of items in the food attitude and dietary behaviours attribute to seven instead of the intended eight items.

Several variables hypothesized to be associated with food literacy, including academic program[35], age[44], gender identity[44,45], health literacy[46,47], income adequacy[40], general and mental health[48], and individual food security status[49], were used to evaluate the construct validity of the resultant shortened measure, similar to procedures used to evaluate the full measure (**Chapter 5**). These analyses were limited to data from the student sample because the variables required for the hypothesis testing were not collected in full in the development data.

Participants selected their academic program from a predefined list of food and nutrition-related programs in Ontario or entered their program name manually in an open-text field. Responses were reviewed and categorized as either food and nutrition programs or other programs. For participants who chose "prefer not to answer" (n=42) or did not answer (n=2) regarding program type, their response from the eligibility screener on whether they were enrolled in a food or nutrition program ("yes" or "no") was used. Participants provided their age, ranging between 18 and 25 years; those who did not disclose their age were excluded from age-related analyses. It is hypothesized that food literacy scores will be higher as age increases. In addition to findings from previous research supporting this association[44], it stands to reason that as individuals age, they accumulate more experience with food and opportunities to manage food-related tasks, leading to higher food literacy scores. Gender identity was also considered testing the hypothesis that women would score higher in food literacy than men, based on previous research[44,45] in addition to social norms, where women are often expected to participate in food preparation, increasing their exposure to different attributes of food literacy[14]. Gender identity was recorded by asking, "What is your current gender identity?". Trans-men and trans-women were included in the categories of men and women, respectively[50]. Due to small sample sizes, data from individuals identifying as genderqueer or non-binary (n=8) or preferring not to disclose their gender (n=3) were not included in the analysis by gender. Perceived income adequacy was assessed by asking participants about the ease with which they met their monthly income needs, with response options ranging from "very difficult" to "very easy," including "don't know" and "prefer not to answer"[40]. Responses of "don't know" (n=9) and "prefer not to answer" (n=13) were excluded from the analysis using this variable. Limited income may restrict individuals' ability to gain and apply food literacy through limitations on engaging in culinary activities that may build skills and confidence and acting on food literacy through a lack of means to acquire food to meet health recommendations[49]. Therefore, it was hypothesized that those who identified as having difficulty making ends meet would have lower food literacy scores.

The relationship between general and mental health and food literacy is a relatively novel area of study[48]. Some research has suggested a link between them[46]. Despite the limited strength of the current evidence, it was hypothesized that individuals who reported better general and mental health would also demonstrate higher food literacy scores. Two questions assessed self-rated general and mental health. General health was measured with the question, "In general, would you say your physical health is...?" (5 response options: poor to excellent)[41], and a similar question assessed mental health with the same response options[51]. Responses left blank (n=3 and n=1, respectively) were excluded from the analysis including these variables.

The Canadian iteration of the Newest Vital Sign© (NVS-C), a tool for gauging health literacy[42], was employed. Indicators of health literacy based on different versions of the NVS have been used in construct validity assessments of other emerging instruments of food literacy[47,52]. The NVS-C includes six multiple-choice questions pertaining to a Nutrition Facts Table, whereby a correct response earns one point toward a health literacy score. Scores were classified with a total score within 0-1 indicating a high chance of limited literacy, 2-3 hinting at possible limited literacy, and 4-6 suggesting adequate literacy[42].

Food security status over the past 12 months was measured using the ten adult-focused items from the Household Food Security Survey Module (HFSSM)[53], developed by the U.S. Department of Agriculture (USDA)[54] and utilized by Health Canada for national health monitoring[43]. These items assess food insecurity among adults in the household over the prior year[53]. For this analysis, question text was revised to remove mention of the household and others in the household, and instead focused on individual experiences. Based on Health Canada's guidelines[43], participants were categorized into four levels of food security: secure, marginally insecure, moderately insecure, and severely insecure, depending on the number of affirmative responses. The HFSSM is designed in a staged manner such that affirmative responses trigger further questions. Any affirmative responses to the three initial questions result in the display of a second set of five follow-up questions. Of those five questions, two (AD1 and AD5) are designed to display a question eliciting the frequency of the coping mechanism. An error was made in the logic flow related to the HFSSM in the administration of the survey. Question AD5, which reads, "In the last 12 months, did you ever not eat for a whole day because there wasn't enough money for food?" is meant to be presented to participants who indicate a 'yes' response to *any* of the questions AD1 – AD4. AD5 was erroneously presented only to participants who responded 'yes' to *all* questions AD1 – AD4 in the survey. An affirmative response to question AD5 prompts a sub-question querying the frequency of not eating due to insufficient money for food. This error affected 66 participants who should have progressed to additional questions within the HFSSM. Eighteen participants had the potential of being reclassified from moderate to severe food insecurity depending on their responses, whereas the other 48 participants' classifications would not be impacted by their responses. No change to the categorization was made for the current analyses.

Statistical Analyses and Collaborative Decision Making

Prior to analyzing the items on the FLit50 using IRT, meetings with the LDCP Healthy Eating Team were used to gain insights into the goals, potential use cases, and requirements of the shortened measure. Discussions centred around the preferred length of the shortened measure and the importance of balance across attributes of the retained items. For example, considerations included whether to retain items reflecting each of the ten attributes, to focus on including several items from each domain, or to select the most informative items without concern for domain or attribute. The decision was made to preserve the underlying conceptual model of the food literacy construct by including at least one item from each food literacy attribute and, for attributes with four or more items, a second item. This specification meant that the shortened version would contain 16 items.

The data from the development and student datasets were combined and cleaned in Microsoft Excel (Redmond, Washington, USA)[55] and imported into R Studio (Boston, Massachusetts, USA)[56] for analysis. IRT analysis was performed at the attribute level to identify which items from within each attribute were the most useful in appropriately scaling respondents. Item response functions were applied to estimate item difficulty and discrimination statistics, from which item characteristic curves (ICCs) were produced to aid in interpretation and decision-making with the LDCP Healthy Eating Team.

IRT analysis was performed using responses to the Flit50 measure from the combined dataset. IRT posits that responses to a given item are a function of individual ability levels and item characteristics[30]. A 2-parameter (2PL) IRT model was used in this analysis, which is a function of the underlying ability level (theta) and two item parameters: the difficulty parameter (beta) and the discrimination parameter (alpha)[57]. A person's ability level is their standardized score on a measure with demonstrated validity, where zero is the average ability level with positive and negative values corresponding with standard deviations of scores above and below the mean[57]. The difficulty parameter of an item defines the ability level required to answer correctly or affirmatively. For item difficulty, IRT returns a value for each item that represents the ability level needed to have a 50% probability of endorsing the correct or positive answer[57]. Easier items have a 50% probability of correctly answering at lower levels of ability, and difficult items require a higher level of ability. The discrimination parameter refers to how well an item accurately defines an ability level through the degree to which the responses to the items change as a function of ability[57]. A higher value of discrimination represents a situation whereby small changes in ability level correspond with large changes in the probability of correctly or affirmatively responding. Items with lower discrimination depict a weaker relationship between ability and the item and may result in lower reliability, thus, more measurement error[58]. Both item difficulty and discrimination parameters can be plotted in the form of an item characteristic curve (ICC)[58]. The ICC is a sigmoid, S-shaped curve with standardized ability levels along the x-axis and probability of correctly or affirmatively responding on the y-axis. The item difficulty parameter shifts the curve left and right along the ability axis, and the discrimination parameter determines the curve's slope[30]. **Figure 14** illustrates different difficulty and discrimination characteristics for two hypothetical items.

Within the FLit50 measure, the graded response questions are assigned a dichotomous score and are suitable for 2-parameter analysis. The 2-parameter analysis was repeated at the domain and food literacy levels, and comparisons were made between the results to ensure that items identified for inclusion in the shortened measure showed consistency at the different conceptual levels.

Resultant tables and ICC curves grouped by attribute were shared with the LDCP team for discussion. Items were compared based on their difficulty parameters, and the most informative items for each attribute were selected, ensuring that each retained item provided the best measure of its respective attribute. For items that were similar in difficulty, the values for the discrimination parameter were considered in addition to the expertise of the LDCP Healthy Eating Team to inform decision-making.

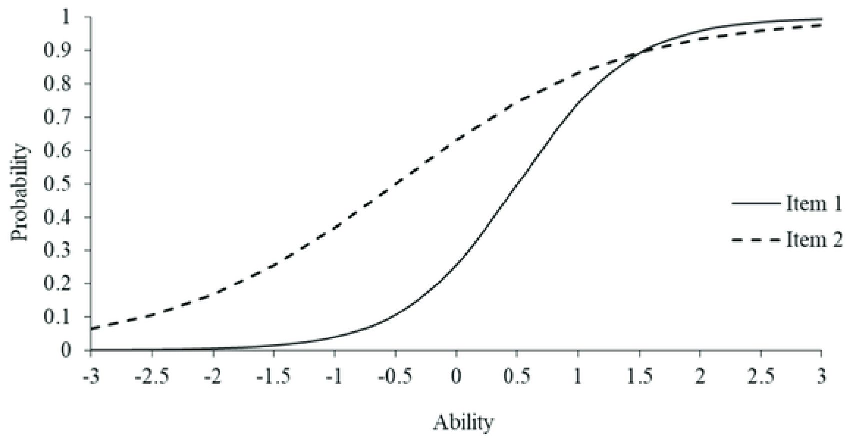

Figure 14: Item characteristic curves for two items with differing difficulty and discrimination. Item 1 is more difficult as the 50% probability of correctly responding is higher on the ability scale. The steeper slope of Item 1 represents the question's capacity to discern better between ability levels. The image is from Immekus JC, Snyder KE, Ralston PA. Multidimensional item response theory for factor structure assessment in educational psychology research. In Frontiers in Education 2019, May 28 (Vol. 4, p. 45). Frontiers Media SA.

Following the identification of 16 items for inclusion in the shortened food literacy measure, scores were calculated following the approach specified in the development of the full measure. One point was awarded for correct multiple-choice items and affirmative responses for Likert scale items[27]. An evaluation of the construct validity of the 16-item measure was then conducted. The strength and direction of the relationship between the scores from the shortened and full measure were assessed using Spearman's Rank coefficient with the combined dataset, for which a strong, positive relationship would indicate acceptable convergent validity[59]. Construct validity was evaluated by employing known group and hypothesis testing techniques associated with CTT[60,61]. Only the student data were used for this assessment, as they encompassed demographic, economic, and health-related information to conduct the evaluation of construct validity. Hypothesis testing was initially conducted using Kruskal-Wallis Analysis of Variance (ANOVA), chosen due to the non-parametric nature of the scores (Shapiro-Wilk $W = 0.952$, $p < 0.001$, skewness = -0.62, **Figure 15**).

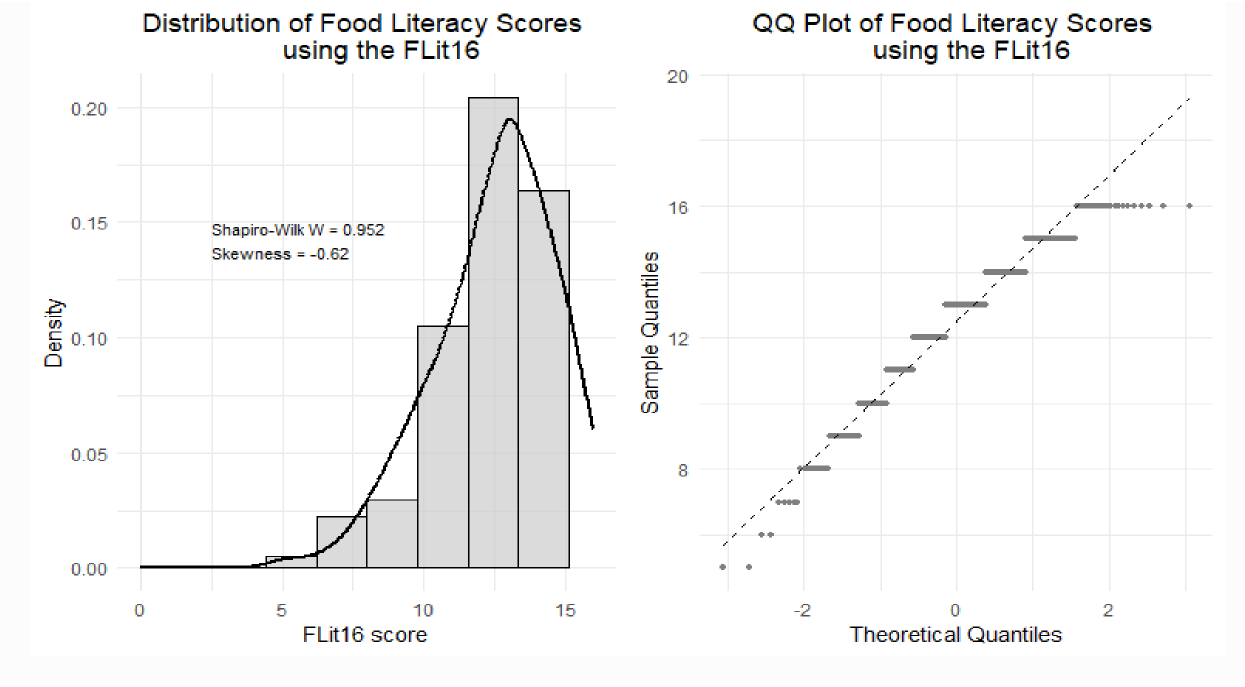

Figure 15: Distribution and normality assessment of food literacy scores using the FLit16.

For variables with more than two group levels and for which ANOVA detected differences between group medians, Dunn's pairwise comparisons with Bonferroni adjustments for multiple testing were used to determine the direction and magnitude of these differences. Additionally, minimal detectable differences (MDD), confidence intervals (CIs), and effect sizes were calculated to evaluate the statistical and practical significance of the findings. The hypotheses tested were that post-secondary students enrolled in food and nutrition-related academic programs would score higher than those in other programs, higher age would be associated with higher food literacy scores, women would score higher than men, higher health literacy would be associated with higher scores of food literacy, individuals with adequate income, higher general and mental health, and individuals experiencing food security would have higher food literacy scores. The specific hypotheses tested are stated in **Table 5**.

Table 5: Hypotheses used to evaluate the construct validity of the FLit16 using Kruskal-Wallis Analysis of Variance (ANOVA).

Variable	Hypothesis
Food program	Food and nutrition students will score higher in food literacy scores than non-food and nutrition students.
Age	With higher age, food literacy scores will be higher.
Gender identity	Individuals identifying as women will score higher on the full food literacy measure than men.
Health literacy	Individuals with higher scores in food literacy scores will have higher health literacy scores.
Income adequacy	Individuals with adequate financial resources will have higher food literacy scores.
Food security status	Individuals experiencing food-security will have higher food literacy scores.
General health	Individuals with better self-rated general health will have higher food literacy scores.
Mental health	Individuals with better self-rated mental health status will have higher food literacy scores.

Once construct validity was evaluated, IRT parameters for the 16 items within the shortened measure were examined using data from the combined dataset to assess item and test information, standard error, predicted true score, and model fit. The individual items were modelled on the sixteen-item food literacy score as a unidimensional construct, whereas previous item-level assessments were modelled on the food literacy attribute scores.

Test information describes the precision of a measure across the entire range of ability levels of a construct. It is calculated using the Test Information Function (TIF) and is usually depicted graphically[62]. There is no singular statistic returned for the TIF; rather, it is a function varying across the ranges of ability. The standard error is inversely related to test information and describes the degree of uncertainty associated with an individual's ability level estimate[62]. The predicted true score forecasts the score that a respondent is anticipated to attain on a measure based on their ability level through the incorporation of item parameters[57]. Lastly, model fit in IRT analysis assesses how well the selected IRT model describes the data from a given measure[63]. A strong fit between the model and the data indicates that the model accurately captures the relationship between item responses and the underlying trait levels[63]. Assessment of model fit involves the examination of disparities between observed responses and those predicted by the model.

6.4 Results

The sample used in the retest phase of the test-retest evaluation, comprising 146 participants, exhibited an average age of 19.9 years (range = 16–25 years), included a majority of females (69%), and a fairly homogenous ethnic representation, with 58% White and 14% Chinese individuals (**Table 6**). The data collected for the confirmatory factor analysis (n=205) had an average age of 19.8 years, similarly showing a female majority (52%) and a diversity of ethnicities, including South Asian (11%), Chinese (11%) and White (60%) individuals. Lastly, the student data was a slightly older sample on average, with a mean age of 21 years, and presents a substantial number of females (75%) compared to males (25%). The student sample predominantly identified as White (40%) but with a substantial Southeast Asian (24%) and South Asian (20%) presence. A majority indicated neither easy nor difficult with respect to income adequacy (44%). In terms of food security status, a large proportion (60%) of individuals were food secure. Self-reported health statuses varied in the student sample, with the largest number (38%) indicating good physical health, though the categories indicating lower mental health were endorsed more often than in general health. Demographic characteristics from each sample used in the combined dataset are presented in **Table 6**.

Table 6: Demographic, economic, and health characteristics of participants completing a food literacy survey across three datasets: Test-retest study, confirmatory factor analysis study, and post-secondary student validation study.

	Retest (n=146)	**Confirmatory (n=205)**	**Post-secondary Students (n= 457)**
Age (range), years	19.9 (16-25)	19.8 (16-26)	21.2 (18-25)
		n (%)	
Population [1]			
Pregnant	14 (9)	0 (0)	-

Parent	52 (36)	6 (3)	-
Pregnant and Parent	7 (5)	0 (0)	-
Youth	99 (68)	199 (97)	-
Student in food and nutrition Program	-	-	116 (25)
Student in non-Food and nutrition program	-	-	341 (75)
Gender			
Woman	101 (69)	106 (52)	343 (75)
Man	42 (29)	94 (44)	103 (23)
Transgender	0 (0)	2 (1)	-
Two Spirit	1 (1)	0 (0)	-
Non-binary	2 (1)	3 (2)	-
Self-describe / Different Identity	1 (1)	2 (1)	3 (1)
Gender queer/gender non-conforming	-	-	8 (2)
Ethnicity [1]			
Black	11 (8)	11 (5)	14 (3)
Chinese	21 (14)	23 (11)	-
Filipino	9 (6)	7 (3)	-
Indigenous	5 (3)	6 (3)	1 (0)
Korean	5 (3)	0 (0)	-
Latin, Central, South American	6 (4)	2 (1)	5 (1)
Southeast Asian	6 (4)	5 (2)	110 (24)
South Asian	13 (9)	23 (11)	93 (20)
West Asian or Arab	3 (2)	6 (3)	21 (5)
White	85 (58)	124 (60)	181 (40)
Another	3 (2)	8 (4)	4 (1)
Mixed racial/ethnic identity	-	-	27 (6)
Not sure	0 (0)	0 (0)	-
Rather Not say	1 (1)	3 (1)	-
Unknown based on response	-	-	1 (0)
Province [2]			
Alberta	4 (3)	-	-
British Columbia	7 (5)	-	-
Manitoba	0 (0)	-	-
New Brunswick	2 (1)	-	-
Newfoundland and Labrador	3 (2)	-	-
Nova Scotia	2 (1)	-	-
Ontario	125 (86)	-	457 (100)
Quebec	1 (1)	-	-
Saskatchewan	1 (1)	-	-
Yukon	1 (1)	-	-
Northwest Territories	0 (0)	-	-
SES Ladder [3]			
10 Most access	7 (5)	14 (7)	-
9	15 (10)	19 (9)	-

8	24 (16)	41 (20)	-
7	30 (21)	55 (27)	-
6	28 (19)	29 (14)	-
5	17 (12)	20 (10)	-
4	13 (9)	14 (7)	-
3	7 (5)	7 (3)	-
2	1 (1)	4 (2)	-
1 Least access	4 (3)	2 (1)	-
Perceived income adequacy			
Very difficult	-	-	71 (16)
Difficult	-	-	95 (21)
Neither easy nor difficult	-	-	200 (44)
Easy	-	-	58 (13)
Very easy	-	-	11 (2)
Don't know	-	-	9 (4)
Prefer not to say	-	-	13 (3)
Food security status			
Food secure	-	-	273 (60)
Marginal food insecurity	-	-	67 (15)
Moderate food insecurity	-	-	71 (16)
Severe food insecurity	-	-	46 (10)
Self-reported general health			
Poor	-	-	23 (5)
Fair	-	-	116 (25)
Good	-	-	172 (38)
Very good	-	-	121 (26)
Excellent	-	-	22 (5)
Don't Know	-	-	3 (1)
Self-reported mental health			
Poor	-	-	94 (21)
Fair	-	-	139 (30)
Good	-	-	149 (33)
Very good	-	-	64 (14)
Excellent	-	-	10 (2)
Don't Know	-	-	1 (0)

1 - Participants could select more than one answer
2 - Province data was not shared for confirmatory data
3 - Measured using the MacArthur Scale of Subjective Social Status

The mean Flit50 score based on the combined dataset was 41.2 (SD = 5.0). The range of scores was 12 to 49. The item difficulty parameters ranged from -3.64 to 3.05 (mean difficulty = -1.72) across all items (**Table 7**). The average difficulty parameter of -1.72 across the 49 items indicates that individuals whose food literacy ability is two standard deviations (rounded) below the mean are expected to have a 50% chance of answering a typical item correctly. Discrimination parameters ranged from 0.33 to 8.43 (mean discrimination = 1.78), which suggests a varying degree of sensitivity across the items. On average, the items have a weak to moderate ability to discriminate among individuals with varying levels of food literacy.

Decisions for item inclusion in the FLit16 were made with consideration of both statistical indicators (i.e., IRT parameters) and the practical relevance of each item within its attribute based on discussions with the LDCP Healthy Eating Team. For the attributes of food knowledge, nutrition knowledge, food and nutrition language, food skills, nutrition literacy, and nutrition self-efficacy, the decisions were relatively straightforward based on item difficulty and no extensive deliberation was necessary. For items belonging to the remaining attributes, collaborative discussion and judgment played a key role in the final decisions.

For the attribute of cooking self-efficacy, one item, "Prepare meals using plant-based proteins (e.g., beans, lentils, tofu)," had parameters that justified its inclusion. The second item chosen was to specify the confidence level to "follow a simple recipe (one that only has a few ingredients and steps)." Although there were other items with greater difficulty, such as using herbs (cooking self-efficacy item 5), making baked goods (cooking self-efficacy item 6), or sautéing (cooking self-efficacy item 4), the decision was influenced by the relevance of recipe-following skills common in public health initiatives. Given that recipe provision is an easy and affordable tool for promoting healthier eating, retaining this question was deemed important by the public health nutrition practitioners to ensure that the measure captures a baseline level of cooking confidence and ability.

For the food attitudes and dietary behaviours attribute, the item "When ordering takeout food or food in a restaurant, it is important that I choose healthier options from those available, most of the time," was included due to strong IRT parameters. A second item, "Eating whole grains (e.g., whole grain pasta and bread, brown rice, oats) is important for my health," was chosen over other items such as eating without distractions (food attitudes and dietary behaviours item 1) or eating with others (food attitudes and dietary behaviours item 3). This decision was influenced by the focus of recent public health efforts, including in Canada's Dietary Guidelines[64], to emphasize the consumption of whole grains—a dietary component that is consumed in inadequate amounts by Canadians[65,66]. The decision to exclude the item "Eating more beans, lentils, tofu, and other plant-based proteins helps me stay healthy" (food attitudes and dietary behaviours item 8) was made because a question related to plant-based foods had already been retained within the cooking self-efficacy attribute.

Lastly, for the attribute related to social determinants of health, the item "It is important that people are able to access foods specific to their culture" was retained based on its item difficulty. Given that items within this attribute showed similar item difficulties, the choice to include "Family, friends, celebrities, and social media can shape/influence what people choose to eat" was made to ensure that the measure captured a range of social influences on food choices.

Table 7: Difficulty and discrimination parameters for items in the FLit50 food literacy measure using a 2-parameter Item Response Theory model by attribute. Italicized items were selected for inclusion in the shortened FLit16 measure. Response options are available in Appendix 1.

Item ID	Item text	Item discrimination (mean = 1.78)	Item difficulty (mean = -1.72)
		(n=808)	
Food Knowledge 1	Which fruit is traditionally grown in Canada?	0.93	-2.38
Food Knowledge 2	Which of the following are protein foods? (Check all that apply)	1.17	-1.63
Food Knowledge 3	Why are food additives (e.g., preservatives, flavours, colours) added to food? (Check all that apply)	1.16	-1.17

Food Knowledge 4	*Which of the following is a source of unsaturated fats?*	*1.00*	*0.10*
Food Knowledge 5	*A breakfast cereal lists "fortified" on its box. This means:*	*1.80*	*-0.90*
Nutrition Knowledge 1	Eating plenty of fruits and vegetables is important to help prevent health problems or diseases.	1.61	-3.53
Nutrition Knowledge 2	*Which of the following is a healthier type of sugar?*	*0.33*	*3.05*
Nutrition Knowledge 3	*The foods that we eat may affect our mood.*	*2.45*	*-2.37*
Nutrition Knowledge 4	Processed food (e.g., boxed mac n' cheese, fast food) usually have more salt than foods cooked at home from basic ingredients (e.g. pasta, vegetables, meat).	1.50	-3.01
Nutrition Knowledge 5	You're deciding between ordering a poutine (fries, cheese and gravy) and a whole grain chicken wrap with vegetables. The menu says the poutine has fewer calories. Does this mean poutine is a healthier choice?	1.16	-3.64
Food & Nutrition Language 1	*If you are steaming vegetables, this means that you are:*	*2.37*	*-1.52*
Food & Nutrition Language 2	If a food package lists "no added sugar", this means that this product must have zero sugar.	2.19	-2.17
Food & Nutrition Language 3	If a food package lists "low in sodium", this means that this product:	1.91	-2.59
Food Skills 1	*Fresh vegetables and fruit should be washed if:*	*0.97*	*-2.15*
Food Skills 2	When cutting raw meat and vegetables for the same meal, you should:	1.58	-2.27
Food Skills 3	Which of the following is a sugary drink?	1.30	-2.90
Nutrition Literacy 1	Who is more likely to give you accurate nutrition information?	1.99	-2.37

Nutrition Literacy 2	The ingredients on a granola bar are listed as follows: rolled oats, sugars, peanuts, chia seeds, whole wheat flour and salt. The ingredient that's present in the largest amount is:	4.14	-1.33
Nutrition Literacy 3	*Is it safe to defrost frozen meat, poultry or fish in a dish on the kitchen counter?*	*0.38*	*-0.99*
	How confident are you in your ability to do each of the following?		
Nutrition Self-Efficacy 1	Find nutrition information you can trust.	1.35	-2.18
Nutrition Self-Efficacy 2	*Choose the healthiest options from foods sold at restaurants.*	*1.46*	*-1.27*
Nutrition Self-Efficacy 3	Prepare a healthy meal for family or friends.	1.27	-1.91
Nutrition Self-Efficacy 4	*Choose the healthiest options from foods sold at grocery stores.*	*8.43*	*-1.31*
	How confident are you in your ability to do each of the following food preparation and cooking activities?		
Cooking Self-efficacy 1	Use a kitchen knife safely (e.g., to cut up raw ingredients)	1.72	-2.08
Cooking Self-efficacy 2	Measure ingredients for a recipe.	1.46	-2.68
Cooking Self-efficacy 3	*Follow a simple recipe (one that only has a few ingredients and steps).*	*2.12*	*-2.56*
Cooking Self-efficacy 4	Sauté (i.e., cook food quickly in a little bit of oil or fat on the stovetop).	2.21	-1.54
Cooking Self-efficacy 5	Use herbs and spices (e.g., basil, thyme, cayenne pepper) to flavour dishes.	2.33	-1.39
Cooking Self-efficacy 6	Make baked goods such as cookies, cupcakes, and cakes etc., using basic ingredients (not from a box).	1.06	-1.66
Cooking Self-efficacy 7	Make soup using basic ingredients (not from a can or box).	1.86	-1.24

Cooking Self-efficacy 8	Cook meat (e.g., stir fry, bake)	1.04	-1.59
Cooking Self-efficacy 9	*Prepare meals using plant-based proteins (e.g., beans, lentils, tofu).*	*1.77*	*-0.79*
Cooking Self-efficacy 10	Change a recipe to make it healthier (e.g., to have less salt, sugar or fat).	1.72	-0.94
Cooking Self-efficacy 11	Prepare meals or snacks using basic ingredients (e.g., pasta, vegetables, meat), with or without a recipe.	2.29	-1.63
	How much do you agree or disagree that each of the following statements are true?		
Food Attitudes & Dietary Behaviour 1	It is important to eat most meals without distractions (e.g. cell phones, tablets, TV, toys).	1.09	-0.26
Food Attitudes & Dietary Behaviour 2	It is important to prepare healthy meals and snacks most of the time.	1.82	-1.82
Food Attitudes & Dietary Behaviour 3	It is important to eat meals with others, when possible.	1.09	-0.60
Food Attitudes & Dietary Behaviour 4[1]	It is important for my health to make most meals or snacks using basic ingredients (e.g. pasta, vegetables, meat).	0.87	-1.42
Food Attitudes & Dietary Behaviour 5	*When ordering takeout food or food in a restaurant, it is important that I choose healthier options from those available, most of the time.*	*1.02*	*-0.08*
Food Attitudes & Dietary Behaviour6	It is important for my health to not skip meals or snacks, when possible.	0.83	-1.69
Food Attitudes & Dietary Behaviour7	*Eating whole grains (e.g., whole grain pasta and bread, brown rice, oats) is important for my health.*	*1.26*	*-1.29*
Food Attitudes & Dietary Behaviour 8	Eating more beans, lentils, tofu, and other plant-based proteins helps me stay healthy.	1.40	-1.01

	How much do you agree or disagree that each of the following statements are true?		
Food Systems 1	Food advertising can influence what we buy.	1.73	-2.41
Food Systems 2	*It is important to use leftovers, when possible*	*2.08*	*-1.79*
Food Systems 3	Reducing the amount of food we throw away is good for the environment.	1.35	-2.76
	How much do you agree or disagree that each of the following statements are true?		
Sociocultural Determinants of Health 1	*Family, friends, celebrities, and social media can shape/influence what people choose to eat.*	*1.51*	*-2.42*
Sociocultural Determinants of Health 2	*It is important that people are able to access foods specific to their culture.*	*1.71*	*-2.09*
Sociocultural Determinants of Health 3	What people eat can be influenced by cultural or family food traditions.	2.79	-2.35
Sociocultural Determinants of Health 4	A person's living situation (such as income, education and housing) can affect their ability to prepare meals.	1.69	-2.84
Sociocultural Determinants of Health 5	A person’s ability to access food can be affected by their living situation (such as income, transportation, where they live)	3.70	-2.25

1 - Food Attitude/Dietary Behaviour Item 4 was unintentionally omitted from the post-secondary student data collection; parameters presented were calculated with the development dataset only.

The Spearman rank order correlation statistics showed that the scores from the shortened measure were strongly and positively associated with the scores from the full measure (Rho = 0.87, $p < 0.01$), demonstrating convergent validity. The results from the Kruskal-Wallis ANOVA showed differences in median food literacy scores between students in food programs versus those in non-food programs (KW $\chi 2 = 84.9$, $p < 0.001$), and by gender identity (KW $\chi 2 = 29.3$, $p < 0.001$) (**Table 8**) in hypothesized directions. Evidence of differences in median food literacy scores by group levels was found for health literacy (KW $\chi 2 = 16.07$, $p < 0.001$), general health (KW $\chi 2 = 31.36$, $p < 0.001$), mental health (KW $\chi 2 = 10.85$, $p = 0.028$), and food security status (KW $\chi 2 = 16.79$, $p < 0.001$), warranting investigation of direction and magnitude of the differences using Dunn's pairwise comparisons. There were no differences in median scores by age (KW χ2 = 7.82, *p* = 0.349) or perceived income adequacy (KW χ2 = 4.04, *p* = 0.401).

Table 8: Results of the Kruskal Wallis Analysis of Variance evaluation of mean and median scores on the 16-item food literacy measure among subgroups with hypothesized differences.

Characteristic	n (%)	Mean FLit16 Score (SD)	Median FLit16 Score (IQR)	df	KW statistic	p values[1]
Food Program	**457**	**12.5 (2.2)**	**13 (3)**	**1**	**84.9**	**< 0.001**
Yes	116 (25%)	14 (1.7)	14 (2)			
No	341 (75)	12 (2.1)	12 (2)			
Gender[2]	**446**	**12.5 (2.2)**	**13 (3)**	**1**	**29.3**	**< 0.001**
Man	103 (23%)	11.6 (2.1)	12 (3)			
Women	343 (75)	12.8 (2.1)	13 (2)			
Age[3]	**449**	**12.5 (2.2)**	**13 (3)**	**7**	**7.82**	**0.349**
18	5 (1%)	13.6 (2.8)	15 (2)			
19	76 (17)	12.3 (2.4)	13 (3)			
20	96 (21)	12.1 (2.2)	12 (3)			
21	110 (24)	12.7 (2.0)	13 (2.75)			
22	64 (14)	12.6 (2.2)	13 (3.25)			
23	46 (10)	12.8 (2.3)	13 (4)			
24	18 (4)	12.3 (1.9)	13 (2)			
25	34 (7)	12.7 (2.0)	13 (2)			
Health literacy	**457**	**12.5 (2.2)**	**13 (3)**	**2**	**16.07**	**< 0.001**
High likelihood of limited literacy	5 (1%)	10.8 (1.5)	11 (1)			
Possibility of limited literacy	51 (11)	11.4 (2.5)	11 (3)			
Adequate health literacy	401 (88)	12.7 (2.1)	13 (3)			
Perceived income adequacy[4]	**435**	**12.5 (2.2)**	**13 (3)**	**4**	**4.04**	**0.401**
Very difficult	71 (16%)	11.5 (2.9)	13 (2)			
Difficult	95 (21)	12.4 (2.4)	13 (3)			
Neither easy nor difficult	200 (44)	12.5 (2.2)	13 (3)			
Easy	58 (13)	12.4 (2.2)	13 (3)			
Very easy	11 (2)	13 (1.8)	13 (1.5)			
General Health[5]	**454**	**12.5 (2.1)**	**13 (3)**	**4**	**31.36**	**< 0.001**
Poor	23 (5%)	10.8 (2.5)	11 (3.5)			
Fair	116 (25)	12 (2.0)	12 (2)			
Good	172 (38)	12.6 (2.1)	13 (2.25)			
Very good	121 (26)	13.1 (2.0)	13 (3)			
Excellent	22 (5)	13.2 (2.3)	13.5 (3)			

Mental Health[6]	**456**	**12.5 (2.2)**	**13 (3)**	**4**	**10.85**	**0.028**
Poor	94 (21%)	12 (2.4)	12 (4)			
Fair	139 (30)	12.3 (2.0)	13 (3)			
Good	149 (33)	12.9 (2.1)	13 (2)			
Very good	64 (14)	12.7 (2.1)	13 (3)			
Excellent	10 (2)	12.4 (2.6)	12.5 (3.75)			
Food security level	**457**	**12.5 (2.2)**	**13 (3)**	**3**	**16.79**	**< 0.001**
Food secure	273 (60%)	12.8 (2.1)	13 (2)			
Marginal food insecurity	67 (15)	12.2 (2.0)	12 (2.5)			
Moderate food insecurity	71 (16)	11.7 (2.4)	12 (4)			
Severe food insecurity	46 (10)	12.2 (2.2)	12 (2.75)			

1 - P values were derived using one-way Kruskal Wallis Analysis of Variance (ANOVA) after the Shapiro-Wilk normality test provided evidence of non-parametricity in the data

2 - Eleven individuals were not included because they identified as gender queer/gender non-conforming and three were not included as they did not report their gender identity.

3 - Eight individuals were not included because they preferred not to report their age

4 - In response to the question, "How difficult is it for you to make ends meet?" nine individuals were not included because they did not know income adequacy and thirteen did not report

5 - Three individuals were not included because they did not report general health status.

6 - One individual was not included because they did not report mental health status.

Differences in mean scores were found between students with a possibility of limited health literacy and those with adequate health literacy (Dunn = 3.47, *p.adj* < 0.001), with mean scores differing by 1.27 (MDD = 0.47, CI = [-1.74, -0.8], ε^2 = 0.008) (**Appendix 9, Supplemental Table 1**). Mean scores ranged from 10.8 (SD = 2.5) among those reporting their health as poor to 13.1 (SD = 2.0) among those reporting their health as very good (Dunn's test = 4.27, *p.adj* < 0.001). The calculated difference in means was -2.27 (MDD = 0.71, CI = [-2.98, -1.57], ε^2 = 0.009). Similar patterns were observed between those reporting fair general health and those reporting very good. The pairwise comparisons of means at different levels of mental health status were less pronounced. The mean food literacy score for individuals reporting good mental health was 12.9 (SD = 2.1), while it was 12.0 (SD = 2.4) for those reporting poor mental health, for a difference of 0.84 ((Dunn's test = 3.07, *p.adj* = 0.021, MDD = 0.38, CI = [-1.22, -0.46], ε^2 = 0.007). Mean scores at higher levels of mental health status were similar. By food security, the most notable difference was between those who were food-secure (mean = 12.8, SD = 2.1) and those experiencing moderate food insecurity (mean = 11.7, SD = 2.4), with a difference in mean scores of 1.1 (Dunn = -3.51, *p.adj* = 0.002, MDD = 0.4, CI = [0.67, 1.47], ε^2 = 0.035). While not all pairwise comparisons showed differences, the overall patterning between groups provides evidence of differences in the hypothesized directions and confidence in the construct validity of the shortened measure. The box plots in **Appendix 9, Supplemental Figure 1** are graphical representations of the differences for the variables with significant differences in medians with three or more categories—health literacy, general health, mental health, and food security status.

The items selected for the FLit16 measure were re-analyzed using 2-parameter IRT to obtain item difficulty and item discrimination parameters in relation to the overall food literacy construct (**Appendix 9, Supplemental Table 2**).

The results of the test-information function (TIF) across the range of ability levels suggest that the 16-item measure provides the most accuracy in scaling respondents at lower levels of ability and has lower accuracy at higher levels of food literacy (**Figure 16**). Correspondingly, the standard error at different levels of ability is an inverse reflection of the test-information function and is found to be higher at the upper end of the food literacy range. The predicted test score analysis results indicate that using the shortened measure, an individual with average ability will score approximately 12 of 16 points (**Figure 17**).

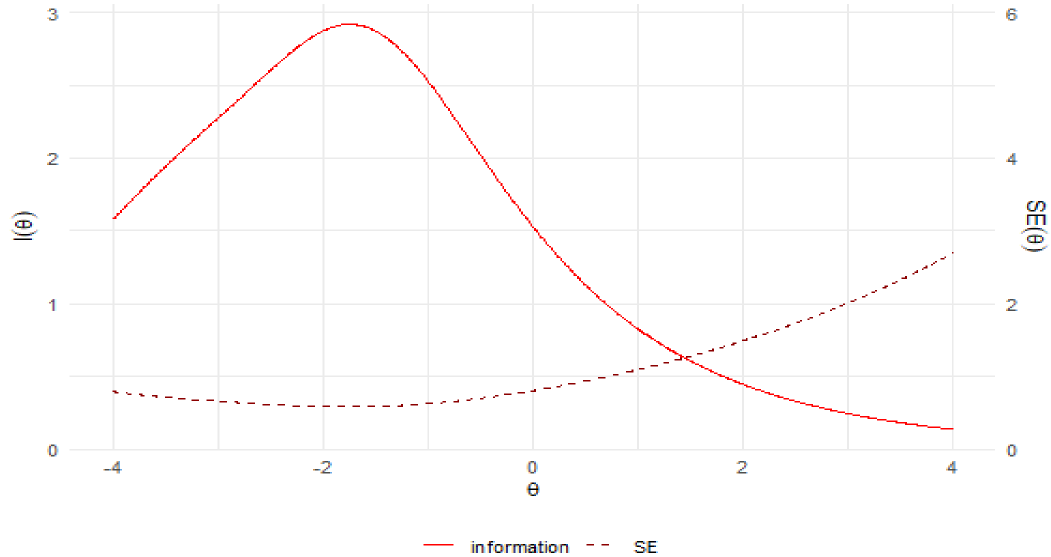

Figure 16: Test information curve depicting test information (I(θ)) (precision) and Standard Error (SE(θ)) (variability in estimation) across food literacy levels for the FLit16 measure. On the x-axis, theta (θ) represents the ability level, with zero indicating average food literacy ability; values above and below zero correspond to standard deviations above and below this average.

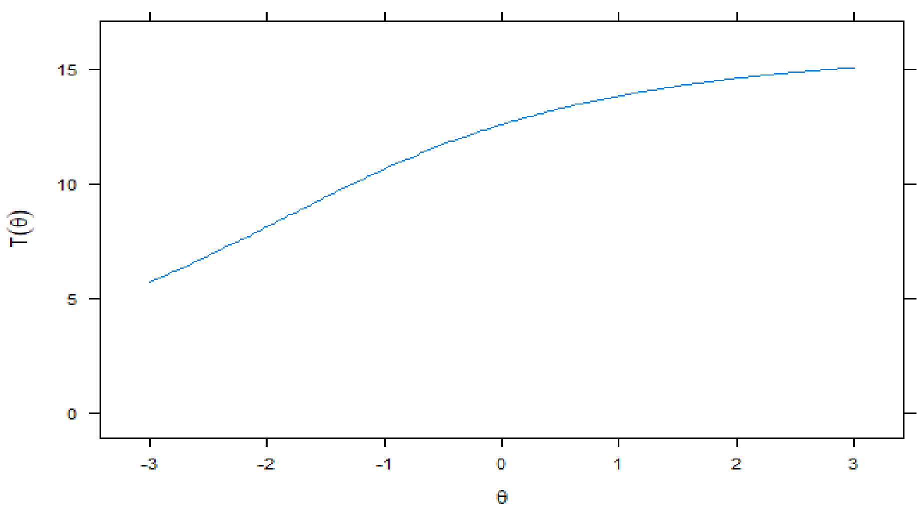

Figure 17: Expected true score prediction curve for the FLit16 measure using Item Response Theory, illustrating the relationship between food literacy level (θ) and predicted score (T(θ)). The x-axis represents theta (θ), where zero indicates average food literacy ability, with values above and below zero referring to standard deviations above and below the average.

In testing the model fit of the shortened version, the M2 statistic was 241.99 (df = 104, $p <$ 0.001) and the M2-based root mean square error of approximation (RMSEA = 0.04). The standardized root mean square (SRMSR = 0.05) satisfied the suggested cutoff values of < 0.06 and <0.08 for good and adequate fit, respectively [67]. The Tucker-Lewis Index (TLI) at 0.82 and Comparative Fit Index (CFI) at 0.84 were somewhat below the 'relaxed' good fit threshold of greater than 0.90[67].

6.5 Discussion

This study employed a 2-parameter IRT to evaluate each question in the FLit50, a 50-item food literacy measure developed for use with young adults in Ontario, Canada, with the intention of selecting items suitable to comprise a shortened measure. Through item-level estimation of difficulty and discrimination parameters and through collaboration discussions with the LDCP Healthy Eating Team that led the development of the food literacy measure, a 16-item measure was produced. The short measure demonstrates convergent validity based on its strong, positive correlation with scores from the full measure and construct validity through its ability to rank respondents consistent with the full version and to differentiate between groups hypothesized to be different with respect to food literacy levels. While the model fit statistics for the FLit16 were slightly below the recommended threshold values for TLI and CFI, this is common when shortening a measure and does not necessarily indicate a poor model but rather reflects the iterative nature of developing an appropriate measure[67]. Whereas the full version of the food literacy measure is devised to capture a multi-dimensional conceptualization of food literacy, the shortened measure is suitable for measuring food literacy as a unidimensional construct, as it does not contain sufficient items reflecting the sub-dimensions. The FLit16 offers a complementary version to the FLit50 to be used in public health practice.

Currently, measures used in food literacy research often contain a large number of items. For example, the Italian Food Literacy Survey (IT-FLS) contains 47 items[52], and the Food Literacy Scale developed for Portuguese respondents consists of 50 items[16]. Available nutrition literacy measures, often used as a proxy for food literacy and considered an attribute in the FLit50 conceptualization, are also lengthy. The Nutrition Literacy Assessment Instrument (NLit)[68] and variations based on the NLit, the NLit-S[69] (Spanish version) and NLit-BCa[70] (Breast Cancer version), have 64 items; the shorter version of the NLit, designed for parents, has 42 items[71]. Food literacy tools exist that are similar in length to FLit16, such as the Food-LIT PRO measure with 25 items across five factors, the International Food Literacy Questionnaire (IFLQ-19) which was reduced from 100 items to 19, and the Short Food Literacy Questionnaire (SFLQ)[73], with 16 items. The Newest Vital Signs tool, designed to capture health literacy through the respondent's interpretation of a nutrition facts table, one aspect of food literacy, has six items[42]. Despite being the shortest measure in use, the NVS, that captures ability to read and interpret a Nutrition Facts Table, does not represent the totality of food literacy, making it an inappropriate measure and incomparable to the FLit16, which used a comprehensive underlying conceptual framework in its design and selection of items.

The increasing availability of short measures can expand the consideration of food literacy in public health research and practice. Nonetheless, the numerous existing and emerging measures of food literacy available for use make comparability and generalizability of findings difficult. Through ‘test equating’ procedures[72,73], IRT can be used to impute a coefficient that can be applied to the scores from one measure (e.g., FLit16) to make accurate comparisons of scores and to make predictions of the score on a different measure (e.g., the SFLQ). This is especially important as more food literacy measures are introduced, potentially tailored to different populations or contexts. For instance, populations such as newcomers to Canada or other specific subgroups may benefit from measures that account for their unique cultural and experiential factors. Test-equating can facilitate meaningful comparisons across these diverse measures, supporting more nuanced and equitable research in food literacy. The application of IRT in evaluating measurement tools represents a significant advancement in psychometric research and can extend beyond facilitating item reduction. For example, IRT allows for the integration and evaluation of newly conceived items alongside existing ones to determine whether new questions are more ‘informative’, thereby fostering the continuous evolution and refinement of the measure. Improvements to both the FLit50 and Flit50 are possible. For example, the IRT parameters indicated that the questions were easy for respondents and the revision of existing questions and responses could improve the measure's capacity to scale individuals more accurately. Evaluating the new or revised questions may make those questions more suitable for inclusion in the FLit16 than those currently selected. IRT can also be used to assess the appropriateness of the response scales for items using a Likert scale[74].

This research included Integrated Knowledge Translation (iKT) principles, a paradigm that prioritizes participatory collaborations between knowledge users, such as policymakers, practitioners, patients, and the public, throughout the research process[75]. Working together to address a research need, the collaboration provided an opportunity to exchange insights from the public practice and research domains. The collaborators are one of the intended user groups of the shortened measure, making the outcomes relevant and increasing the likelihood of the FLit16 being used in public health practice. Through collaboration with a working group of public health nutrition practitioners, the shortening process was guided by professionals entrenched in the practical application of such measures, ensuring the research was grounded in real-world relevance and applicability. This approach enriched the research with practical insights and aligned the study's design and outcomes with the immediate needs of and constraints faced by these professionals. Their insight was particularly valuable in making decisions on which item to retain when multiple items had similar parameters. For example, within the food attitude/dietary behaviour attribute, an item related to preparing a meal using plant-based proteins was selected over an item with similar difficulty related to confidence in changing a recipe to make it healthier, as an item about following a recipe had already been selected. The team's experiences promoting plant-based protein foods in community public health were noted, as was their familiarity with Canada's Dietary Guidelines, which calls for increased plant-based food consumption[64]. As the collaborators represent one of the primary user groups, this synergy between research and public health practice makes the research outcomes practically viable and immediately relevant.

More than half of the sample used for the IRT analysis consisted of post-secondary students representing a specific age and a common level of educational attainment. The inclusion of the development data, drawn partially from groups who traditionally experience social vulnerability, added diversity to the sample and enhanced the robustness of the IRT analysis. Despite this, the overall sample was somewhat homogeneous with respect to racial/ethnic identity, thus not allowing exploration of the measure's validity in diverse groups including young adults identifying as Indigenous, Black, and of Latin heritage. To address these gaps, future research should prioritize diverse samples, particularly racialized communities in Canada, to assess the measure's cross-cultural applicability. Using IRT's Differential Item Functioning (DIF) analysis can be instrumental in uncovering potential biases and ensuring the measure accurately reflects the diverse experiences and abilities across ethnic groups[76]. Additionally, validity should be evaluated with individuals across a broader range of ages to inform the use of the Flit16 with other groups.

The combination of three datasets provided a larger sample from which to characterize the items, strengthening the estimation procedures. However, the study is limited in that the construct validity of the FLit16 was evaluated using only the data from post-secondary students. These data were also included in the IRT parameter estimations, and the results of the validity analyses may be compromised by multiple testing bias or circularity[77]. The decision to use the student data in the IRT model instead of using separate training and validation sets was based on the sample size, with the preference for a larger sample size for accuracy in the item parameter estimations. Additionally, many of the variables used in evaluating the shortened measure's construct validity were not available for the development data or dissimilar from those within the student dataset.

In the process of analyzing the item characteristics of the FLit50 to identify items for inclusion in the shortened measure, the IRT results gave valuable insight. The findings indicate that many of the questions are easy for people with some level of food literacy to answer correctly. A measure that returns scores that are high due to item easiness can mask areas of actual deficiency and make it difficult to target interventions. These insights are valuable in directing future revisions of the items included in the full measure and guide the development of more suitable items to better scale individuals' food literacy ability.

6.6 Conclusion

This study resulted in a shortened version of the food literacy measure—the FLit16—and demonstrated its convergent and construct validity. Approaching the selection of items for inclusion in the shortened measure in a manner that balanced statistical rigour with the professional expertise of those working in public health nutrition and food literacy allowed for inclusion of the items most suited to the Canadian context. The full version of the measure was developed to reflect the multi-dimensional conceptualization of food literacy, whereas the shortened measure captures food literacy as a unidimensional construct. The development and validation of a short food literacy measure supports more efficient measurement, with positive implications for improving the understanding and promotion of food literacy in public health contexts.

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CHAPTER 7: CORRELATES OF FOOD LITERACY AMONG POST-SECONDARY STUDENTS IN ONTARIO, CANADA

Target journal: Canadian Food Studies

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7.1 Overview

Background

Food literacy is a set of knowledge, skills, attitudes, and beliefs that contribute to navigating the current food system. Post-secondary students face unique challenges when transitioning to independent living, including establishing new food relationships and eating patterns. Food literacy has been posited as a potential contributor to unfavourable dietary patterns among post-secondary students. Understanding factors associated with food literacy among post-secondary students can inform research to develop and evaluate interventions targeted at improving food literacy.

Objective

The objective was to examine associations between food literacy and demographic, educational, environmental, economic, and health characteristics among post-secondary students.

Design

Cross-sectional food literacy and sociodemographic data were collected from a sample of post-secondary students.

Participants/setting

Data from 413 post-secondary students in Ontario, Canada collected from March to May 2022 through an online survey were used in this analysis.

Statistical analyses

Food literacy was assessed using a 49-item measure of food literacy. Multiple linear regression with adjustments for robust standard errors due to residual heteroskedasticity was used to assess associations between food literacy and characteristics related to demographics (age, gender racial/ethnic identity), educational characteristics (institution type, domestic or international student, academic program), environmental (on-campus or off campus, household composition), income

adequacy, health characteristics (self-rated general and mental health status), and individual food security status over the past 12 months.

Results

Women scored 2.5 points higher on the food literacy measure compared to men ($p < 0.001$), while students identifying as East/Southeast Asian, South Asian, or other racial/ethnic groups scored lower than their White counterparts ($p < 0.001$). Students enrolled in food and nutrition programs scored 3.0 points higher on average compared to those in other programs ($p < 0.001$). Students living in on-campus housing had marginally lower food literacy scores compared to those living off-campus ($p = 0.073$). Higher general health status was associated with higher food literacy by 1.7 points ($p < 0.001$), while experiencing food insecurity was associated with lower food literacy by 1.3 points ($p = 0.004$). Age, mental health, income adequacy, and living situation did not show significant associations with food literacy scores.

Conclusions

These findings provide insight into correlates of food literacy, informing research to develop and tailor educational and programmatic interventions to improve food literacy among post-secondary students.

Keywords

Food literacy, Emerging adults, Post-secondary students, Public health nutrition, Intervention design, Health disparities

7.2 Introduction

Ongoing research is revealing the connections between food intake and susceptibility to prevalent illnesses such as cancer, type 2 diabetes, coronary heart disease, and stroke[1,2]. The incidence and magnitude of diet-related health issues across the globe have elevated food and nutrition research as a matter of public health priority in many nations, Canada included[3–5]. Currently, a large portion of the Canadian population does not meet dietary recommendations[6,7], with inadequate dietary patterns contributing to adverse physical and mental health outcomes[8,9]. These concerning dietary patterns are prevalent across all life-stages[10], including emerging adulthood[11].

Emerging adulthood is the stage of development that captures the unique transition between adolescence and young adulthood[12,13], as it is a time of establishing identity, navigating new eating independence, and building lifelong health-related habits[14,15]. Research suggests that emerging adulthood is characterized by a marked decline in diet quality[16], with practices like meal-skipping, frequent snacking, and high intakes of fast food, sugar-sweetened beverages, foods high in saturated fats, and low fruit and vegetable consumption commonplace[17–19]. Emerging adulthood is an important time to encourage healthy eating, as it is suggested that practices developed during this period persist into adulthood[12,20,21], making it an ideal stage to intervene[22,23]. Research about food literacy is growing, spurred by its potential in shaping food practices and as a possible lever in improving health[24].

Food literacy is a multidimensional construct, encompassing the skills, behaviours, and knowledge individuals need to navigate the food environment and meet their nutritional and health needs[25]. It may be influenced by a spectrum of interrelated factors, from individual to external determinants[26,27] that can be conceptualized using the socioecological framework[28], which is commonly used in public health research and practice[29,30]. Attributes such as food and nutrition knowledge, language, attitudes, and perceptions may be shaped by personal experiences and interpersonal interactions, such as those with peers or family[28,31,32]. Conversely, the external environment may shape food literacy through avenues like community and school-based education programs, public health initiatives, media exposure, and policy and regulatory frameworks[25,33,34].

Post-secondary institutions play an important role in public health activities given their engagement with those transitioning from adolescence to adulthood. There exists a growing movement to integrate health promotion into college and university campuses, which has gained significant momentum with the adoption of the Okanagan Charter[35], an international framework developed in 2015 to guide post-secondary institutions in embedding health into all aspects of campus culture and to "lead health promotion action and collaboration locally and globally"[36]. In Canada, this has led to the formation of the Canadian Health Promoting Campuses network[37], which aims to implement these principles by fostering environments that promote well-being and academic success. Within this framework, aspects related to food, including food literacy, play an important role. Adequate nutrition is essential for student health[38], directly influencing academic performance[39], mental health[40], and overall well-being[41,42]. Despite its importance, food literacy remains a relatively understudied area among emerging adults and on campuses. Campus programming and education aimed at enhancing food literacy may benefit students by equipping them with the knowledge and skills to engage with complex food environments and in healthier dietary practices[43]. However, with a lack of a common conceptualization and standardized measures for the Canadian context, little is known about food literacy among students and how it may differ by factors related to studentship.

Within the population of emerging adults, post-secondary students represent a unique cohort that merits attention due to their transitional life stage[44]. This period is marked by significant shifts in living situations, adaptation to educational pressures, economic challenges, and evolving health needs[44,45]. Examining aspects of health in relation to individual and environmental factors among post-secondary students can contribute to our understanding of the complex realities of student life[28,45–47] and facilitate research to interrogate how these factors might influence food literacy as a component of overall dietary health[48–54].

Research that incorporates individual-level factors has found that food literacy tends to improve with age[55,56], likely due to the accumulation of experiences and opportunities to engage with food-related activities. Gender differences have been noted, with women typically having higher food literacy[31,57–59] and behaviours thought to stem from food literacy, like using labels[60] and consuming home-prepared meals more frequently[61]. Some evidence suggests lower food literacy among racialized groups[62]. However, educational attainment and income are also linked with food literacy[63,64], suggesting that inequitable socioeconomic dynamics may confound findings related to racial and ethnic identity. The research to date highlights the importance of considering a spectrum of individual characteristics in the study of food literacy.

Research quantifying the association between food literacy and characteristics related to education is limited. Despite a lack of direct examination of food literacy, researchers have considered educational characteristics related to other health behaviours and outcomes, noting that more can be done to explore health phenomena of students[13]. For example, differences in health behaviours by post-secondary institution type have found more pronounced risk in terms of poor diet, smoking status, and lower physical activity in vocational schools[65–68]. Attention has been given to differences in health and health behaviours in relation to student status, with differences between domestic and international students related to dietary challenges, resulting in unfavourable eating practices and adverse health outcomes[69–71]. The nature of the program of study has also been the focus of research, with findings indicating that those studying in health-related programs have higher engagement with positive health behaviours[72–76]. Examining characteristics association with education is not straightforward, as there are complex influences involved in decisions to pursue a particular educational route, with that route potentially influencing health and wellbeing in different ways, such as through curricular content, time demands and constraints that may affect opportunities to gain food literacy[77–80]. These intersecting educational factors are important to understanding varying student experiences and the opportunities and challenges in developing food literacy and, thereby, diet quality.

The nature of student accommodation deeply influences daily experiences and health behaviours as young adults gain independence. Attending post-secondary education often marks the first experience of living independently for many students, a transition that significantly influences their health behaviours[81–83]. Living on campus versus off campus can significantly impact a student's lifestyle[84–86] and has been found to be associated with differences in campus food purchases and food preparation activities[87]. The dynamics of household composition, such as residing alone, with peers, or with family, can further influence eating patterns[54,88]. Students who choose to remain in their familial homes might experience a slower transition to acquiring independent living skills[89,90], including with respect to food literacy[17,91] and eating practices[92–94]. In such settings, the concept of food gatekeepers—who manage food shopping and preparation—may play a crucial role in shaping dietary habits[95]. Economic challenges commonly faced by students can affect their food literacy development[96–99]. Economic constraints remain a critical factor contributing to food insecurity, a significant concern on Canadian campuses[100–103]. Research examining the link between food literacy and food security is mixed, with some studies finding an association[51,80,104–106] and others finding none[107,108].

Self-rated general and mental health status reflects perceptions of well-being and can serve as useful correlates in examining other health-related constructs, such as food literacy. The dynamic relationship between health status and health behaviours has drawn attention in health research, as low perceived health can influence motivation for improving health and engaging in health-related actions[109]. This dynamic is particularly critical among young adults, including college students, who face high rates of mental health challenges[110]. General health and well-being have been shown to correlate positively with food literacy[111]. However, the association between mental health and food literacy ability is less clear, despite an association between better mental health and positive health behaviours[40,112–114]. Understanding how food literacy interacts within general health and wellbeing is crucial for developing interventions that can address and mitigate barriers related to aspects of health in this vulnerable population.

Despite the growing interest in food literacy and its potential influence on health through diet, research assessing the correlates of food literacy among post-secondary students in Canada is limited. Earlier research to evaluate the construct validity of a food literacy measure (FLit50) in **Chapters 5 and 6** explored bivariate associations between food literacy and some individual characteristics, but without accounting for potential confounders. In the absence of a clear framework to guide studies of food literacy among post-secondary students, exploring a wide range of student factors is both practical and appropriate. This study capitalizes on data collected from students to assess a novel food literacy measure, allowing for exploration of various individual and environmental factors linked to student life in relation to food literacy. This study aimed to examine associations between food literacy and demographic, educational, environmental, economic, and health characteristics among post-secondary students in Ontario, Canada.

7.3 Methods

Data were collected in a cross-sectional survey of post-secondary students attending colleges or universities in Ontario, Canada. Between March and May 2022, social media advertisements and emails forwarded through institutional partners were used to recruit participants. The data were initially collected to assess the construct validity of a novel food literacy measure, the FLit50, using quota sampling to recruit students enrolled in food and nutrition programs and other programs. Eligible participants were aged 18 to 25 years old and in their second year of study or above in a university or college in Ontario, Canada. Potentially interested participants completed a screening questionnaire to assess their eligibility based on age and student status, with verification through an institution-issued email address. Eligible participants were provided a personalized link to a Qualtrics-hosted survey[115], where they reviewed study details and were asked to consent to participate. The survey contained the FLit50 alongside questions on demographic, educational, environmental, economic and health characteristics, as well as an assessment of individual food security over the past 12 months. To ensure data integrity and reduce the risk of bot activity, five attention-check questions were included throughout the survey. Participants received a $10 honorarium upon completion of the survey. The study was reviewed and approved by the University of Waterloo Office of Research Ethics (ORE # 43057).

A total of 472 students consented and responded to the survey (**Figure 18**). Respondents who completed the survey in less than seven minutes— based on one-third of the time to complete the FLit50 items in the test-phase from a previous evaluation of the measure of 11.2 mins[116], with time added to allow for additional questions—and who did not meet the attention-check criteria (correctly answering at least 3 of 5 questions), were excluded from the dataset (n=15). Data from 413 students were included in these analyses after accounting for missing data and small cell counts on the characteristics of interest.

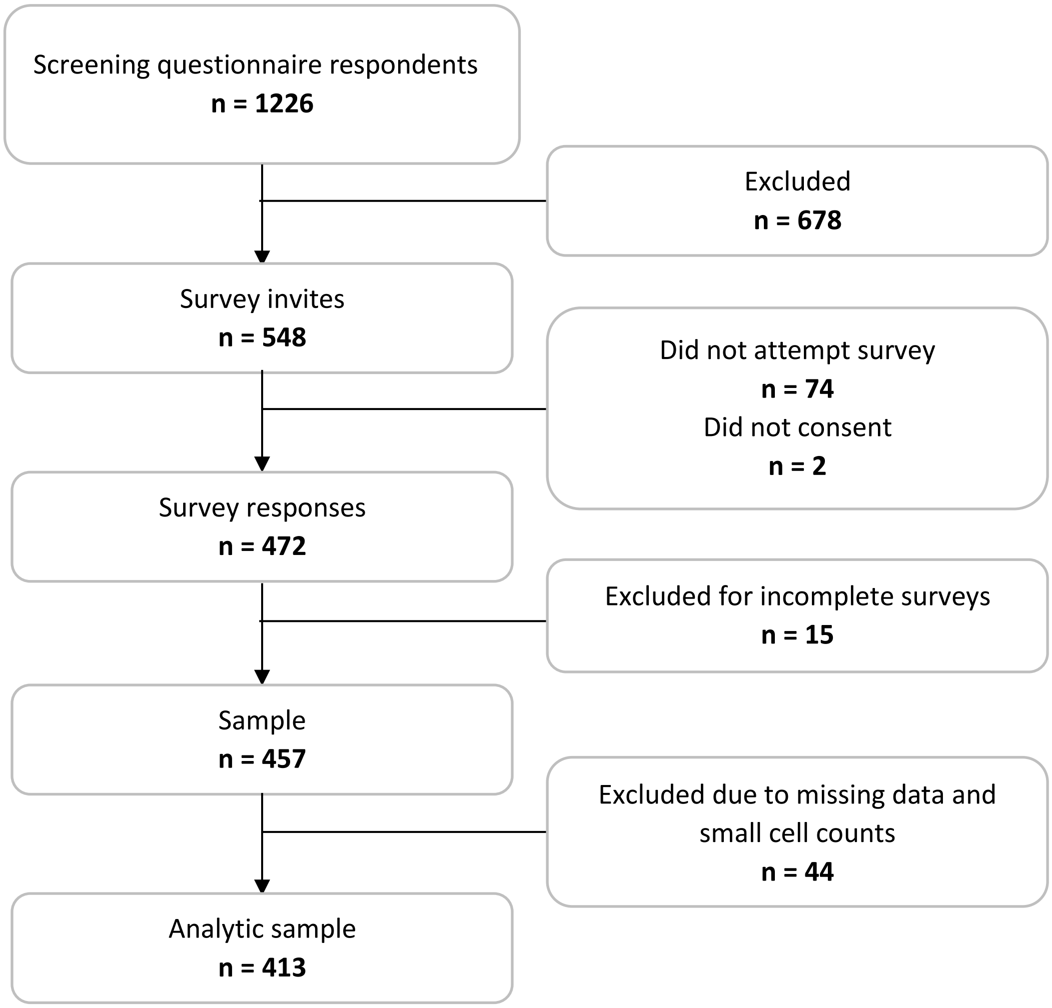

Figure 18: Participant flow to analytic sample for a study examining the correlates of food literacy amongst post-secondary students.

Variables

Food literacy was measured using the FLit50, a recently developed measure tailored for use with individuals aged 16–25 years residing in Ontario, Canada[116] (**Appendix 1**). This 50-item measure is grounded in a multi-dimensional framework of food literacy, encompassing ten distinct attributes of food literacy[25,33] (**Figure 19**). The items contributing to these attributes are aggregated into four domains, including food and nutrition knowledge, food skills, self-efficacy and confidence, and ecological factors. Scores for the domains are combined to produce an overall food literacy score. The FLit50 comprises 19 multiple-choice questions targeting food knowledge, nutrition knowledge, food and nutrition language, food skills, and nutrition literacy. Fifteen items assess nutrition self-efficacy cooking self-efficacy through a Likert scale, requiring participants to indicate their confidence level across four options (ranging from not confident to very confident). Additionally, 16 items evaluate food attitudes and dietary behaviours, food systems, and sociocultural and social determinants of health using a five-point Likert scale (ranging from strongly disagree to strongly agree, with a neutral response option). The scoring method, as directed by the developers[116], assigns one point for each correct response to the knowledge questions and one point for affirmative Likert scale responses (indicating agreement or confidence). Responses that indicated disagreement or neutrality were not awarded points. Due to a digitization error, one question was inadvertently omitted, reducing the total to 49 items, with seven items instead of eight for the food attitude and dietary behaviours attribute. The FLit50 has demonstrated face, content, and aspects of construct validity within the study population[116] (**Chapter 5**), allowing for confidence in the measured scores. For analysis purposes, the food literacy score was treated as a continuous variable.

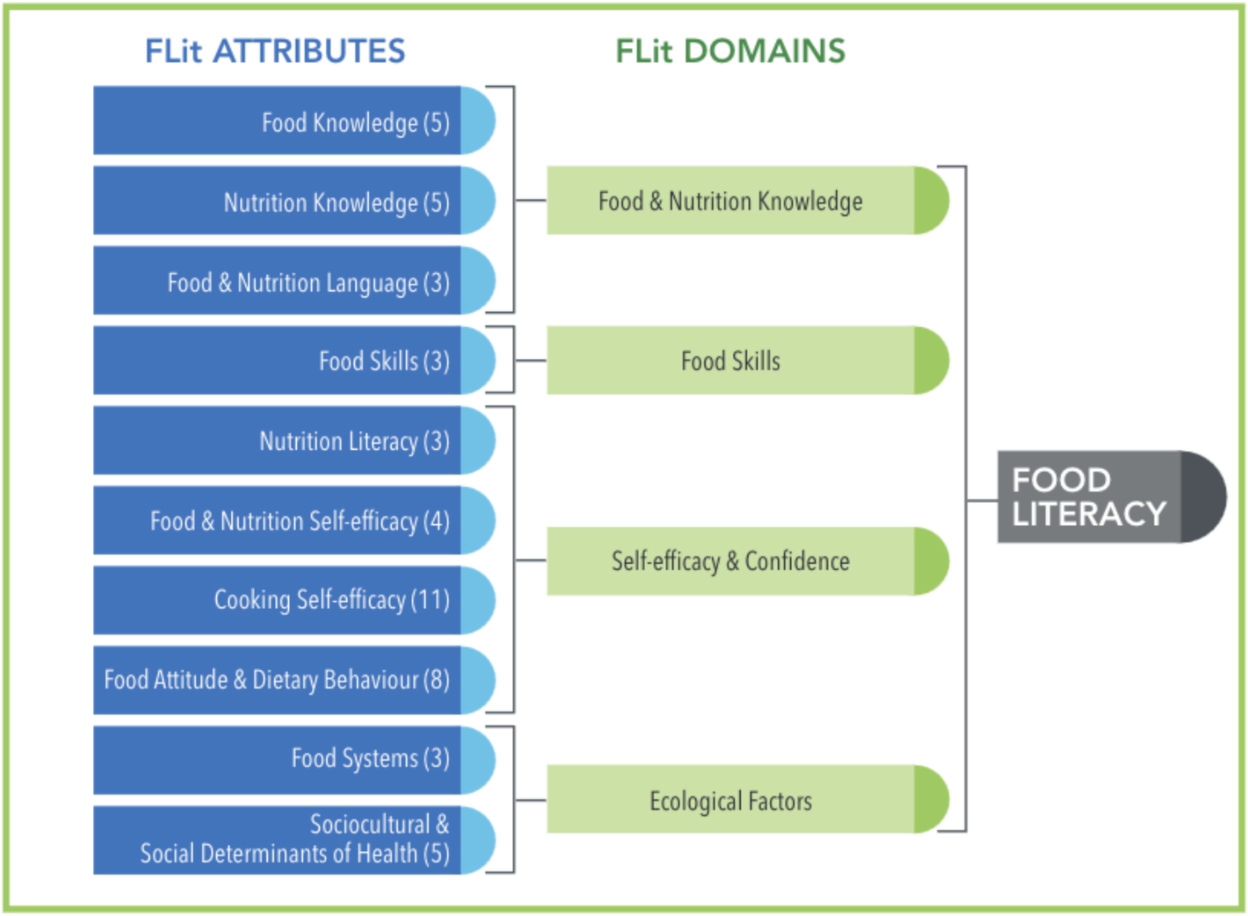

Figure 19: Conceptual model underlying the food literacy measure. Values in parentheses represent the number of items on the food literacy measure related to each reflective attribute and formative domains. Drawn from the Food Literacy (FLit) Measures Guide (Appendix 7).

Demographic characteristics included age, gender identity, and racial/ethnic identity. Individuals indicated their age from a list ranging from 18 to 25 years old. Gender identity was assessed with a question: "What is your gender identity?"[117]. Trans men and women were included as men and women, respectively. Those who identified as genderqueer or non-conforming (n=8) or affirmed other identities (n=3) were excluded due to low cell counts. Racial and ethnic identities were queried based on classifications suggested by Hughes and colleagues[118]. White (Caucasian, European descent), East/Southeast Asian, and South Asian identities garnered sufficient responses for use as independent categories. Those identifying as Black, Indigenous, Latino, and Middle Eastern, along with participants who selected mixed racial or ethnic identity, 'prefer not to say', or described their identity in an open-text box were grouped into an 'Other' category due to smaller counts. One record was excluded as their racial and ethnic identity could not be discerned for categorization.

Characteristics related to education, including the school type (college or university), academic program area (food and nutrition-related academic programs and others), and enrollment status (domestic and international students) were queried. Students were asked to identify their school from a selection of schools that offer food and nutrition related programs (data used to evaluate the validity of the food literacy measure in **Chapter 5**) or provide their school's name. School names were manually coded and categorized as a college or university. Four participants indicated their preference to not identify their institution, and their data were removed from the analytical sample. Participants were categorized as either studying in food and nutrition related programs or non-food and nutrition related programs. Students could select from common food and nutrition programs listed or provided in Ontario or identify their academic program name in an open text entry, which were manually coded; in cases in which no response was provided, the student's response on the screening questionnaire (yes or no to studying in a food and nutrition related program) was used. Student status was queried as a domestic student from within Ontario, domestic student from within Canada, or international student. The two domestic options were combined into one category for the analysis. One record was excluded because of missing data on student status.

Living arrangement characteristics were captured through variables pertaining to housing type and household composition[104]. Housing type was categorized as on-campus vs. off-campus[103]. Those with precarious housing situations (n=2) were removed from the analysis as the small count would make it difficult to draw meaningful conclusions from their inclusion. One respondent preferred not to respond to the question and their data were removed. Students were asked to indicate whether they lived alone, with roommates, with a spouse or common-law partner with or without children, or with parents/guardians/extended family. These response options were collapsed to living alone, with peers/roommates (including both spouse options), and with family (parents/guardians/extended family).

Income adequacy was queried through a single question, asking, "Thinking about your total monthly income, how difficult is it for you to make ends meet?"[119]. Responses were collapsed into experiencing difficulty making ends meet (combining the responses of 'very difficult' and 'difficult') and not experiencing difficulty (responses of 'neither easy nor difficult', 'easy' or 'very easy'). Responses of 'Don't know' or those who preferred not to say were removed (n=21).

Respondents were asked to report their general and mental health status using a five-option Likert scale[120,121]. Responses to these questions were transformed into binary categories representing a negative (responses of 'poor' and 'fair') and positive (responses of 'good', 'very good', or 'excellent') self-assessment. Responses of 'don't know' (n=3) were excluded from the analysis.

The ten adult-referenced questions of the Household Food Security Survey Module (HFSSM)[122] was used to assess food security status over the previous 12 months. The HFSSM, developed by the US Department of Agriculture (USDA)[123] is widely used in food security monitoring and research, including in Canadian surveillance[124]. The items within the HFSSM range in severity from worrying about running out of food, to not being able to eat balanced meals and skipping meals, to going a whole day without food[123]. The question text of the HFSSSM was modified to capture the individual level of food security, removing reference to the household. Based on the number of affirmative responses individuals were categorized as being food secure (no experiences of food insecurity) or food insecure (any experiences of food insecurity).

Statistical analysis

The data were exported from Qualtrics survey software (Provo, Utah) to Microsoft Excel (Redmond, Washington)[125] for data cleaning and coding before being imported to R Studio (Boston, Massachusetts, USA)[126] for analyses.

Descriptive statistics, including measures of central tendency and dispersion, were generated and the distribution of respondents across characteristic levels were examined. A multiple linear regression analysis was conducted to assess associations between food literacy scores and the various independent variables. A single model with all variables was used to allow for examination of the association of each variable with food literacy while adjusting for a range of potential confounders. Diagnostic tests were performed to evaluate the standard assumptions of regression analysis. The results of multicollinearity tests showed that no variables had a VIF of over 1.25, meeting the threshold of below 10[127] indicating reliability in the regression estimates. A histogram of the residuals appeared to show a normal distribution, though the Shapiro-Wilk test found the residuals were not normally distributed ($W = 0.97$, $p < 0.001$). The Breusch-Pagan test indicated significant heteroskedasticity ($\chi^2(1) = 32.32$, $p < 0.001$), suggesting the presence of non-constant variance in the residuals of the model. Given the exploratory nature of the study, the issue of heteroskedasticity was addressed using adjustments for robust standard errors, as it is less invasive and preserves the original scale and interpretation of the model in contrast to transformations of food literacy scores or employing different modelling methods[128]. Results from the regression model are described and interpreted using p-values, confidence intervals, and standardized effect sizes (Cohen's d)[129].

7.4 Results

The average age of participants was 22.5 years (**Table 9**). Seventy-seven percent identified as women. Most individuals identified as White (40%). East/Southeast Asian and South Asian groups were represented at 25% and 20% of the sample, respectively. Most students were from within Canada (95%), and 26% of participants were training in academic programs related to food and nutrition, while the remainder were studying in other programs. Related to their living situation, 95% were living in off-campus housing. Most participants lived with roommates (57%), 38% lived with family (parents or relatives), and 6% lived alone. Eighty-five percent of the respondents indicated it neither easy nor difficult, easy, or very easy to make ends meet each month. Seventy-one percent of students rated their general health as being positive, whereas 50% reported a negative self-assessment of their mental health. Sixty-one percent of students were classified as being food secure.

Table 9: Sample characteristics and distribution of variables among Ontario post-secondary students in a study on covariates of food literacy scores

Sample characteristic	Total sample (n=413) n (%[1])
Gender identity	
Man	96 (23)
Women	317 (77)
Age	
18	5 (1)
19	61 (15)
20	85 (21)
21	101 (24)
22	61 (15)
23	45 (11)
24	16 (4)
25	32 (8)
Age not reported	7 (2)
Racial/Ethnic Identity	
White (Caucasian, European descent)	166 (40)
East/Southeast Asian (Chinese, Korean, Japanese, Taiwanese descent; Filipino, Vietnamese, Cambodian, Thai, Indonesian, other Southeast Asian descent)	103 (25)
South Asian (South Asian descent, e.g., East Indian, Pakistani, Bangladeshi, Sri Lankan, Indo-Caribbean etc.)	84 (20)
Other	60 (15)
School Type	

University	397 (96)
College	16 (4)
Academic Program area	
Non-food and nutrition program	305 (74)
Food and nutrition program	108 (26)
Student Status	
Student from within Canada	387 (95)
International Student	26 (5)
Household composition	
Alone	24 (6)
With other peers (roommates)	233 (57)
With family	155 (38)
Housing situation	
Off campus	391(95)
On Campus	22 (5)
Perceived income adequacy	
Difficult, Very difficult	61 (15)
Neither easy nor difficult, Easy, Very easy	352 (85)
Self-reported general health	
Poor / Fair	120 (29)
Good / Very good/ Excellent	293 (71)
Self-reported mental health	
Poor / Fair	205 (50)
Good / Very good/ Excellent	208 (50)
Food security status	
Food secure	253 (61)
Food insecurity	160 (39)

1 – Percentages are rounded and may not add up exactly to 100

The mean food literacy score was 42 of a possible 49 (SD = 4.7), with a median score of 42, an interquartile range (IQR) of 6, a mode of 45, and a range of 25 to 49 (n=413). The skewness of the distribution -0.74, indicating a negative skew toward higher scores, and the kurtosis was 0.19, suggesting a non-normal distribution. The distribution of scores is depicted in **Figure 20**.

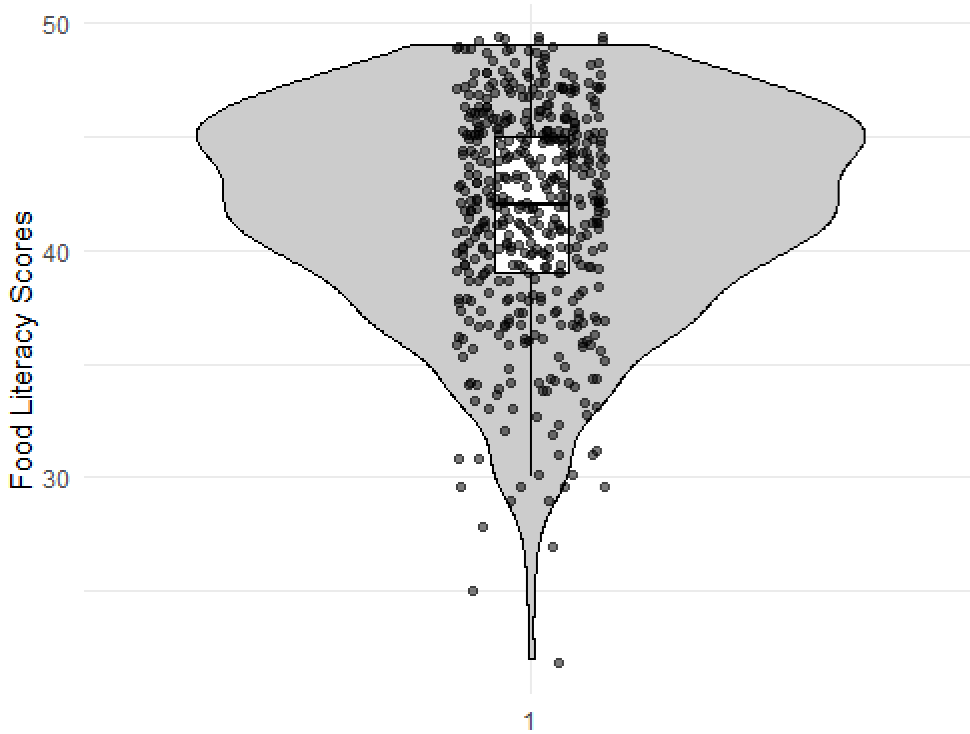

Figure 20: Distribution of food literacy scores using the FLit50 with violin and boxplot overlay.

Age was not associated with food literacy scores (β = 0.02, 95% CI [-0.02, 0.05], *p* = 0.397, d = 0.003) (**Table 10**). Women had higher food literacy scores on average compared to men, with a mean difference of 2.5 points (β = 2.51, 95% CI [1.52, 3.50], *p* < 0.001, d = 0.53), indicating a moderate effect size. East/Southeast Asian students scored 2.0 points lower (β = -2.04, 95% CI [-3.04, -1.04], *p* < 0.001, d = -0.43), South Asian students scored 2.4 points lower (β = -2.41, 95% CI [-3.46, -1.35], *p* < 0.001, d = -0.51), and those identifying as "Other" racial or ethnic identities scored 1.6 points lower on average (β = -1.57, 95% CI [-2.69, -0.44], *p* = 0.007, d = -0.33) than those identifying as White.

Neither school type (college or university) nor whether students were from within or outside of Canada were associated with food literacy. Students enrolled in food and nutrition-related academic programs had higher mean food literacy scores on average compared to those in other programs, by 3.0 points (β = 3.01, 95% CI [2.23, 3.79], *p* < 0.001, d = 0.64). Food literacy scores were lower among students residing in on-campus housing, by 1.5 points, than those living off-campus (β = -1.46, 95% CI [-

3.04, 0.13], *p* = 0.073). Whether students lived alone, with peers/roommates, or with family was not associated with food literacy scores.

Income adequacy was not found to be associated with food literacy. Students who rated their general health as positive or neutral scored 1.7 points higher on average than those with poor general health (β = 1.74, 95% CI [0.83, 2.66], $p < 0.001$, d = 0.37), indicating a moderate effect size. Mental health status was not meaningfully associated with food literacy. Students who had experienced food insecurity in the past 12 months scored 1.3 points lower on average compared to those who were food-secure (β = -1.27, 95% CI [-2.14, -0.41], $p = 0.004$, d = -0.27).

The model explained approximately 40.3% of the variance in food literacy scores ($R^2 = 0.403$), adjusted $R^2 = 0.380$), a residual standard error of 3.716 on 396 degrees of freedom, and an overall significance of F(15, 396 DF) = 17.79, $p < 0.001$.

Table 10: Regression results showing estimates, confidence intervals, and effect sizes of demographic, educational, environmental, economic and health correlates of food literacy in Ontario post-secondary students.

	Estimate	Std. Error	P-value	Lower.CI	Upper.CI	Effect Size[1]
(Intercept)	39.687	1.175	< 0.001	37.39	41.99	8.409
Age	0.015	0.018	0.397	-0.02	0.05	0.003
Women[2]	2.509	0.504	< 0.001	1.52	3.50	0.532
East/Southeast Asian[3]	-2.036	0.510	< 0.001	-3.04	-1.04	-0.431
South Asian[3]	-2.409	0.538	< 0.001	-3.46	-1.35	-0.511
Other racial/ethnic identity[3]	-1.568	0.574	0.007	-2.69	-0.44	-0.332
College institution[4]	-1.075	1.019	0.292	-3.07	0.92	-0.228
International Student[5]	-0.921	0.919	0.317	-2.72	0.88	-0.195
Food and nutrition academic program[6]	3.010	0.397	< 0.001	2.23	3.79	0.638
On campus housing[7]	-1.457	0.810	0.073	-3.04	0.13	-0.309
Live with peers/roommates[8]	0.803	0.749	0.285	-0.67	2.27	0.170
Live with family[8]	0.552	0.789	0.485	-1.00	2.10	0.117
Income adequacy – difficult[9]	0.520	0.620	0.402	-0.69	1.73	0.110
Positive and neutral general health[10]	1.743	0.465	0.000	0.83	2.66	0.369
Positive and neutral mental health[11]	0.591	0.379	0.120	-0.15	1.33	0.125

Experiences with food insecurity[12]	-1.274	0.443	0.004	-2.14	-0.41	-0.270

1 – standardized effect size calculated using Cohen's d
2 – the reference category is men
3 – the reference category is individuals who identify as White (Caucasian, European descent)
4 – the reference category is those who attend a University institution
5 – the reference category is Domestic student (Canada)
6 – the reference category is those studying in Other (non-food and nutrition) academic program
7 – the reference category is those residing in off campus housing
8 – the reference category is those who live alone
9 – the reference category is those who report their income adequacy as easy to make ends meet at the end of each month
10 – the reference category is those who self-rate their general health negatively
11 – the reference category is those who self-rate their mental health negatively
12 – the reference category is those who report no experiences of food insecurity in the past 12 months

The residual diagnostic plots (for the multiple linear regression model are shown in **Figure 21**. The Residuals vs Fitted plot assesses linearity and homoscedasticity; the plot shows a slight curvature, indicating some non-linearity and potential heteroscedasticity. The Normal Q-Q plot checks the normality of residuals, and although most points align with the theoretical quantiles, deviations at the tails suggest some non-normality. The Scale-Location plot further assesses homoscedasticity by displaying the spread of standardized residuals; the slightly uneven spread across fitted values suggests mild heteroscedasticity. Finally, the Residuals vs Leverage plot identifies influential data points, with one point showing moderate leverage, but none appear excessively influential. Overall, these diagnostics suggest the model is reasonably well-fitted, though slight violations in assumptions are present.

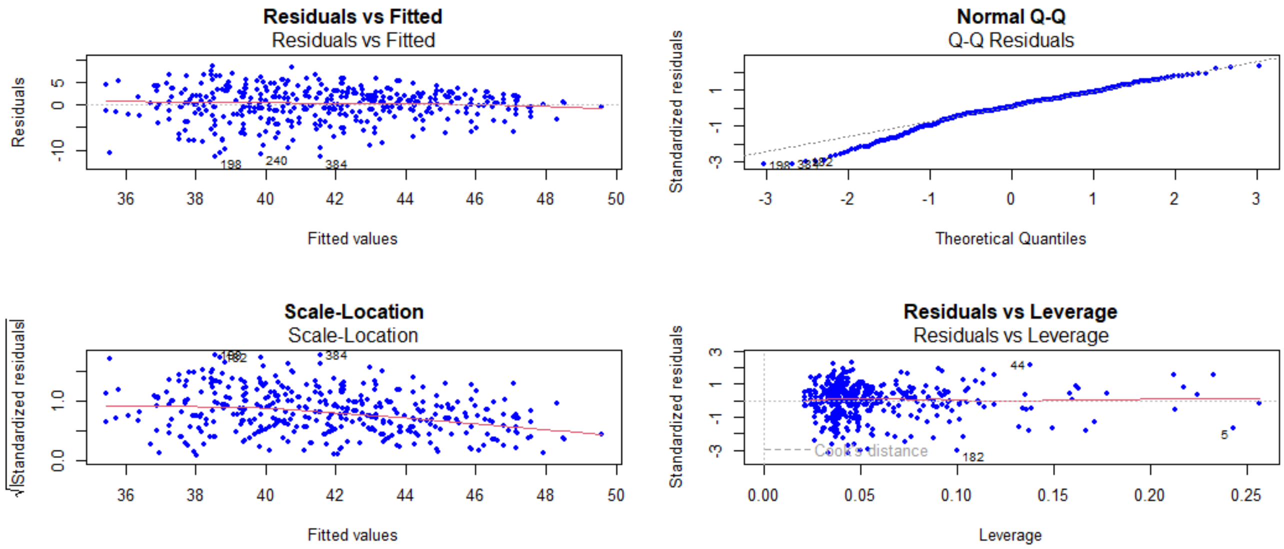

Figure 21: Residual diagnostic plots for the multiple linear regression model examining correlates of food literacy among post-secondary students. The plots include (a) Residuals vs Fitted, (b) Normal Q-Q, (c) Scale-Location, and (d) Residuals vs Leverage.

7.5 Discussion

This study leveraged data from a sample of postsecondary students to investigate how demographic, educational, environmental, economic, and health-related factors are associated with food literacy. The regression analysis revealed associations between each of gender identity, racial/ethnic identity, academic program, housing situation, general health status, and food security and food literacy. Specifically, women, individuals identifying as White, students enrolled in food and nutrition programs, those living off-campus, and individuals with higher self-reported general health exhibited higher food literacy scores, when controlling for other variables. These findings underscore the multidimensional nature of food literacy and suggest that factors related to both individual demographic characteristics and broader life circumstances may contribute to food literacy. Building on these findings to inform research that allows for causal inferences can inform targeted interventions and educational strategies to address disparities in food literacy among postsecondary populations.

Gender differences in food literacy, favourable toward women, have been shown in other research[60,73,130–132], and with other related abilities, such as nutrition literacy[133,134] and planning and managing food[135] However, other research has found negligible or no association between gender identity and food literacy[31,42,60]. Higher food literacy scores among women in this study may stem from their greater presence in food and nutrition-related academic programs; of those studying in food and nutrition programs, 90% were women. Higher food literacy among women may also be linked to the continuation of traditional gender roles related to food[136] and be influenced by societal pressures related to health and body image[137,138].

The differences in food literacy among individuals with different racial and ethnic identities are consistent with published research[32,62,139,140]. In this study, individuals identifying as White scored higher on the FLit50 than those with other racial and ethnic identities, aligning with findings from a study of food and nutrition knowledge levels with adolescents in Ontario[31]. The observed disparities and the magnitude of differences in food literacy across different ethnicities suggest that approaches to improving food literacy may need to be tailored to address the variations related to food knowledge, attitudes, and beliefs among different groups. Differences in food literacy may be a product of socioeconomic factors, such as income levels, educational attainment, and access to healthy food options[31,135,141], reinforcing the need for food literacy to be included in efforts to enhance food equity and justice initiatives[142,143]. The design of the food literacy measure may not reflect food literacy as it is experienced among diverse groups, and efforts should be made to evaluate it with diverse populations. The FLit50, for instance, might focus on aspects of food literacy that are less relevant or unfamiliar to individuals from different backgrounds.

Education and training in fields related to food and nutrition programs have been shown to be positively associated with food literacy[72,73], consistent with the findings of this study. This finding suggests the role of education in promoting food-related knowledge and supports calls to expand food-related education into earlier schooling and community programs[144–147]. The integration of food and nutrition training through school and other community institutions has the potential to improve dietary practices and health outcomes across diverse populations. The development of education and training programs aimed at improving food literacy should recognize differences among sub-groups.

Food insecurity is a substantial issue on campuses in Canada[148,149] and was associated with lower food literacy scores in this study, consistent with some published research[104,150]. The small negative effect size observed between food literacy scores and food insecurity—whereby those experiencing food insecurity exhibit lower food literacy compared to who are food-secure—raises the possibility that food literacy may contribute to resilience against food insecurity[151]. However, food insecurity is understood to be driven by material deprivation, such as income inadequacy[152]. Differences in food literacy scores based on income adequacy were not observed in this study, diverging from results in other studies[31,135,141]. Income adequacy was assessed using a single question about the perception of being able to make ends meet. While this question provides some insight, it does not fully capture the complexities of economic behaviours, as strategies used to stretch funds could obscure the true impact of income inadequacy. Other studies have used other indicators, like median household income[31], the MacArthur scale of subjective social status[153], or a socioeconomic status index[154], likely contributing to differences in findings.

The relationship between food literacy and general and mental health is a scarcely studied area to date and is identified as a factor requiring more investigation[111]. The findings from this analysis reveal an association between positive general health and higher food literacy. Consistently, a study of Ontario adolescents found higher food knowledge was related to higher ratings of positive mental health status[31]. It is conceivable that food literacy and health share a bidirectional relationship, whereby better health could foster an interest in and capacity to practice food literacy, and conversely, enhanced food literacy may lead to improved health, thereby creating a reinforcing cycle of health and knowledge and ability[155,156]. There are suggestions that mental health may benefit from interventions aimed at improved food literacy[40]. In this study, general and mental health were assessed with a single question each, which masks the complexities. Future research should employ more comprehensive assessments of health and wellbeing statuses[157,158]. Beyond food literacy, half of students in the current study—which was conducted during the SARS-COV-2 pandemic—rated their mental health negatively, raising broader concerns that warrant further investigation.

Other factors included in the model did not demonstrate meaningful associations with food literacy. Age was not found to be strongly linked, which is in line with findings from another Canadian study of adolescents[31]. Food literacy evolves throughout the lifespan reflecting the varying levels of responsibility individuals assume over their lifetime[56,63,159]. It is possible that differences in food literacy are not readily observed in this study due to the small age range during emerging adulthood. Differences in food literacy by housing type and composition were found, though the magnitude of differences was not practically significant. Research has provided evidence of differences in food acquisition behaviours between those on and off campus[87]. The on-campus residential environment and campus housing regulations, such as those that restrict cooking equipment and promote meal plan purchases, impact opportunities to gain experience with food preparation activities[160]. Though this research did not indicate differences in household composition and food literacy, interpersonal interactions and patterns with food among roommates and family exist and should be further explored. With more young adults delaying their move from the familial home[161], public health initiatives could facilitate the development of food literacy acquisition prior to moving out. Educational characteristics, such as the type of institution (college vs university), part-time vs full-time enrollment, and domestic vs. international student, did not demonstrate associations with food literacy scores.

Small counts for some of the characteristic levels studied prevented a full analysis of the association of each variable. This is important as it lowers the chance of detecting an association when one may exist. In interpreting the results of the regression model, it is important to consider the slight deviations from model assumptions indicated through the residual diagnostic plots (**Figure 21**). The presence of mild non-linearity and heteroscedasticity suggests that while the model provides a reasonably good fit, some caution is needed when interpreting the findings. The slight deviation from normality in the residuals, particularly at the tails, could be attributed to the skewed nature of the food literacy scores, reflecting the overall high levels of food literacy in the sample, and could imply that additional variables or interaction terms may be needed in future analyses. Additionally, based on the examination of residuals and leverage plot, certain observations may be disproportionately affecting the model's estimates. Future research should use larger and more diverse samples to support robust investigations. Advanced modeling techniques that are less sensitive to these assumption violations can also be explored. Despite these modelling issues, this study provides a foundation for exploring food literacy and variables common to post-secondary students, offering a valuable starting point from which future research can build.

This research contributes to the literature through its exploration of relatively understudied correlates of food literacy particular to students. The variables included in this analysis account for only a small portion of the variance in food literacy scores ($R^2 = 0.403$, adj. $R^2 = 0.380$, $p = < 0.01$), indicating other associative factors that were not considered in this model. This points to opportunities to further understand the complexities involved in developing food literacy. Future research should continue to include factors that may shed light on potential influences of food literacy. Qualitative research can be used to enrich the understanding of food literacy and how it manifests in decision-making, self-efficacy, and other capacities and beliefs related to food. The focus of this analysis was on food literacy overall. However, food literacy is acknowledged to be a multi-dimensional construct. Further analysis incorporating food literacy domain scores (food and nutrition knowledge, food skills, self-efficacy and confidence, and ecological factors) could reveal more nuanced results.

This exploratory study lays the groundwork for expanding the theoretical understanding of food literacy among young adults by identifying correlates, including individual and environmental. However, its cross-sectional design limits ascriptions of causality. Longitudinal research would help to understand shifts in food literacy over time and in relation to changes in correlates. This study was based on a convenience sample of students recruited mainly through social media, limiting generalization of the findings. Despite these limitations, the sample size (n=413) enabled a preliminary exploration of food literacy levels among post-secondary students. The data were collected in 2022, amid the global SARS-COV-2 pandemic, which profoundly altered student life[163–164] and may have affected food literacy[165], as well as who participated in the survey and their responses. The correlates considered in the study do not include all potentially relevant correlates and a systematic approach to exploration is recommended. For example, a collaborative construction of Directed Acyclic Graphs (DAGs)[166] with experts, practitioners, and researchers could facilitate a more comprehensive and directed modelling of factors hypothesized to shape food literacy and better position the design and validity of future studies.

Post-secondary students, as emerging adults, occupy a unique transitional life stage with profound impact on their lifestyles and dietary health[44,45]. It is a period of developing independence related to food, and acquiring and practicing food behaviours. How individual and environmental complexities of student life are associated with food literacy is important in positioning food literacy as an integral part of overall health.

7.6 Conclusion

This study found associations between gender identity, racial/ethnic identity, academic program, housing situation, health status, food security and food literacy scores among a sample of post-secondary students in Ontario, Canada. Future research building on this study can further interrogate these associations and shed light on the factors that particularly influence the development and application of food literacy among emerging adults. Such research should include more diverse populations and contexts to ensure that the growing evidence base is relevant to efforts to improve food literacy among subgroups.

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CHAPTER 8: DISCUSSION

8.1 Overview

Food literacy is increasingly recognized for its potential role in shaping dietary quality and food-related practices. Studies indicate that individuals with higher food literacy tend to adopt healthier diets[21,196,197], consuming more fruits and vegetables[95,198] and fewer processed foods [100,101], while also enjoying their food more[199]. As interest in food literacy grows globally, efforts to define and measure it have intensified[1]. Robust measurement tools based on comprehensive conceptualization are essential to accurately assess and track changes in food literacy and have been called for by a number of researchers [2,24,200]. A decade-long effort among public health nutrition practitioners in Ontario, Canada, has led to significant progress in conceptualizing food literacy with a unique, multi-dimensional framework[32] and the development of a corresponding measure[127] for use within the Canadian context. This measure was designed for the target population of emerging adults, a group undergoing significant life transitions and an important group for establishing healthy practices[108,201].

The studies within this dissertation were designed to evaluate the FLit50 food literacy measure for construct validity among post-secondary students; analyze item-level characteristics of the FLit50 to inform items for inclusion in a shortened version of the measure using data from post-secondary students and a broader sample of young adults; and explore the demographic, educational, environmental, economic, and health correlates of food literacy among a sample of post-secondary students in Ontario. This research, done in close collaboration with the LDCP Healthy Eating Team, the public health nutrition practitioner team that worked to conceptualize food literacy and develop the measure, aims to enhance the measurement and understanding of food literacy and its determinants in the young adult population within the Canadian context.

8.2 Summary of Key Findings

Chapter 5 presents an evaluation of the FLit50 measure's construct validity among postsecondary students (n=457) through hypothesis testing based on theoretical premises and findings of existing literature. The FLit50 showed adequate construct validity, evidenced by higher food literacy scores among students in food and nutrition programs, women, those with adequate health literacy, those with higher general health, those with higher mental health, and those experiencing food security, as hypothesized. No differences were observed by age or perceived income adequacy. Differences in group means were observed as hypothesized for scores on items reflecting the underlying domains of food and nutrition knowledge and self-efficacy and confidence but not food skills or ecological factors.

Chapter 6 examines the item-level properties of the FLit50 measure using Item Response Theory (IRT), diverging from the Classical Test Theory (CTT) approach used in **Chapter 5**, with the aim of identifying items suitable for inclusion in a shortened version. Using data from the post-secondary students and a broader sample of young adults, item difficulty and discrimination parameters were generated to inform sixteen items selected for inclusion in the shortened measure, the FLit16, in collaboration with the public health nutrition practitioners. The FLit16 demonstrated convergent validity relative to the Flit50 and construct validity among the sample of post-secondary students. Scores from the two versions of the measure were strongly and positively correlated and the short measure was able to differentiate among groups, consistent with the full measure. This study combined the student data with data collected from young adults across Canada for the prior evaluation of the measure[127].

The study presented in **Chapter 7** drew from post-secondary student data to investigate potential individual and environmental correlates of food literacy with a variety of variables related to student life. Data from 413 students were included in these analyses after accounting for missing data on the characteristics of interest. The mean food literacy score was 40 of 49 points. Food literacy was higher among women compared to men, those studying in academic programs related to food and nutrition, and those who reported positive or neutral general health. Food literacy was lower among individuals identifying as Southeast Asian, South Asian, and other racial/ethnic identities compared to those identifying as White. Food literacy was also lower among those who lived on-campus, and those experiencing food insecurity in the previous 12 months. Food literacy scores did not differ by age, income adequacy, domestic or international studentship, whether students attended college or university, household composition, or self-reported mental health status. In the context of increasing emphasis on food literacy education and interventions for young adults, these findings are a foundation for future research to build the evidence base to inform interventions that not only improve food literacy broadly but are tailored to address the nuanced needs of different student sub-groups.

8.3 Strengths and Limitations

The findings of this dissertation should be viewed with an understanding of its strengths and limitations. Notable limitations, categorized into themes associated with methodological choices and those stemming from the data, are highlighted below.

Chapters 5 and 6 focused on evaluating the construct validity of the FLit50 measure and its domains and the development and evaluation of the FLit16. The studies were designed to assess different types of construct validity. Known group validity was employed as a primary indicator, comparing students in food and nutrition-related programs against their peers in other disciplines from the second year onward. The exclusion of first-year students, who may not yet exhibit significant educational impacts from their courses of study, was strategically chosen to reduce Type II errors. The need to target respondents from food and nutrition programs to satisfy the requirements of this analysis reduced the generalizability of the sample, as random recruitment was not possible. This method of employing known-group validity to compare food and nutrition students with others is consistent with approaches used in prior research[169].

Hypotheses related to known differences among groups, such as by gender identity, were formulated based on a review of existing literature and consultations with experts, including the LDCP Healthy Eating Team. The selection of variables was challenging due to the limited research on food literacy in similar contexts and inconsistent findings among published papers. There is a lack of consistency in the variables used across studies of food literacy, along with how food literacy is conceptualized and measured[2,24,200]. The hypotheses tested were consistent across all evaluations of construct validity. However, domain-level analyses may have benefited from uniquely generated hypotheses related to their content. Despite challenges in formulating hypotheses for testing due to inconsistencies in results of previous food literacy studies in different locales, the variables included are grounded in the extant literature.

The concept of measurement is central to research in public health and demands considered approaches to testing, interpretation, and communication. Essentially, validating a measure involves rigorous psychometric analysis, which at its core is subjective, relying on researchers' judgment aided by a thorough description of methods, interpreting results, and disseminating findings. Validity cannot be encapsulated by a single analytical method but rather an accumulation of evidence gathered systematically to support claims of validity[202]. Previous studies of the FLit50 measure have demonstrated face, content, cognitive and factorial validity[127], and this research sought to further establish types of construct validity. Through this research, the FLit50, FLit16, and two domains were described as exhibiting 'reasonable' or 'adequate' validity for our target population. Ultimately, future users of the measures will use these results and judge whether they meet the validity requirements for specific study designs and populations. To help in this judgement, a user guide (**Appendix 7**) was collaboratively developed with the LDCP Healthy Eating Team to outline the evaluation process and clarify the appropriate settings and contexts for using the FLit measure.

The data collection from post-secondary students presented several unique challenges that merit careful consideration. Our study specifically required a targeted sample to analyze known group validity, which culminated in data collected from 116 students from food and nutrition programs and 341 from other disciplines. Although this sample size was statistically sufficient, its composition—predominantly women and students from the University of Guelph—restricts the generalizability of our findings to the broader student body. This limitation stems from non-random selection and the localized nature of the sample. Additionally, the use of self-reported data, a common approach in health research[203], introduces inherent biases such as classification and social desirability biases[204,205]. These factors may lead to a misclassification of the variables used in the studies. Such limitations necessitate a prudent interpretation of the results and emphasize the necessity for broader recruitment in future research.

The studies contained in this dissertation rely on the FLit50, which has some caveats. The development of the measure follows accepted procedures for developing measures. However, certain characteristics of the measure can impact results from its use. The measure itself was fairly easy for the groups sampled, and the observed scores were quite high. Additionally, two of the domains had questions that did not provide extensive differentiation between respondents. For example, the food skills domain only had three items, and most respondents scored full points on these items. It is likely that differences in food skills between individuals exist and that the items belonging to this attribute do not adequately reflect the construct. Two attributes are designed to form the ecological factors domain (sociocultural determinants of health and ecological factors), which also demonstrated an inability to differentiate between respondents. These attributes and items can be revised in the future to improve the measure's ability to differentiate among food literacy levels. The unbalanced nature of the Flit50 means that attributes with more items disproportionately influence overall and domain scores. This imbalance may result in misinterpretations given that higher scores on the measure may reflect specific strengths in overrepresented attributes rather than food literacy overall. It will be essential to account for this weighting issue when interpreting FLit50 scores to ensure an accurate understanding of food literacy. For example, domain scores could be considered along with the overall food literacy score.

The evaluation of construct validity in **Chapter 5** used methods based on CTT, which introduces several psychometric limitations. CTT operates under the assumption that all items contribute equally to the measurement of the underlying trait, neglecting variations in item-specific characteristics such as difficulty[206]. This can lead to inaccuracies in the validity assessment, as CTT does not accommodate the nuanced contributions of individual items or the complexity of the construct itself. Furthermore, CTT lacks the capacity to provide detailed insights into item functioning that more advanced models like IRT offer. Despite these limitations, the widespread use of CTT in academic training and its prevalence in published research may offer a sense of familiarity and accessibility to the readers of this study[136].

The research in **Chapter 6** uses more advanced modelling techniques of IRT to evaluate the items within the FLit50 measure, addressing some of the limitations inherent in CTT. The use of IRT was particularly beneficial, given the high scores observed in the initial study. The difficulty parameters confirmed that much of the differentiation of food literacy scores likely relied on a small number of questions. The difficulty and discrimination parameters, along with consultation from practitioners in public health nutrition, were used to inform the selection process for the shortened measure. However, the predominance of easy questions narrowed the choice of items for the FLit16. Ideally, a robust shortened measure should include questions that span the full range of difficulty—high, medium, and low—to effectively differentiate among various levels of food literacy[207]. Very few of the questions could be considered difficult, and the relatively high scores on the measure across the sample did not allow for this optimal range in question difficulty.

Discussions with the LDCP Healthy Eating Team informed decisions regarding key characteristics of the shortened measure, such as the ideal length and maintaining the conceptual framework and balance of the FLit50 measure. It was decided that each attribute should be represented by at least one question, and for attributes with four or more items in the original design, a second question was to be included to preserve attribute representation in the shortened measure. A specification in the IRT model was needed with a focus on the attribute level rather than on the global food literacy level. For instance, in the case of the food knowledge attribute, both parameters were assessed using scores derived from its five component items rather than on the parameters based on the total food literacy score. This strategy ensured that results were attribute-specific and not influenced by scores from other attributes, such as cooking self-efficacy. Multi-dimensional IRT models that can incorporate scores from different levels of a construct[208,209] could be considered for future studies. To ensure accuracy, the analysis was extended to examine the item parameters modelled on domain scores and food literacy and compared for consistency in difficulty and discrimination parameters. This thorough approach enhanced confidence in the selection of items for the shortened measure and confirmed the methodological soundness of the current strategy.

Due to the imbalance of items belonging to each attribute, it was logical to maintain a proportional representation of items per attribute in the shortened version. This approach resulted in the selection of items with less favourable difficulty levels from some attributes, which might not have been selected under different criteria. This was confirmed in an analysis of item characteristics of the FLit16, whereby several items did not contribute much information to the scaling of food literacy ability. Including these items maintained the conceptual structure of the measure, will not likely increase participant burden, and offers little risk with their inclusion. To evaluate the FLit16 for construct validity, the same hypotheses that were studied in **Chapter 5** were employed using the student data, with the findings suggesting that it is adequate for use. A decision was made to apply the IRT analysis to a combined dataset, as the higher number of records in the analysis was thought to improve the precision of the results. Another approach would have been to use the development data as a training dataset to inform the item selection and the student data used to evaluate the shortened version. The sample size of the development dataset (n=351) was sufficient but not ideal.

The FLit16 is conceptualized as a unidimensional construct focused on food literacy, differing from the multi-dimensional nature of the FLit50. Having two measures for the same construct offers several advantages: the short measure facilitates the quick capture of food literacy, can be integrated with larger population health surveys for rapid assessment, and provides essential data efficiently. However, the FLit16's streamlined approach may limit the depth of information compared to the FLit50, which could impact the specificity of programmatic and educational interventions. This might lead to confusion among researchers and professionals about which measure is most appropriate for their needs. To mitigate such confusion, the user guide (**Appendix 7**) was developed that outlines specific details of each measure with consideration of when to use each measure and insights into the interpretation of scores resulting from their use.

The findings in **Chapter 7** are subject to certain limitations due to both the inherent characteristics of regression analysis, particularly when assumptions are not met, and specific issues related to the dataset and variables of interest. Diagnostic tests on the data indicated that it was not ideally suited for traditional multiple linear regression. Although the data suggested a pattern consistent with a normal distribution, the Shapiro-Wilk test confirmed deviations from normality. While no multicollinearity was detected, heteroskedasticity was present, necessitating adjustments to the regression model, including the use of robust standard errors to enhance the reliability of the results[210]. Alternative regression techniques, such as transforming the dependent variable, could have been employed to address these statistical issues. However, these methods were not used to maintain a straightforward interpretation of the results.

The sample and variable selection in the study presented limitations. The targeted sampling method, aimed at recruiting students from food and nutrition programs, potentially skewed the results due to the demographic predominance of women in these programs and their higher food literacy scores. This restricted sampling method limited generalizability to a broader student population.

Moreover, the primary researcher's deep familiarity with the student life cycle, informed by years of experience in student affairs, influenced the selection of variables for the study. These variables were chosen to establish a baseline knowledge, supplemented by factors used in previous research. Consequently, the novelty and practical relevance of these variables remain uncertain, complicating the evaluation of their impact and whether they warrant further investigation. While a larger sample size might have lent more credibility to the findings, the study nonetheless unveiled intriguing dynamics worth exploring in future research. **Chapter 7** underscores the need for developing a systematic conceptual framework for variable modeling in this field. Establishing such a framework would provide structured guidance for future studies, incorporating diverse contexts to ensure robust and relevant research outcomes, akin to ongoing efforts to redefine food literacy. This approach would enhance the consistency and applicability of research in food literacy across different settings.

The sample of post-secondary students used in much of this study was chosen to suit the needs of the research. However, students following other educational pathways, such as through technical programs, apprenticeships, and private colleges, were not included. Individuals pursuing these alternative pathways may exhibit differences in food literacy requiring unique public health approaches[211]. Future research should consider including participants from a broader range of educational backgrounds to capture a more comprehensive understanding of food literacy across different segments of the young adult population.

Other limitations of the study detailed in **Chapter 7** arise from broader contextual challenges during data collection, notably the SARS-COV-2 pandemic's extensive disruption to students' educational experiences, living situations, and lifestyles—affecting populations worldwide[212,213]. Between 2019 and 2022, educational institutions adapted to fluctuating conditions, influencing students' living arrangements significantly[214,215]. Many students returned to their family homes amid the uncertainty of face-to-face classes, potentially increasing their involvement in household food preparation and thereby enhancing their food literacy. Additionally, with limited social interactions, increased online engagement may have exposed students to more food-related content, potentially further influencing their food literacy. However, it is critical to note that the dataset developed through a research collaboration with the Dalla Lana School of Public Health at the University of Toronto, incorporated in analysis in **Chapter 6**, was collected in 2019, prior to the pandemic. The similarity in scores between this pre-pandemic data and data collected during the pandemic suggests that the pandemic might not have significantly skewed the food literacy scores in either direction, though it is not possible to conclude this with confidence given the cross-sectional data from different samples.

8.4 Implications for Public Health and Research

The research in this dissertation has several implications for the developing science around food literacy and for public health practice, including contributing to efforts in measuring and evaluating food literacy, informing the understanding of food literacy among emerging adults in Canada, and fulfilling a research need by partnering with the LDCP Healthy Eating Team.

Contributing to Efforts in Measuring and Evaluating Food Literacy

One area of contribution of this research centers on the measurement of food literacy. The development of reliable and valid measures is fundamental to the field, as these tools enable researchers and practitioners to quantify and understand the nuances of food literacy and are the backbone of effective public health interventions and educational programs aimed at improving nutritional outcomes and food-related behaviours. Ensuring that measurement tools are robust, like was done in these studies, enhances their applicability. Well-validated tools are also vital to contribute to the body of evidence needed to advocate for policy changes and obtain funding for programmatic efforts[216]. Ultimately, by improving the measurement of food literacy, we lay a stronger foundation for research and interventions that can adapt to evolving public health challenges and promote sustainable dietary practices.

Thoroughly evaluating a measure not only tests its current efficacy but also highlights potential areas for improvement to ensure high-quality and accurate measurement tools. Through the studies in this dissertation (**Chapters 5 and 6**), some areas for improvement within the existing measures have been revealed, offering clear opportunities for refinement. Specifically, the analysis highlighted individual items and items belonging to attributes that may not effectively contribute to scaling respondents. Iterative revisions are vital in continuing the development of measures that remain responsive to the evolving needs of the field and increase the utility of assessments of food literacy. This process not only benefits the immediate stakeholders but also contributes broadly to the field of public health by providing a robust tool for future research and practice.

While food literacy encompasses a broad understanding of food-related knowledge, skills, and behaviours, the nuances of regional food systems necessitate the development of localized measures[217]. Food systems are deeply embedded within cultural, policy, environmental, and socioeconomic contexts that vary significantly across different geographical regions[218] and highlight the need for a 'domestically' produced food literacy measure. In Canada and Ontario, distinct cultural practices, dietary habits, food policies, marketing strategies, and availability of food resources contribute to unique food environments. Existing measures developed in other regions may not fully capture these localized nuances, leading to potential gaps in assessment and addressing food literacy effectively. Region-specific measures for Canada and Ontario ensure that the diverse and context-specific factors influencing food literacy are accurately reflected. This could provide relevant and actionable insights for policymakers, educators, and health practitioners that measures developed elsewhere may not deliver. Nonetheless, the extent to which the FLit measures and the underlying framework adequately capture food literacy among diverse subgroups of the population warrants attention.

A psychometrically grounded, well-conceived measure of food literacy can be integrated into a nationwide monitoring and surveillance system. A robust measure allows for the accurate capture of the current state of food literacy, reflecting the specific characteristics and dynamics of the contemporary understanding of food and food systems. Data stemming from the FLit measures can aid in identifying gaps in education and public health messaging, informing policy decisions, and tailoring interventions to address specific needs within the population. As interventions are enacted, monitoring and surveillance facilitate the evaluation of their impact, ensuring that they achieve the desired outcomes and informing necessary adjustments. Embedding food literacy into a nation- or province-wide surveillance system allows for the detection of changes and trends in food literacy levels, providing insights into how societal shifts, such as changes across the public health nutrition landscape, influence population health.

The integration of food literacy assessment is urgent as it lays the foundation for a proactive and informed public health approach, ensuring that efforts to enhance food literacy are data-driven and evidence-based. The rapid and drastic changes in our food system over the last few decades[219] make it imperative to assess the current standing of food literacy[220]. However, it is important to recognize that the development of measurement tools is an iterative process[221]. The FLit measures have been demonstrated to be a strong foundation, yet progress through continual revision, with consideration of psychometric principles, should be welcomed [221]. Researchers, practitioners, and community members engaged in food literacy, within emerging adults and beyond, can play an important role in contributions to enhancing the Flit measures.

Informing the Understanding of Food Literacy among Emerging Adults in Canada

This dissertation expands the exploration of food literacy in the post-secondary student population. An aim of this work was to explore the associations between food literacy and correlates related to student life (**Chapter 7**). Analyzing factors associated with food literacy among the emerging adult population is gaining traction[64,199,222–226] accompanied by a movement to improve food literacy and its component attributes through education and practical interventions[227–232]. Those developing curriculum and programming strategies are increasingly relying on research evidence to inform the direction of these strategies[233]. The selection of variables was guided by their potential relevance to health behaviours and outcomes in emerging adults. The study added to the existing knowledge base through the inclusion of less commonly studied variables—such as educational characteristics and environmental factors like living situations—predicated on the hypothesis that these factors may play an important, yet underexplored, role in shaping food literacy during this developmental transition phase.

Insights from this work can have implications for policy makers and educational leaders through the recognition that food literacy is likely shaped by factors across the socio-ecological spectrum[55,64]. Improving food literacy or food literacy attributes will likely take a multi-faceted approach that incorporates nuance in the delivery of interventions. For example, women and men may have different motivations and experiences with food that can be harnessed to create interventions that incorporate these differences. Similarly, those living with family may require different intervention settings, such as community kitchens, to allow them to experience food preparation and build confidence away from the primary family food preparer. Uniquely tailored programs can meet students where they are.

Integrated Knowledge Translation: Partnering to advance scientific goals

A main feature of this research is its employment of iKT. iKT is an approach that involves researchers collaborating with partners to conduct research that directly addresses a practical need and involves them throughout the research process[158]. This approach ensures the research is immediately applicable, enhancing its impact by directly informing and improving public health practice[167]. The iKT approach offers several benefits for both researchers and practitioners. For researchers, especially trainees, it offers the chance to be involved in research that is relevant to real-world needs, offers access to professionals involved in the field of interest, and can have a direct and immediate impact to contribute to food literacy practice. The practitioners involved in the LDCP Healthy Eating Team are able to engage in tailored research support for their specific needs and evidence to inform their practice. Through involvement in these studies, the practitioners engaged in professional development and skill enhancement in research methods through involvement in the research design, the interpretation of the results and their implications, and the development of the measure user guide to be shared with their colleagues and future users. Through this direct involvement in the research processes, the practitioners may have been spurred to engage in further work, not only related to food literacy, but to measurement of constructs relevant to public health nutrition practice.

In the research making up this thesis, the practitioners involved in the LDCP Healthy Eating Team were involved in communicating their research needs, discussing the sample requirements, and presenting ideas about effective recruitment of respondents. Results were shared on an ongoing basis, and discussions on their implications for the practice of public health nutrition and future use of the measure were insightful. For the shortening of the measure presented in **Chapter 6**, the practitioners provided valuable guidance on the conceptualization of the short measure and were centrally involved in decisions when nuance was required to identify the items to include. The practitioners also held the institutional knowledge from past efforts to develop and evaluate the measure. Lastly, as a group, and since the measure is intended to be used by others outside this collaboration, a measure guide was developed as an accompanying resource. While the researchers contributed an understanding of measurement and psychometric methods, the practitioners were key to translating the language describing the development and evaluation of the measures in a way that would be most relevant to practitioners, as well as identifying the topics and types of information that would be most useful to them. This work culminated in a user guide to provide potential measure users with the background on the project, what the measures were designed to do, the practicalities of administering the measure, and how to interpret the results and/or combine them with other health measures (**Appendix 7**). Health Canada and the federal funding agencies are encouraging more researchers and groups to take this iKT approach to research as it helps to build better synergy between groups[161].

8.5 Future Studies/Next Steps

This dissertation opens several paths for future research, focusing both on measuring food literacy and exploring the characteristics associated with it and the potential impact of food literacy on other health outcomes and behaviours.

There are aspects of the current food literacy measure that require further evaluation. While the findings of this research have demonstrated adequate construct validity for post-secondary students and young adults more broadly, the target audience for the FLit50 measure, it is important to test its applicability across broader age ranges, particularly among adults, to fully establish its utility. The findings suggest differences in food literacy scores based on demographic characteristics, including gender and racial/ethnic identity. Future research should investigate potential biases in the measure, particularly whether the measure is appropriate to assessing food literacy in diverse groups. Analyzing response patterns by demographic traits could reveal if variations are due to differing abilities of food literacy or through differences in understanding, interpretation, and responses of the items. Identifying differential patterns in the measure could help guide targeted revisions of the measure and ensure the accuracy of measurement across population groups.

The FLit50, FLit16, and domain-level measures currently lack criteria for categorizing food literacy, for example, as high or low, for use in practice. As more data accumulates from the use of the measures, it may be possible to identify classification thresholds. Thresholds can provide a clear cut-off that can simplify the interpretation of results for researchers and practitioners[234]. Establishing categorizations can aid in understanding the distribution of food literacy or domains within a population, which is particularly useful in public health and education. Benchmarks can also be used to set population health goals and track progress in improving food literacy over time. The current guidance for the FLit measures advises benchmarking scores against the mean scores established through the studies in this dissertation and previous evaluations of the measure, with 41 out of 50 points established as the average score for adolescents and young adults for the full measure. The predicted mean score for the FLit16 was 12 of 16 points, based on IRT modelling. This approach has been detailed in the measure's user guide (**Appendix 7**) to help users interpret their results appropriately until future studies can identify criteria based on larger and more diverse samples. Additionally, given its multi-dimensional nature, future efforts can explore how best to use the total food literacy score along with scores for the domains for comprehensive interpretation.

Given the increasing interest in developing interventions to improve food literacy among young adults, including educational programs and curriculum integration[223,235,236], there is a critical need for reliable measures that can detect change post-intervention. Members of the LDCP Healthy Eating Team have indicated their desire to use the measures to help design intervention programs in their public health work and to assess any improvements to food literacy and its domains once the intervention is delivered. As such, there is a pressing need to evaluate the FLit measures to determine their ability to detect their sensitivity to changes following interventions through specially designed assessments of the measure.

As the understanding of food literacy evolves, there is a risk that the current conceptualization upon which the FLit measures are based may become outdated. For the measures to remain accurate in describing food literacy, there is an opportunity for the LDCP Healthy Eating Team to remain engaged with the developments in conceptualizations of food literacy and refine the framework and measures as necessary. For example, the growing importance of sustainability[237,238], food safety[239], and food justice[240,241] in the food system could stimulate an expansion of the conceptualization of food literacy and the measure. Establishing new attributes and items can potentially enhance the measure's relevance. Further psychometric evaluation would be necessary to assess any modifications made to the measure.

Test equating is a critical area for future research, especially given the variety of existing and developing food literacy measures. This statistical method, often based on IRT, allows for the alignment of scores across different tests by applying specific coefficients to ensure comparability[242,243]. Such equating facilitates meaningful cross-country comparisons of food literacy, addressing a significant gap in current research. Domestically, test equating enables the consistent evaluation of new measurement tools within the Canadian research framework, ensuring that different instruments yield comparable understandings of food literacy levels. By standardizing assessments across various tools, test equating enhances our ability to generalize results and consolidate data from diverse sources, thereby providing a more detailed and unified view of food literacy trends both globally and locally[24].

Computerized Adaptive Testing (CAT) offers an innovative method for assessing health constructs like food literacy[151]. CAT uses a well-defined item bank and an algorithm that dynamically adjusts the sequence of questions based on previous responses until a confidence threshold in the food literacy level is achieved[244]. This enhances the assessment's efficiency and precision. The adoption of CAT could transform food literacy measurement, particularly for diverse populations, by ensuring that questions are tailored to each participant’s specific understanding, geographic location, racial/ethnic identity, and age. Developing CATs would not only streamline the process, allowing for extensive comparisons and targeted dimension assessments, but also integrate all existing measures and items. While ambitious, the growing global focus on food literacy[1] may provide the necessary momentum to realize such a project.

The FLit50 and FLit16 measures lay a strong foundational framework for advancing our understanding of food literacy and its direct and indirect effects on diet quality among Canadians. Future research should use these measures in conjunction with dietary intake data to explore the relationship between food literacy and dietary quality. For example, using tools such as the Healthy Eating Food Index-2019, which quantifies how well dietary patterns align with recommendations within the 2019 Canada's Food Guide[245], can provide insights into how food literacy is associated with diet quality. Future research could explore the association between food literacy and domain scores highlighting specific areas where food literacy may enhance diet quality.

Food literacy can also be examined in relation to other food-related practices and attitudes, such as the enjoyment of food[246], the role of food in social interactions[247] and in cultural and heritage transmission[248], and in connection with food sovereignty movements[249,250]. These concepts, among others, are important dimensions of food systems studies within which food literacy may prove to be a noteworthy component in terms of how individuals engage with food in their daily lives. Investigating these aspects in depth could offer a holistic view of the relevance of food literacy to well-being. As we continue to unravel the intricate relationships between food literacy, diet quality, and broader food-related behaviours, these measures will undoubtedly contribute to more effective public health strategies and educational initiatives aimed at fostering a healthier society.

8.6 Conclusions

The studies in this dissertation, drawing primarily upon a sample of post-secondary students in Ontario, are valuable in improving our understanding of food literacy. The analyses in **Chapter 5** outline the assessment of the FLit50 for construct validity, an important property of the measure that gives confidence to any results stemming from its use in public health contexts. Further evaluation of the measure's items was performed to inform the development of a shortened version of the measure in **Chapter 6**. The availability of these two robust measures marks substantial progress in quantifying food literacy. The analysis in **Chapter 7** explored potential correlates of food literacy, including a range of characteristics related to studentship, the results of which can help public health practitioners and policymakers craft evidence-based and targeted initiatives to improve food literacy in young adults and inform future research. Overall, this dissertation lays a solid foundation for future research, opening avenues to further explore how food literacy is positioned within the broader field of food studies and guiding enhancements to food literacy measurement tools.

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APPENDIX 1 – 50-ITEM FOOD LITERACY MEASURE (FLIT50)

Which fruit is traditionally grown in Canada?	a) Apples b) Bananas c) Avocado d) Pineapple e) Don’t know
Which of the following are protein foods? (Check all that apply)	a) Legumes (e.g., beans, lentils, chickpeas) b) Eggs c) Tofu d) Don’t know
Why are food additives (e.g., preservatives, flavours, colours) added to food? (Check all that apply)	a) To make food taste better b) To make food look better c) To prevent food from going bad d) To make food last longer e) Don’t know
Which of the following is a source of unsaturated fats?	a) Olive oil b) Coconut oil c) Butter d) Don’t know
A breakfast cereal lists "fortified" on its box. This means:	a) The cereal package is made to last a long time b) The cereal is made to last a long time c) Some nutrients are added to the cereal when it is made d) Some nutrients are removed from the cereal when it is made e) Don’t know
Eating plenty of fruits and vegetables is important to help prevent health problems or diseases.	a) Yes b) No c) Not sure
Which of the following is a healthier type of sugar?	a) White sugar b) Brown sugar c) Honey d) It doesn't matter; all types of sugar are pretty much the same e) Don’t know
The foods that we eat may affect our mood.	a) Yes b) No c) Not sure
Processed food (e.g., boxed mac n’ cheese, fast food) usually have more salt than foods cooked at home from basic ingredients (e.g. pasta, vegetables, meat).	a) Yes b) No c) Not sure

You're deciding between ordering a poutine (fries, cheese and gravy) and a whole grain chicken wrap with vegetables. The menu says the poutine has fewer calories. Does this mean poutine is a healthier choice?	a) Yes b) No c) Not sure
If you are steaming vegetables, this means that you are:	a) Boiling vegetables in water for longer than a minute b) Boiling vegetables in water and then cooling them off in ice water c) Placing vegetables above boiling water until they get cooked d) Don't know
If a food package lists "no added sugar", this means that this product must have zero sugar.	a) Yes b) No c) Don't know
If a food package lists "low in sodium", this means that this product:	a) Only has a little bit of salt b) Has very few calories c) Has no calories d) Has no salt e) Don't know
Fresh vegetables and fruit should be washed if:	a) They are organic b) They will be peeled or cut (e.g. whole watermelon, potato) c) They look clean d) All of the above e) None of the above f) Don't know
When cutting raw meat and vegetables for the same meal, you should:	a) Use the same cutting board for raw meat and vegetables b) Use the same cutting board for raw meat and vegetables, rinsing in between uses c) Use a separate cutting board for raw meat and vegetables d) Don't know
Which of the following is a sugary drink?	a) Chocolate milk b) Fruit juice c) Energy drinks d) All of the above e) None of the above f) Don't know
Who is more likely to give you accurate nutrition information?	a) Celebrities or athletes b) Fitness instructors c) Health professionals (e.g., dietitian, doctor, nurse) d) Health store employees e) Social media influencers f) Don't know
The ingredients on a granola bar are listed as follows: rolled oats, sugars, peanuts, chia seeds, whole wheat	a) Salt b) Whole wheat flour c) Chia seeds

flour and salt. The ingredient that's present in the largest amount is:	d) Sugars e) Rolled Oats f) All ingredients are equal g) Don't know
Is it safe to defrost frozen meat, poultry or fish in a dish on the kitchen counter?	a) Yes b) No c) Don't know
How confident are you in your ability to do each of the following?	
Find nutrition information you can trust.	Not at all confident Not very confident Somewhat confident Very confident
Choose the healthiest options from foods sold at restaurants.	Not at all confident Not very confident Somewhat confident Very confident
Prepare a healthy meal for family or friends.	Not at all confident Not very confident Somewhat confident Very confident
Choose the healthiest options from foods sold at grocery stores.	Not at all confident Not very confident Somewhat confident Very confident
How confident are you in your ability to do each of the following food preparation and cooking activities?	
Use a kitchen knife safely (e.g., to cut up raw ingredients)	Not at all confident Not very confident Somewhat confident Very confident
Measure ingredients for a recipe.	Not at all confident Not very confident Somewhat confident Very confident
Follow a simple recipe (one that only has a few ingredients and steps).	Not at all confident Not very confident Somewhat confident Very confident
Sauté (i.e., cook food quickly in a little bit of oil or fat on the stovetop).	Not at all confident Not very confident Somewhat confident Very confident
Use herbs and spices (e.g., basil, thyme, cayenne pepper) to flavour dishes.	Not at all confident Not very confident Somewhat confident Very confident
Make baked goods such as cookies, cupcakes, and cakes etc., using basic ingredients (not from a box).	Not at all confident Not very confident

	Somewhat confident Very confident
Make soup using basic ingredients (not from a can or box).	Not at all confident Not very confident Somewhat confident Very confident
Cook meat (e.g., stir fry, bake)	Not at all confident Not very confident Somewhat confident Very confident
Prepare meals using plant-based proteins (e.g., beans, lentils, tofu).	Not at all confident Not very confident Somewhat confident Very confident
Change a recipe to make it healthier (e.g., to have less salt, sugar or fat).	Not at all confident Not very confident Somewhat confident Very confident
Prepare meals or snacks using basic ingredients (e.g., pasta, vegetables, meat), with or without a recipe.	Not at all confident Not very confident Somewhat confident Very confident
How much do you agree or disagree that each of the following statements are true?	
It is important to eat most meals without distractions (e.g. cell phones, tablets, TV, toys).	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to prepare healthy meals and snacks most of the time.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to eat meals with others, when possible.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important for my health to make most meals or snacks using basic ingredients (e.g. pasta, vegetables, meat).	Strongly disagree Disagree Neutral Agree Strongly agree
When ordering takeout food or food in a restaurant, it is important that I choose healthier options from those available, most of the time.	Strongly disagree Disagree Neutral Agree Strongly agree

It is important for my health to not skip meals or snacks, when possible.	Strongly disagree Disagree Neutral Agree Strongly agree
Eating whole grains (e.g., whole grain pasta and bread, brown rice, oats) is important for my health.	Strongly disagree Disagree Neutral Agree Strongly agree
Eating more beans, lentils, tofu, and other plant-based proteins helps me stay healthy.	Strongly disagree Disagree Neutral Agree Strongly agree
How much do you agree or disagree that each of the following statements are true?	
Food advertising can influence what we buy.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to use leftovers, when possible	Strongly disagree Disagree Neutral Agree Strongly agree
Reducing the amount of food we throw away is good for the environment.	Strongly disagree Disagree Neutral Agree Strongly agree
How much do you agree or disagree that each of the following statements are true?	
Family, friends, celebrities, and social media can shape/influence what people choose to eat.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important that people are able to access foods specific to their culture.	Strongly disagree Disagree Neutral Agree Strongly agree
What people eat can be influenced by cultural or family food traditions.	Strongly disagree Disagree Neutral Agree Strongly agree

A person's living situation (such as income, education and housing) can affect their ability to prepare meals.	Strongly disagree Disagree Neutral Agree Strongly agree
A person’s ability to access food can be affected by their living situation (such as income, transportation, where they live)	Strongly disagree Disagree Neutral Agree Strongly agree

APPENDIX 2 – RECRUITMENT MATERIALS

Below is the copy of the recruitment advertisements used in the various social media sites, including the images used and the text accompanying the image on the posts. The shorter text were used in Twitter where character lengths are limited and the longer posts were used on Reddit and Facebook.

Social Media Ad Text

Seeking students in postsecondary food and nutrition programs in their second year or above to participate in online study - $20 honorarium

Click here for information and to complete the screening questionnaire. (Link to Qualtrics Screening Questionnaire)

____

Seeking students in postsecondary in their second year or above to participate in online food and nutrition study - $20 honorarium

Click here for information and to complete the screening questionnaire. (Link to Qualtrics Screening Questionnaire)

____

Now recruiting Ontario university students for an online food and nutrition study - $20 honorarium

If you are a student at an Ontario postsecondary institution and between 18 and 25 years of age and in your second year or above visit the link to learn more. (Link to Qualtrics Screening Questionnaire)

____

Are you between 18 and 25 years of age and in your second year or above of post-secondary studies?

We are recruiting young adults to participate in an online food and nutrition study. If you meet our eligibility requirements through a screening survey, you will be asked to complete two online surveys and receive $20 for your time.

To learn more, click here. (Link to Qualtrics Screening Questionnaire)

This study has been reviewed by, and received ethics clearance the University of Waterloo Office of Research Ethics , ORE#43057

Gate Keeper Email Script

[Attach: Study Information Letter]

Subject Line: Students aged 18-25 years invited to participate in food and nutrition study with a $20 thank you

Dear _____:

We are writing to request your assistance with a study we are conducting in the School of Public Health and Health Systems at the University of Waterloo. We are seeking students enrolled in post-secondary education in Ontario to participate in a study about food literacy, eating practices, and food security.

We are seeking your assistance in sharing our study information through your email list. **We have attached an email script to distribute to your students.** The script includes the link to a website to find out more about the study, as well as a short eligibility screener.

- Individuals visiting the website will be provided with information about the study and invited to respond to a short questionnaire so we can determine if they are in our target group (students aged 18 to 25 years who are in at least in their second year of post-secondary studies).
- Eligible individuals will be presented with an informed consent form and make their own independent decision as to whether they would like to be involved.
- Participants will then be asked to complete an initial online survey, followed by an online dietary recall. Participants who complete the survey and recall will receive a $20 honorarium (via Interac transfer) in appreciation of their time. Those who complete the survey only will receive an honorarium of $10.
- Please refer to the information letter and informed consent form (link to Google Doc) for additional details about the study, as well as protections to individuals' privacy and confidentiality of their information.

Healthy eating is an important determinant of health. What we learn from this study will help public health practitioners to understand factors that shape students' eating patterns. We also hope to understand the potential role played by individuals' food literacy levels in shaping their food security status. The findings will be shared through a report to Public Health Ontario and publications and presentations. This project will be part of the PhD and MSc thesis research of members of our team. This study has been reviewed and received ethics clearance through a University of Waterloo Office of Research Ethics (ORE#43057).

If you have questions, please contact the student investigators (Martin Holmes, Mona Qutub) or principal investigator, Dr. Sharon Kirkpatrick, using the information provided below. We appreciate your support and time.

Martin Holmes, PhD(c), Student Investigator
School of Public Health Systems, University of Waterloo
foodliteracy@uwaterloo.ca

Mona Qutub, MSc(c), Student Investigator
School of Public Health Systems, University of Waterloo
foodliteracy@uwaterloo.ca

Dr. Sharon Kirkpatrick, Principal Investigator
School of Public Health Systems, University of Waterloo
skirkpatrick@uwaterloo.ca

APPENDIX 3 – ELIGIBILIITY SCREENING QUESTIONNAIRE

We are seeking students to participate in a study to help us learn about a measure related to food literacy and eating practices. Participation in the study involves two parts, a survey and a dietary recall to be sent within a week of survey completion.

Please answer the following eligibility screening questions. You are free to skip any questions you prefer not to answer. If you meet the eligibility criteria, you will receive an email from the study coordinator with a link to a survey website. The survey site will have the study information letter, a declaration of consent, and the survey questions to complete part one of the study. The responses for those who do not meet the eligibility requirement to participate will be deleted at the end of the data collection period (April 2022).

Your identity will be confidential. Data collected will be stored in secure drives on password-protected computers on servers hosted by the University of Waterloo, accessible only to members of the study team, and retained according to University of Waterloo policies. Information that could identify you (email address) will be stored separately from your survey responses.

This study has been reviewed and received ethics clearance through the University of Waterloo Office of Research Ethics (ORE #43057).

For more information about this study, please see the information form linked here.

If you have questions about the study, please contact foodliteracy@uwaterloo.ca.

1. Are you between the age of 18 and 25 years?
   Yes
   No

2. Are you currently a post-secondary student in Ontario?
   Yes
   No

3. Are you currently in your first year of post-secondary studies?
   Yes
   No

4. Are you currently enrolled in a food-related academic program? (For example, dietetics, nutrition, food management, culinary arts, etc.)
   Yes
   No

5. reCAPTCHA – Click to indicate “I’m not a robot”
6. Please provide your email address.

This study requires participants to be current post-secondary students. To confirm this status, please use your college/university student account (e.g., henry@uwaterloo.ca):

7. Please confirm your email address.

Message presented if ineligible:
Thank you for your interest in this research study. Unfortunately, you are not eligible to participate in this study. Your survey responses will be deleted. You can now close your browser window.

Message presented if eligible:
Thank you for your interest in participating in this study.

We will review the responses to these screening questions and, should you be in our target group, you will receive an email from the study coordinator with a link to the website to complete the first survey. After completing the first survey, you will receive an email in the next week asking you to complete the second survey, the dietary recall.

After completing both surveys, you will receive a $20 Interac transfer in appreciation of your time. If you complete only the first survey, an e-transfer of $10 will be provided. The honorarium will be sent using an Interac e-transfer to the email address used to communicate for the study.

If you have any other comments or questions, please contact the study coordinators at foodliteracy@uwaterloo.ca.

Martin Holmes, PhD(c), Student Investigator
Mona Qutub, MSc(c), Student Investigator
School of Public Health Systems, University of Waterloo
foodliteracy@uwaterloo.ca

APPENDIX 4 – STUDY INFORMATION LETTER AND CONSENT INDICATION

Study title: Learning about a measure of food and eating practices

You are invited to participate in a study to help us learn about a measure related to food and eating practices. The results will support public health efforts related to healthy eating. This study is being conducted as part of Martin Holmes' PhD thesis under the supervision of Dr. Sharon Kirkpatrick at the University of Waterloo. Funding for this study has been provided by Public Health Ontario through the Locally Driven Collaborative Projects program.

What does this study involve?

Complete online survey: You will be asked to complete an online survey including questions about your food and eating practices and demographic characteristics, such as your gender and educational attainment. Demographic questions will be asked to describe the characteristics of the participants in this study. The survey will take about 15 minutes to complete. Once you've completed the survey, you will be asked to provide your name and email address so we can send you a $5 Interac transfer to thank you for your time and contact you for the next part of the study.

Complete dietary recall: Within a week of completing the online survey, you will receive an email asking you to visit a website to complete an online dietary recall. You will be asked to log in to the website to complete the recall on the same day you receive this email. The recall will guide you through questions about the foods and beverages you consumed the prior day. Completing this recall will take approximately 25 to 30 minutes. After completing the recall, you will receive $10 in appreciation of your time through an Interac e-transfer sent to your email address.

Participation and remuneration

Participation in this study is voluntary. You will receive a $5 Interac transfer following participation in the first survey and a $10 Interac transfer for participation in the dietary recall. This amount received is taxable. It is your responsibility to report this amount for income tax purposes.

You may decline to answer any questions presented during the study if you so wish. Further, you may decide to discontinue the surveys at any time, including part way through the surveys, by closing your browser and not submitting your responses. If you choose to discontinue your participation in the study, but wish to be remunerated for partial completion, you can email the study coordinator by email (foodliteracystudy@uwaterloo.ca) requesting your payment. You can choose to remove your information (online survey and/or dietary recall) by contacting the study coordinator by email (foodliteracystudy@uwaterloo.ca) within 1 month of completing the survey or recall.

Potential benefits for study participants

There are no direct benefits to the participants. The insights gained will be used to inform public health practice related to healthy eating, including among young people.

Risks to participation in the study

There are no known or anticipated risks from participating in this study.

Confidentiality

If you choose to participate, your participation will be confidential. All data will be summarized, and no individual will be identifiable from the summarized results. A summary of the findings will be shared with Public Health Ontario and may be published and presented in academic settings. You will not be identifiable in the published findings.

When information is transmitted over the internet, privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). University of Waterloo researchers will not collect or use internet protocol (IP) addresses or other information that could link your participation to your computer or electronic device without first informing you.

The data collected from this study will be maintained on password-protected computers in a secure drive that can only be accessed by the student investigator, his supervisor, and research assistants. The data will be maintained for a minimum of 7 years and destroyed according to University of Waterloo policy.

Questions and research ethics clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Office of Research Ethics (ORE#43057). If you have questions, please contact the Office of Research Ethics at 1-519-888-4567, ext. 36005 or ore-ceo@uwaterloo.ca.

If you have questions, please contact the student investigator Martin Holmes or principal investigator Dr. Sharon Kirkpatrick, using the information provided below. The results of this study will be posted at www.foodliteracy.ca and highlights of the study will be shared at the project webpage on the Public Health Ontario website.

Thank you for your interest in our research and for your assistance with this project.

Contact information

Martin Holmes
School of Public Health and Health Systems, University of Waterloo
foodliteracystudy@uwaterloo.ca

Dr. Sharon Kirkpatrick
School of Public Health and Health Systems, University of Waterloo
skirkpatrick@uwaterloo.ca

Consent to Participant

PLEASE CHECK THE BOX BELOW TO AGREE TO PARTICIPATE IN THE STUDY

I have read the information presented in the information letter about a study being conducted by Dr. Sharon Kirkpatrick and Martin Holmes of the School of Public Health and Health Systems at the University of Waterloo.

- I have had the opportunity to ask any questions related to this study and to receive satisfactory answers to my questions and any additional details I wanted.
- I understand my participation in this study involves an online survey, requiring approximately 15 minutes to complete, and a dietary recall, taking approximately 25 minutes to complete.
- I understand I may decline to answer any questions presented during the study if I wish.
- I understand that I can decide to stop at any time, even part-way through the surveys, for whatever reason.
- I am aware my identity will remain confidential.
- I understand there are no known or anticipated risks to me as a participant in this study.
- This study has been reviewed by and received ethics clearance through a University of Waterloo Office of Research Ethics (ORE#43057).
- By providing my consent, I am not waiving my legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.
- With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

- [ ] "I agree to participate."
- [ ] "I do not wish to participate (please close your web browser now)."

APPENDIX 5 – STUDY SURVEY

Demographic questions

Question	Response options
Demographic, educational, housing, economic, food and health related questions	
What is your age in years:	Numeric dropdown
What sex were you assigned at birth, meaning on your original birth certificate?	Male Female
What is your current gender identity?	Man Woman Trans male/trans man Trans female/trans woman Gender queer/gender non-conforming Different identity → Please specify: [open-text] Don't know Refuse to answer
How would you describe your ethnicity/race? Please check all that apply.	Black (African, Afro-Caribbean, African-Canadian descent) East/Southeast Asian (Chinese, Korean, Japanese, Taiwanese descent; Filipino, Vietnamese, Cambodian, Thai, Indonesian, other Southeast Asian descent) Indigenous (First Nations, Métis, Inuit descent) Latino (Latin American, Hispanic descent) Middle Eastern (Arab, Persian, West Asian descent, e.g., Afghan, Egyptian, Iranian, Lebanese, Turkish, Kurdish, etc.) South Asian (South Asian descent, e.g., East Indian, Pakistani, Bangladeshi, Sri Lankan, Indo-Caribbean etc.) White (European descent) Other, please specify: Prefer not to answer
Which best describes your student status?	Domestic student from Ontario Domestic student from another province International student
At which academic institution are you currently enrolled?	Centennial College George Brown College Georgian College Humber College Ryerson University Western University/Brescia College University of Guelph University of Ottawa

	Other institution → Please specify: [open-text]
What is the name of the academic program/area of study are you currently enrolled in?	Applied Human Nutrition Culinary Arts & Science Culinary Management Family Relations & Applied Nutrition Food and Beverage Management Food and Nutrition Sciences Food and Nutrition Management Food Science Technology Food Service Worker Food Studies Integrated Food Sciences Nutrition and Food Service Management Nutrition and Food Nutrition and Healthy Lifestyle Promotion Nutritional and Nutraceutical Sciences Other program → Please specify: [open-text]
Derived - is the program from D7 a food program?	Yes No Prefer not to answer
What is your current year of study?	2nd year 3rd year 4th year 5th year Other year → Please specify: [open-text]
What is your current enrollment status?	I am a full-time student I am a part-time student
Which of the following best describes your living situation.	On campus residence Off campus residence (e.g., rented apartment or house) My housing situation is unstable (e.g., unhoused, shelter, temporarily staying with friends) Other (e.g. housing cooperative) Prefer not to answer
Which of the following best describes your household composition.	I live alone I live with roommates I live with spouse/common-law partner, WITH children I live with spouse/common-law partner, WITHOUT children I live with parents/guardians/extended family Prefer not to answer
Thinking about your total monthly income, how difficult or easy is it for you to make ends meet?	Very difficult Difficult Neither easy nor difficult Easy

	Very easy Don't know Refuse to answer
Do you typically hold employment as a student during the academic terms?	Yes, Full time (> 30 hr/week) Yes, Part Time (< 30 hr/week) No Prefer not to say
What sources of income have you used to support yourself financially to cover your expenses during the school year? (check all that apply)	Employment Financial support from family and/or friends Government financial assistance (i.e. OSAP) Scholarships and other awards Student line of credit (i.e. through a private bank) Co-op / placement work-term earnings Other Prefer not to answer
What source of income has made the GREATEST contribution to supporting yourself financially during the school year?	Employment Financial support from family and/or friends Government financial assistance (i.e. OSAP) Scholarships and other awards Student line of credit (i.e. through a private bank) Co-op / placement work-term earnings Other Prefer not to answer
How often are you responsible for food shopping in your household?	Always Very Often Sometimes Rarely Never
How often are you responsible for food preparation in your household?	Always Very Often Sometimes Rarely Never
Do you have regular access to a kitchen to prepare your own meals?	Yes No Prefer not to answer
Do you currently have a meal-plan for use at on-campus eateries?	Yes No Prefer not to answer
If yes, how sufficient is your meal plan in covering your food costs based on your food preferences during the term?	Extremely sufficient Sufficient Insufficient Extremely insufficient
In general, would you say your physical health is... ?	Excellent Very good Good Fair

	Poor Refuse to answer Don't know
In general, would you say your mental health is…?	Excellent Very good Good Fair Poor Refuse to answer Don't know

FLit Measure

Which fruit is traditionally grown in Canada?	a) Apples b) Bananas c) Avocado d) Pineapple e) Don't know
Which of the following are protein foods? (Check all that apply)	a) Legumes (e.g., beans, lentils, chickpeas) b) Eggs c) Tofu d) Don't know
Why are food additives (e.g., preservatives, flavours, colours) added to food? (Check all that apply)	a) To make food taste better b) To make food look better c) To prevent food from going bad d) To make food last longer e) Don't know
Which of the following is a source of unsaturated fats?	a) Olive oil b) Coconut oil c) Butter d) Don't know
A breakfast cereal lists "fortified" on its box. This means:	a) The cereal package is made to last a long time b) The cereal is made to last a long time c) Some nutrients are added to the cereal when it is made d) Some nutrients are removed from the cereal when it is made e) Don't know
Eating plenty of fruits and vegetables is important to help prevent health problems or diseases.	a) Yes b) No c) Not sure
Which of the following is a healthier type of sugar?	a) White sugar b) Brown sugar c) Honey d) It doesn't matter; all types of sugar are pretty much the same e) Don't know

The foods that we eat may affect our mood.	a) Yes b) No c) Not sure
Processed food (e.g., boxed mac n' cheese, fast food) usually have more salt than foods cooked at home from basic ingredients (e.g. pasta, vegetables, meat).	a) Yes b) No c) Not sure
You're deciding between ordering a poutine (fries, cheese and gravy) and a whole grain chicken wrap with vegetables. The menu says the poutine has fewer calories. Does this mean poutine is a healthier choice?	a) Yes b) No c) Not sure
If you are steaming vegetables, this means that you are:	a) Boiling vegetables in water for longer than a minute b) Boiling vegetables in water and then cooling them off in ice water c) Placing vegetables above boiling water until they get cooked d) Don't know
If a food package lists "no added sugar", this means that this product must have zero sugar.	a) Yes b) No c) Don't know
If a food package lists "low in sodium", this means that this product:	a) Only has a little bit of salt b) Has very few calories c) Has no calories d) Has no salt e) Don't know
Fresh vegetables and fruit should be washed if:	a) They are organic b) They will be peeled or cut (e.g. whole watermelon, potato) c) They look clean d) All of the above e) None of the above f) Don't know
When cutting raw meat and vegetables for the same meal, you should:	a) Use the same cutting board for raw meat and vegetables b) Use the same cutting board for raw meat and vegetables, rinsing in between uses c) Use a separate cutting board for raw meat and vegetables d) Don't know
Which of the following is a sugary drink?	a) Chocolate milk b) Fruit juice c) Energy drinks d) All of the above e) None of the above f) Don't know
Who is more likely to give you accurate nutrition information?	a) Celebrities or athletes b) Fitness instructors c) Health professionals (e.g., dietitian, doctor, nurse)

	d) Health store employees e) Social media influencers f) Don't know
The ingredients on a granola bar are listed as follows: rolled oats, sugars, peanuts, chia seeds, whole wheat flour and salt. The ingredient that's present in the largest amount is:	a) Salt b) Whole wheat flour c) Chia seeds d) Sugars e) Rolled Oats f) All ingredients are equal g) Don't know
Is it safe to defrost frozen meat, poultry or fish in a dish on the kitchen counter?	a) Yes b) No c) Don't know
How confident are you in your ability to do each of the following?	
Find nutrition information you can trust.	Not at all confident Not very confident Somewhat confident Very confident
Choose the healthiest options from foods sold at restaurants.	Not at all confident Not very confident Somewhat confident Very confident
Prepare a healthy meal for family or friends.	Not at all confident Not very confident Somewhat confident Very confident
Choose the healthiest options from foods sold at grocery stores.	Not at all confident Not very confident Somewhat confident Very confident
How confident are you in your ability to do each of the following food preparation and cooking activities?	
Use a kitchen knife safely (e.g., to cut up raw ingredients)	Not at all confident Not very confident Somewhat confident Very confident
Measure ingredients for a recipe.	Not at all confident Not very confident Somewhat confident Very confident
Follow a simple recipe (one that only has a few ingredients and steps).	Not at all confident Not very confident Somewhat confident Very confident
Sauté (i.e., cook food quickly in a little bit of oil or fat on the stovetop).	Not at all confident Not very confident Somewhat confident Very confident

Use herbs and spices (e.g., basil, thyme, cayenne pepper) to flavour dishes.	Not at all confident Not very confident Somewhat confident Very confident
Make baked goods such as cookies, cupcakes, and cakes etc., using basic ingredients (not from a box).	Not at all confident Not very confident Somewhat confident Very confident
Make soup using basic ingredients (not from a can or box).	Not at all confident Not very confident Somewhat confident Very confident
Cook meat (e.g., stir fry, bake)	Not at all confident Not very confident Somewhat confident Very confident
Prepare meals using plant-based proteins (e.g., beans, lentils, tofu).	Not at all confident Not very confident Somewhat confident Very confident
Change a recipe to make it healthier (e.g., to have less salt, sugar or fat).	Not at all confident Not very confident Somewhat confident Very confident
Prepare meals or snacks using basic ingredients (e.g., pasta, vegetables, meat), with or without a recipe.	Not at all confident Not very confident Somewhat confident Very confident
How much do you agree or disagree that each of the following statements are true?	
It is important to eat most meals without distractions (e.g. cell phones, tablets, TV, toys).	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to prepare healthy meals and snacks most of the time.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to eat meals with others, when possible.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important for my health to make most meals or snacks using basic ingredients (e.g. pasta, vegetables, meat).	Strongly disagree Disagree Neutral Agree

	Strongly agree
When ordering takeout food or food in a restaurant, it is important that I choose healthier options from those available, most of the time.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important for my health to not skip meals or snacks, when possible.	Strongly disagree Disagree Neutral Agree Strongly agree
Eating whole grains (e.g., whole grain pasta and bread, brown rice, oats) is important for my health.	Strongly disagree Disagree Neutral Agree Strongly agree
Eating more beans, lentils, tofu, and other plant-based proteins helps me stay healthy.	Strongly disagree Disagree Neutral Agree Strongly agree
How much do you agree or disagree that each of the following statements are true?	
Food advertising can influence what we buy.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important to use leftovers, when possible	Strongly disagree Disagree Neutral Agree Strongly agree
Reducing the amount of food we throw away is good for the environment.	Strongly disagree Disagree Neutral Agree Strongly agree
How much do you agree or disagree that each of the following statements are true?	
Family, friends, celebrities, and social media can shape/influence what people choose to eat.	Strongly disagree Disagree Neutral Agree Strongly agree
It is important that people are able to access foods specific to their culture.	Strongly disagree Disagree Neutral Agree

	Strongly agree
What people eat can be influenced by cultural or family food traditions.	Strongly disagree Disagree Neutral Agree Strongly agree
A person's living situation (such as income, education and housing) can affect their ability to prepare meals.	Strongly disagree Disagree Neutral Agree Strongly agree
A person’s ability to access food can be affected by their living situation (such as income, transportation, where they live)	Strongly disagree Disagree Neutral Agree Strongly agree

Newest Vital Sign – Canada tool

This information is on the back of a 500-ml container of ice cream.

Nutrition Facts
Serving Size 1/2 cup (125 mL)
Servings Per Container 4

Calories 250	% Daily Value*
Fat 13 g	17 %
Saturated 9 g + Trans 0 g	45 %
Carbohydrate 30 g	
Fibre 0 g	0 %
Sugars 23 g	23 %
Protein 4 g	
Cholesterol 30 mg	
Sodium 55 mg	2 %
Potassium 150 mg	3 %
Calcium 175 mg	13 %
Iron 0.5 mg	3 %
Vitamin A 100 µg	11 %

*5% or less is **a little**, 15% or more is **a lot**

Ingredients: Cream • Skim milk • Sugars (liquid sugar, brown sugar, sugar) • Water • Egg yolks • Milk fat • Peanut oil • Butter • Salt • Carrageenan • Vanilla extract.

1. If you eat the entire container, how many Calories will you eat?	a) 250 Calories b) 300 Calories c) 500 calories d) 1000 Calories e) I do not know
2. If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have?	a) ½ cup (125 mL) b) 1 cup (250 mL) c) 2 cups (500 mL) d) 4 cups (1000 mL) e) I do not know
3. Your doctor advises you to reduce the amount of saturated fat in your diet. You usually have 42 g of saturated fat each day, which includes one serving of ice cream. If you stop eating ice cream, how many grams of saturated fat would you be eating each day?	a) 9 grams b) 15 grams c) 33 grams d) 42 grams e) I do not know
4. If you usually eat 2,500 calories in a day, what percentage of your daily value of Calories will you be eating if you eat one serving of ice cream?	a) 5% b) 10% c) 20% d) 250% e) I do not know
5. Pretend that you are allergic to the following substances: penicillin, peanuts, latex gloves and beestings. Is it safe for you to eat this ice cream?	a) Yes b) No c) I do not know
6. (Answer only if you responded "No" to question 5) Why not?	a) Contains egg b) Comes from bees c) Contains peanut or peanut oil d) Contains ingredients that may be harmful e) I do not know

Individual Food Security Survey Module (adapted from Household Food Security Survey Module)

The following questions are about your food situation in the past 12 months.	
HH1: Which of these statements best describes the food eaten by you in the last 12 months:	a) You always had enough of the kinds of foods you wanted to eat. b) You had enough to eat, but not always the kinds of food you wanted. c) Sometimes you did not have enough to eat. d) Often you didn't have enough to eat. e) Don't know f) Refuse to answer
HH2: You worried that food would run out before you got money to buy more.	a) Often true b) Sometimes true c) Never true d) Don't know e) Refuse to answer
HH3: The food that you bought just didn't last, and there wasn't any money to get more.	a) Often true b) Sometimes true c) Never true d) Don't know e) Refuse to answer
HH4: You couldn't afford to eat balanced meals.	a) Often true b) Sometimes true c) Never true d) Don't know e) Refuse to answer
AD1: In the last 12 months, since last (name of current month), did you ever reduce the size of your meals or skip meals because there wasn't enough money for food?	a) Yes b) No c) Don't know d) Refuse to answer
AD1a: How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	a) Almost every month b) Some months but not every month c) Only 1 or 2 months d) Don't know e) Refuse to answer
AD2: In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	a) Yes b) No c) Don't know d) Refuse to answer
AD3: In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?	a) Yes b) No c) Don't know d) Refuse to answer
AD4: In the last 12 months, did you lose weight because there wasn't enough money for food?	a) Yes b) No

	c) Don’t know d) Refuse to answer
AD5: In the last 12 months, did you ever not eat for a whole day because there wasn't enough money for food?	a) Yes b) No c) Don’t know d) Refuse to answer
AD5a: How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?	a) Almost every month b) Some months but not every month c) Only 1 or 2 months d) Don’t know e) Refuse to answer

APPENDIX 6 – ETHICS APPROVAL CERTIFICATE

UNIVERSITY OF WATERLOO

Notification of Ethics Clearance to Conduct Research with Human Participants

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Principal Investigator: Sharon Kirkpatrick (School of Public Health Sciences)

Student investigator: Martin Holmes (School of Public Health Sciences)

Research assistant: Ailish Margaret Westaway (School of Public Health Sciences)

Collaborator: Elsie Azevedo Perry (Haliburton, Kawartha, Pine Ridge District Health Unit)

Collaborator: Heather Thomas (Middlesex-London Health Unit)

File #: 43057

Title: Evaluating the validity of a novel food literacy measurement tool

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The Human Research Ethics Committee is pleased to inform you this study has been reviewed and given ethics clearance.

Initial Approval Date: 06/29/21 (m/d/y)

University of Waterloo Research Ethics Committees are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS, 2nd edition), International Conference on Harmonization: Good Clinical Practice (ICH-GCP), the Ontario Personal Health Information Protection Act (PHIPA), the applicable laws and regulations of the province of Ontario. Both Committees are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREC) and IRB00007409 (CREC).

This study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Expiry Date: 06/30/22 (m/d/y)

Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.

Level of review: Delegated Review

Signed on behalf of the Human Research Ethics Committee

Joanna Eidse

Joanna Eidse, Research Ethics Officer, jeidse@uwaterloo.ca, 519-888-4567, ext. 37163

This above named study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

APPENDIX 7 – FLIT USER GUIDE

* Accessible via foodliteracy.ca

FLit
Food Literacy Measures
USER GUIDE

Locally Driven Collaborative Project (LDCP)

Healthy Eating Team

FOOD LITERACY FOR LIFE

Citations for reports and publications, including this User Guide, the two food literacy measures and answer keys, are available at www.foodliteracy.ca. As they become available, citations for subsequent publications describing the development and evaluation of the measures will be posted to the website.

The website also includes resources for health professionals and community partners, including the video 'What is food literacy?', and food literacy tips for the public.

SUGGESTED CITATION

Locally Driven Collaborative Project (LDCP) Healthy Eating Team. Food Literacy (FLit) Measures User Guide. 2024. Available at www.foodliteracy.ca.

DISCLAIMER

The views expressed in this publication are those of the project team and do not necessarily reflect those of Public Health Ontario. All opinions expressed reflect those of the authors.

ACKNOWLEDGEMENTS

The Locally Driven Collaborative Project (LDCP) Healthy Eating Team gratefully acknowledges **Public Health Ontario** for supporting our work to conceptualize food literacy and to develop and evaluate measures of food literacy for use in public health practice.

LDCP HEALTHY EATING TEAM MEMBERS

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The LDCP Healthy Eating Team is grateful to:

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> The LDCP Team is indebted to the experts who provided feedback on the conceptualization of food literacy and the draft food literacy measure, and the young adults who participated in the studies to refine and evaluate the measure.

EXECUTIVE SUMMARY

Public Health Ontario's Locally Driven Collaborative Projects (LDCP) initiative supports evidence-based public health practice by bringing together and collaborating with public health units, academic partners, and other key partners to fund and support research projects on public health issues/needs of shared interest related to the Ontario Public Health Standards.

The LDCP Healthy Eating Team (herein referred to as the "LDCP Team") was funded by the LDCP initiative and conducted research on food literacy since 2013. The team, consisting of public health practitioners from several public health units in Ontario, initially sought to explore the meaning of food skills with priority populations, including young adults. Concurrently, the broader concept of food literacy was emerging in the literature and informed the team's subsequent work.

Through the team's research, food literacy was defined as a set of interconnected attributes organized into the domains of *food and nutrition knowledge, skills, self-efficacy/confidence, food decisions, and ecologic (external) factors* such as income security and the food system. Food literacy is important in the context of public health practice because, along with strategies to create healthy food environments and address social determinants of health, food literacy is increasingly understood as an integral component to improving dietary patterns and health.

The project concluded with the development of two evidence-informed and evaluated food literacy measures for use in public health practice. Steps in the process of developing the measures included consulting the literature and experts to develop a definition and conceptual framework for food literacy, and searching the literature for existing measures of food skills and food literacy. Subsequently, the team iteratively developed, refined, and evaluated 50-item and 16-item measures of food literacy. This User Guide provides an overview of the research informing the measures and guidance for using the measures.

The use of standardized and evidence-informed measures of food literacy in public health practice can enable the assessment and monitoring of food literacy and inform programs to support food literacy. The use of the measures will contribute to a growing evidence base on the role of food literacy in shaping eating patterns, with implications for the health and well-being of individuals and the planet.

CONTENTS

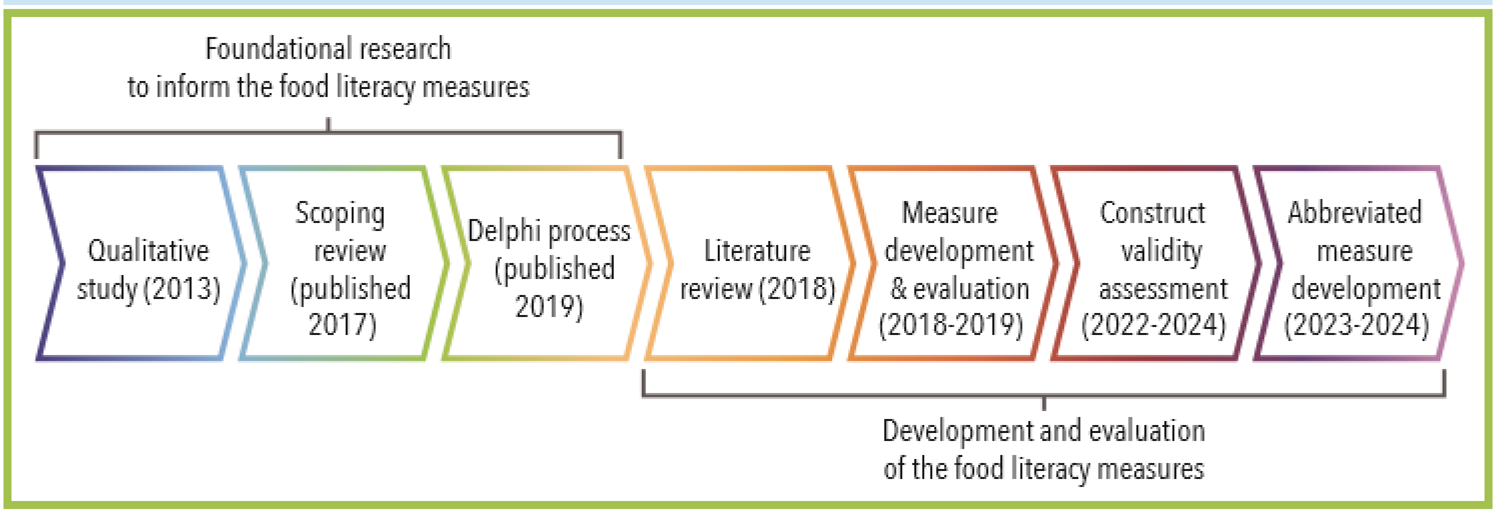
INTRODUCTION

The LDCP Healthy Eating Team (herein referred to as the "LDCP Team") was funded by Public Health Ontario's Locally Driven Collaborative Projects (LDCP) initiative and conducted research on food literacy since 2013. The LDCP Team, consisting of public health practitioners from several public health units in Ontario, initially sought to explore the meaning of food skills with priority populations, including young adults, through a qualitative study.

Concurrently, the broader concept of food literacy was emerging in the literature and informed the team's subsequent work to define and develop a conceptual framework for food literacy. Based on this conceptualization, two evidence-informed and evaluated food literacy measures were developed for use in public health practice.

Steps in the process (**Figure 1**) included consulting the literature and experts to inform the food literacy definition and conceptual framework and searching the literature for existing measures. The LDCP Team then iteratively developed, refined, and evaluated the 50-item and 16-item food literacy measures for use with young adults.

Figure 1: Steps in the process of developing and evaluating the 50-item and 16-item food literacy measures



This User Guide provides an overview of the research informing the measures and provides guidance on using the measures. The Guide is intended to support practitioners in public health and community settings, as well as researchers, in using the measures to broaden our understanding of food literacy.

FOUNDATIONAL RESEARCH TO INFORM THE FOOD LITERACY MEASURES

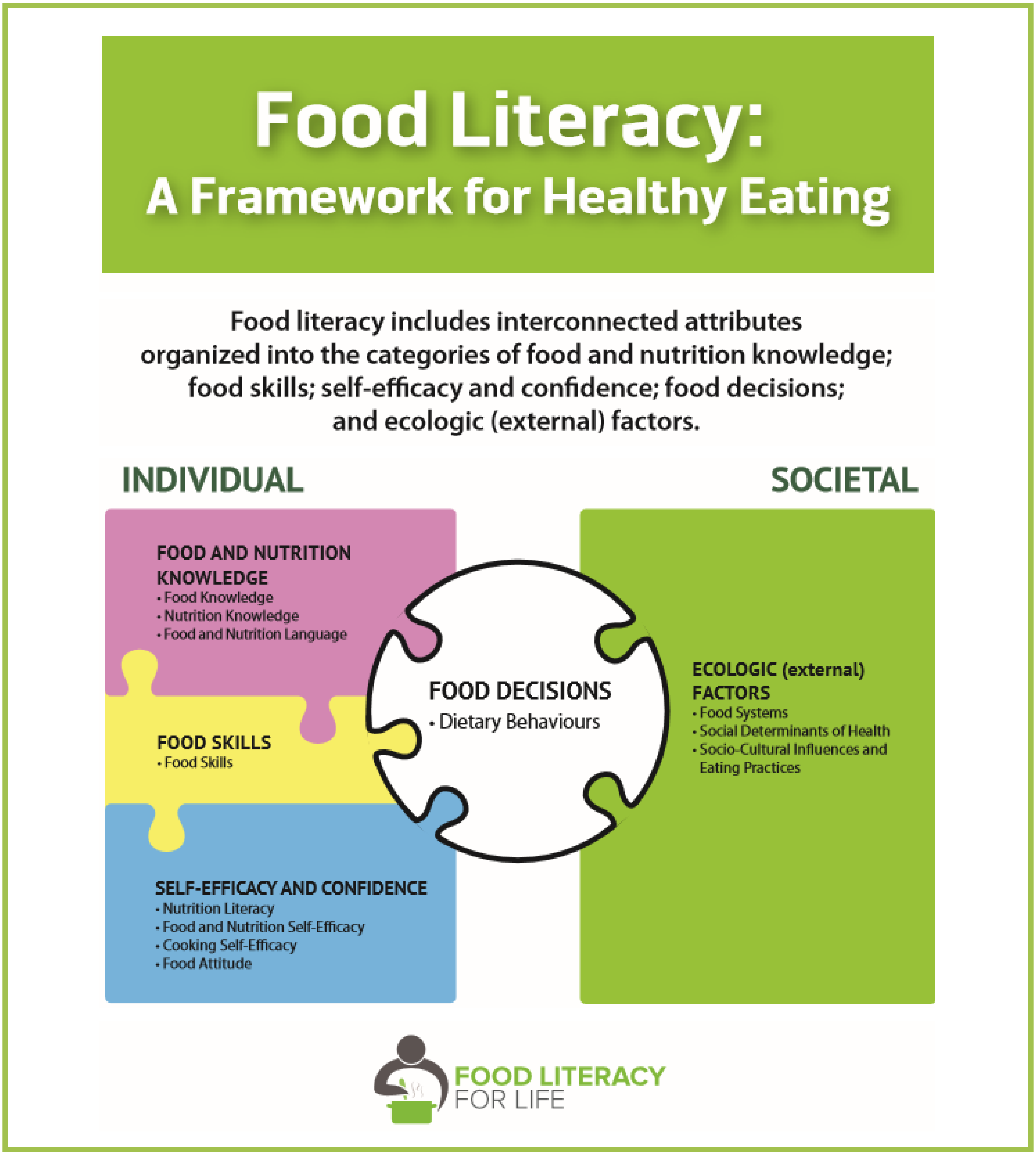
The LDCP Team was initially funded to conduct qualitative research[1] to explore the meaning of food skills and identify barriers and facilitators to food skills acquisition and practice among priority populations. Priority populations identified by the LCDP Team included youth aged 16 to 19 years, pregnant individuals aged 16 to 25 years, and young parents aged 16 to 25 years, who were at risk of experiencing negative social determinants of health, such as constrained income and food insecurity. A key finding was that food skills depended on both personal dimensions and external determinants.

The findings suggested a conceptualization of food skills beyond technical ability and knowledge, consistent with the construct of food literacy[2,3] that was emerging in the academic literature. The team therefore conducted further research to define and develop a conceptual framework for food literacy. First, a scoping review of peer-reviewed and grey literature was conducted[4] to identify the domains and key attributes of food literacy. Subsequently, a Delphi study, which is a consensus building process[5], was conducted with public health practitioners and community partners/agencies who implement food literacy and/or food skills programs and/or who are involved with food literacy research. The Delphi study was conducted to evaluate and verify the language used to describe each of the food literacy attributes, to obtain input on the relevance and importance of these attributes within a public health context, and to determine priority attributes for measurement.[6]

Based on the consensus-building process, a definition of food literacy and a conceptual framework including 11 attributes were developed. After further consultation with Registered Dietitians in Public Health in Ontario, an attribute describing socio-cultural influences and eating practices that had been identified based on the scoping review was reintegrated into the framework. The final Food Literacy Framework includes 12 attributes clustered into five domains (**Figure 2**). The domains and attributes are further detailed in Appendix A.

The interdependent nature of the food literacy attributes has important implications for public health strategies and interventions to support healthy eating. For example, it may be difficult for some individuals to achieve food literacy without opportunities to develop relevant knowledge and skills and to apply them. However, neither knowledge nor ability may be relevant without access to resources for purchasing food, equipment, and supplies for food preparation.

Figure 2: Conceptual framework for food literacy, identifying domains and attributes



DEVELOPMENT AND EVALUATION OF THE FOOD LITERACY MEASURES

To support implementation of the conceptual framework of food literacy in related policies and programs, it was recognized that a standardized and evidence-informed measure of food literacy was needed. Such a measure was sought to contribute to the evidence base for informing, implementing, and evaluating policies and programs related to food literacy. The measure was developed and evaluated in several steps, described below.

LITERATURE REVIEW TO INFORM MEASURES OF FOOD LITERACY

To inform the development of a food literacy measure, a review of peer-reviewed and grey (i.e., unpublished) literature was conducted to identify existing items and/or tools to measure food literacy. To complete the review, the LDCP Team partnered with Public Health Ontario Library Services and researchers at the University of Guelph[7]. Considering publications available in English since 2005, a total of 1016 unique records were identified and 145 were selected for detailed examination based on screening of the titles, abstract, and full text. Of these 145 publications, 52 included items and/or tools for measuring food literacy or similar constructs (e.g., food skills) in the manuscript or supplementary material. These 52 publications included 36 peer-reviewed articles, 10 theses or dissertations, 4 reports, and 2 non-peer-reviewed articles. The research described in the publications was completed predominantly in the USA (21 publications). Most of the studies described were observational in design (41 publications). Most studies focused on adults (37 publications), followed by elementary school children (9 publications). Most measures or items to assess food literacy or food skills used in the studies were modified from existing tools (30 publications), whereas the measures or items described in the other publications were novel (22 publications).

Building on the literature review, the LDCP Team worked with researchers at the University of Toronto to identify an initial set of items for inclusion in a measure of food literacy[8]. The items and tools described in the 52 publications identified by the literature review were further examined, with consideration of the extent to which evaluation or validity testing of the items and tools was described. The level of validity testing described in the original publications was rated as excellent (multiple methods of validity testing clearly described), good (at least one method of validity clearly described), minimal (validity testing mentioned, but unclear what was done), or absent. Further, the authors of the 93 potentially relevant publications identified by the literature review that did not include items and/or measures were contacted for a copy of the items and/or tool. This resulted in the consideration of items and/or tools from an additional eight publications.

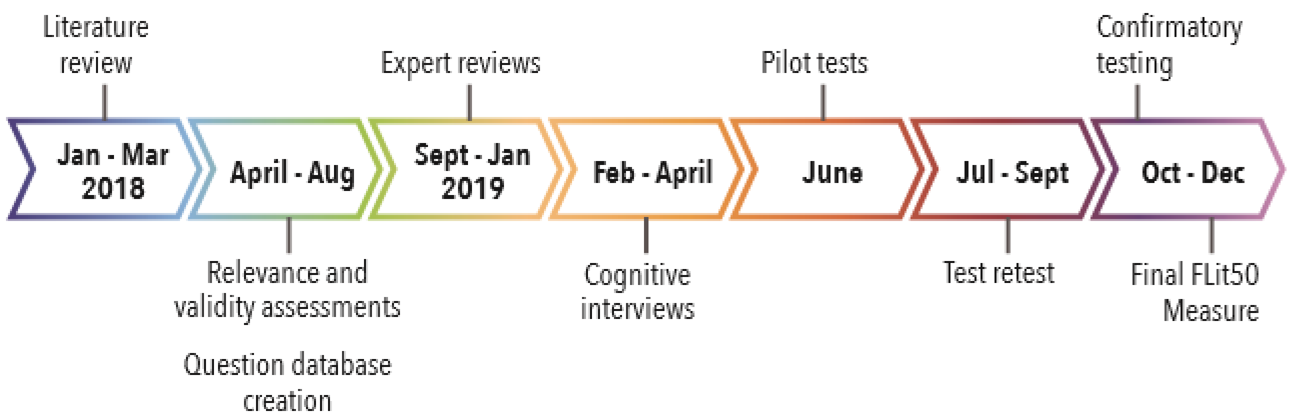
> Drawing upon the pool of existing items and/or tools from the literature, 30 to 60 items were identified for each of the attributes. Based on discussion about the relevance of potential items to the food literacy conceptualization, along with their applicability to a Canadian context, a first iteration of the measure included 126 items (questions or statements).

Items to assess dietary intake were not included in the measure, since it is hypothesized that intake is influenced by, rather than being part of, food literacy.[9] Further, dietary intake is shaped by a range of factors aside from food literacy, such as economic resources. Items in the measure instead focus on individuals' understanding of the relationship between intake and health. Similarly, items to assess household food insecurity were not considered for inclusion, as household food insecurity is conceptually distinct from food literacy. Dietary intake and food insecurity can be assessed separately from food literacy using established and well-evaluated measures (Appendix B).

EVALUATION AND REFINEMENT OF THE 50-ITEM FOOD LITERACY MEASURE

The measure was evaluated and refined in an iterative fashion (**Figure 3**).

Figure 3: Food literacy measure development and preliminary testing (January 2018-December 2019)



First, seven international experts, including academics involved in food literacy research and dietitians working in public health in Ontario, provided feedback on the draft measure to assess its face and content validity. That is, did the measure appear to be capturing the underlying construct of food literacy and did it contain appropriate items to capture food literacy and its attributes.

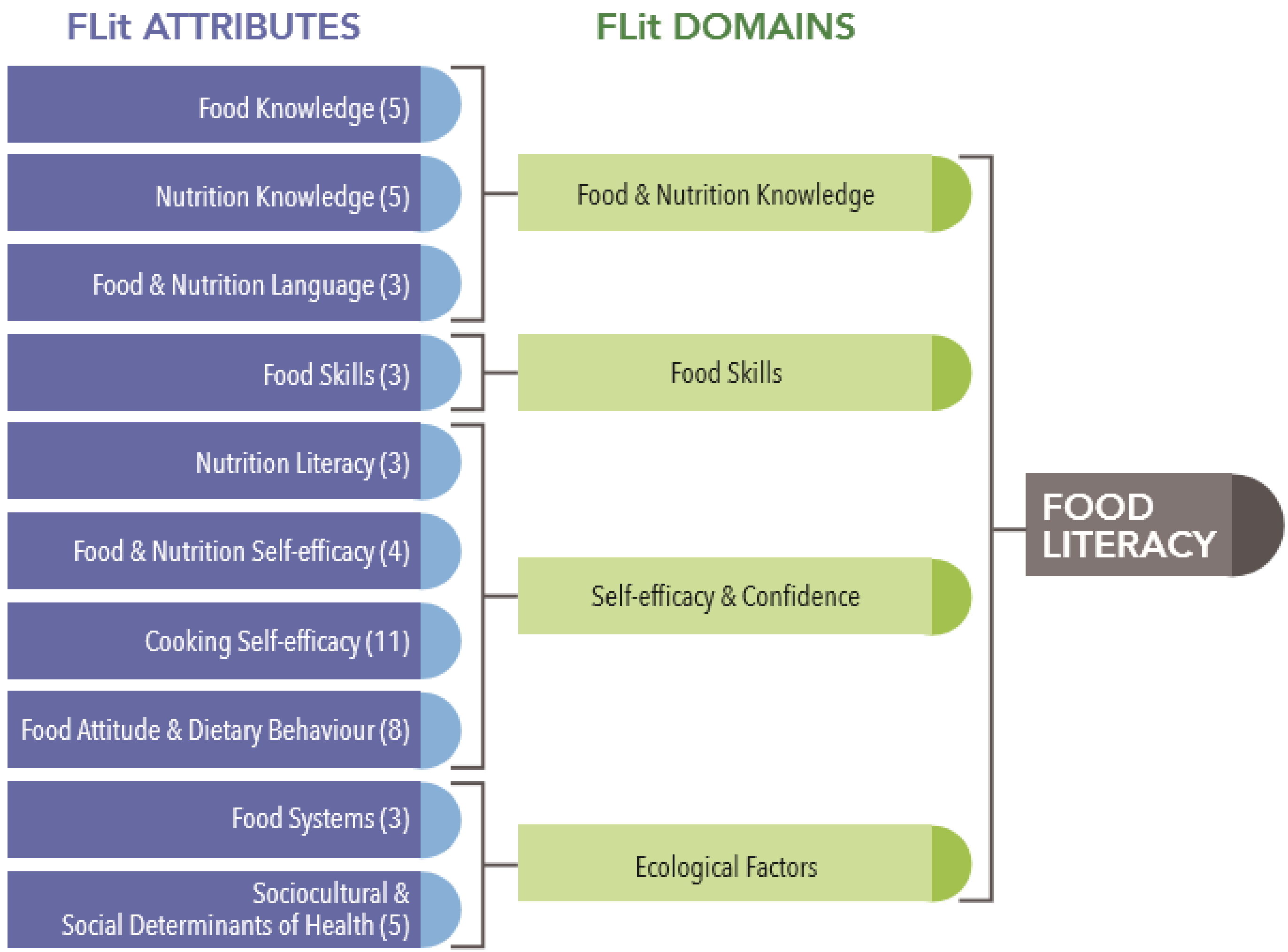
Second, cognitive interviews were conducted with 25 individuals from the identified priority populations, including individuals aged 16 to 19 years and pregnant/young parents aged 16 to 25 years. Participants lived in Canada in diverse geographic contexts, including urban, rural, and mixed-density areas. The cognitive interviews aimed to assess whether the items on the measure were understood as intended, the process of responding to items, perceptions about the difficulty of the items, and the appropriateness of the language used and the response categories. The interviews were also aimed to identify if an item might cause harm or provoke an emotional response in participants. The interviews took place in two rounds, with refinements made to the items on the food literacy measure between rounds based on the findings of the initial interviews.

Third, the online administration of the measure, as well as a broader survey developed for a larger evaluation study, was pilot-tested with seven young adults. The pilot testing led to further refinement of the food literacy measure. Finally, members of the target population were invited to complete the online food literacy measure to evaluate its validity, reliability, and feasibility (Appendix C provides an overview of the types of validity and reliability assessed). Specifically, interest was in whether the measure was capturing the construct of food literacy as intended, whether repeat administrations of the measure in the same individuals led to consistent scores, and whether it was deemed feasible to complete by participants. This testing took place with samples of 255 and 147 young adults who were recruited using paid ads on social media (Facebook and Instagram) and via community programs. Information on socio-demographic characteristics, including age, gender identity, socio-economic status (SES), racial/ethnic identity, pregnancy/parental status, and geographic location was also collected.

> The result of this iterative process was a 50-item food literacy measure, referred to as FLit50, with the evaluation suggesting reasonable face and content validity and test-retest reliability[8].

Based on factor analysis, used to reduce many variables into a smaller number of factors or item groupings, most items grouped as expected based on the food literacy conceptual framework (**Figure 4**). However, items related to the attributes of *food attitudes* and *dietary behaviour* grouped together and those for *socio-cultural influences and eating practices* and *social determinants of health* also grouped together. Compared to the original framework, the conceptual model underlying the 50-item measure therefore reflects a slightly different structure, with 10 groupings of attributes categorized into the domains of *food and nutrition knowledge, food skills, self-efficacy and confidence,* and *ecological factors* (excluding the food decisions domain, based on the grouping of *dietary behaviour* with *food attitudes*).

Figure 4: Conceptual model underlying the 50-item food literacy measure (FLit50). Values in parentheses represent the number of items on the measure intended to capture each attribute. The domains to which each attribute belongs are also indicated.



FURTHER EVALUATION OF THE FOOD LITERACY MEASURE

To assess the construct validity of the measure, that is, how well the measure assesses food literacy, a subsequent study was conducted with 457 post-secondary students in Ontario. Construct validity was assessed by examining whether the measure could differentiate among groups that were expected to have different levels of food literacy, including those enrolled in food and nutrition-related academic programs versus those enrolled in other programs, as well as in relation to other characteristics, such as gender identity (**Table 1**). The evaluation also assessed whether food literacy scores based on the measure were associated with scores on a measure of health literacy. The overall measure was evaluated, along with the subsets of items on the measure reflecting each of the domains.

Table 1: Hypotheses evaluated to assess the construct validity of the food literacy measures among post-secondary students

Characteristic	Hypothesis
Enrolled in a food- or nutrition-related program	Food and nutrition students will score higher in food literacy and domain scores than non-food and nutrition students.
Age	With higher age, food literacy and domain scores will be higher.
Gender identity	Individuals identifying as women will score higher on the full food literacy measure and for the domains than men.
Health literacy	Individuals with higher scores in food literacy and domain scores will have higher health literacy scores.
Income adequacy	Individuals with adequate financial resources will have higher food literacy and domain scores.
Food security status	Individuals in food-secure households will have higher food literacy and domain scores.
General health	Individuals with better self-rated general health will have higher food literacy and domain scores.
Mental health	Individuals with better self-rated mental health status will have higher food literacy and domain scores.

The results of this work suggested that the FLit50 has acceptable construct validity for measuring food literacy. For example, the FLit50 score among students enrolled in food and nutrition programs was 45 compared to 41 among students not enrolled in food and nutrition programs. Further, the evaluation suggested that items reflecting two of the four domains—*food and nutrition knowledge* and *self-efficacy and confidence*—can potentially be used as stand-alone measures. Assessment of the FLit50 suggests that the measure can differentiate well between above and below average food literacy levels, though, the ability to classify individuals at ends of the spectrum, such has high and very high levels of food literacy are less precise. Further research across larger samples may provide more information at these levels of detail.

ABBREVIATED 16-ITEM FOOD LITERACY MEASURE (FLit16)

The LDCP Team sought to develop a shorter version of the measure to expand its potential use in various public health contexts. The items included in the abbreviated measure were informed by analytic techniques that helped to understand the difficulty of each item and how well the measure differentiated people based on their food literacy level, along with discussions with the LCDP Team. The analysis drew upon data collected by University of Toronto researchers during the development and preliminary evaluation of the measure, as well as data collected by University of Waterloo researchers to assess the construct validity of the measure among post-secondary students.

The shortened version includes items corresponding to each attribute represented in the full 50-item measure. For attributes represented by four or more items within the full measure, two questions were included in the shortened measure. For attributes with less than four questions, one question was retained. The construct validity of the resulting 16-item measure, referred to as FLit16, was examined by comparing scores on the short measure with those on the full 50-item measure, as well as with a measure of health literacy. The evaluation also considered whether the short measure was able to differentiate among groups expected to have different levels of food literacy, consistent with the evaluation of the full measure described above. The evaluation suggested that the short measure can differentiate well between high and low food literacy levels. However, it may not be able to detect more granular differences in food literacy, for example, between high and very high levels of food literacy.

USING THE FOOD LITERACY (FLit) MEASURES

> The food literacy measures were developed in English and have been evaluated for use with individuals ages 16 to 19 years and pregnant individuals and young parents ages 16 to 25 years. They are freely available for use.

The measures can be used to assess food literacy in young adults. Further evaluation with diverse populations will be useful, as most participants who took part in the evaluation studies identified as White and as women. The measures can potentially be used with other populations—although the measures have not yet been evaluated in populations beyond young adults, the underlying conceptualization of food literacy is not specific to young adults.

The measures can be used to assess and monitor food literacy. Future evaluation of the measures is needed to inform their use to evaluate interventions, as their sensitivity to changes in food literacy is not yet known.

The measures have been evaluated using online administration. Paper-based administration has not yet been evaluated. If using a paper-based version of the measure, pilot testing with a small sample of participants is recommended.

FEATURES AND USES OF THE 50-ITEM AND 16-ITEM FOOD LITERACY MEASURES

Table 2 provides a comparison of key features of the 50-item and 16-item food literacy measures.

Table 2: Comparison of Key Features of the full 50-item food literacy measure (FLit50) and the abbreviated 16-item measure (FLit16)

	FLit50	FLit16
Purpose	To assess overall food literacy To assess the following food literacy domains: Food and Nutrition Knowledge Self-efficacy and Confidence	To assess overall food literacy
Number of items	50	16
Time to complete	~10 minutes	~3 minutes

The FLit50 can be used to assess food literacy overall and results in a total score of up to 50 points. The FLit50 measure has been evaluated in full to date and it is possible that an individual's responses to items in some domains may influence their responses to items in other domains. However, the evaluation suggested that the sets of items used to measure the *food and nutrition knowledge* (13 items) and *self-efficacy and confidence* (26 items) domains can be used as standalone modules. Accordingly, scores for these two domains can be calculated based on responses to the full measure or the items reflecting the domain of interest can be administered separately to obtain a score for that domain only. The sets of items reflecting the other two domains, *food skills* and *ecological factors*, should not be used separately based on the evaluations to date.

Aside from the use of the full sets of items related to the domains of *food and nutrition knowledge* and *self-efficacy and confidence* to measure those domains specifically, it is not recommended that items from the 50-item measure be extracted to create a shorter measure or that items are removed from the measure.

The abbreviated 16-item measure that has been evaluated can be used in cases in which a shorter measure is desired. The shorter measure is suitable for instances in which respondents have less time to complete the measure and/or when a short measure is desired to administer along with other standardized measures in a broader survey. All 16 items in the measure should be administered to assess food literacy overall. As noted above, it is likely that the short measure allows only differentiation of high versus low food literacy and not assessment of finer or more granular differences in food literacy.

SCORING AND INTERPRETING SCORES

The scoring keys for the two measures are available online.

The scoring approach differs depending on the item type, which includes multiple choice questions with correct and incorrect responses, and statements with Likert scale response options. The maximum score associated with the items reflecting each food literacy attribute and domain, the response types, and scoring criteria for the full 50-item measure are outlined in **Table 3**. The 16-item measure includes a subset of the items from the 50-item version, with consistent scoring approaches.

Table 3: Overview of scoring approaches for items within the 50-item food literacy measure.

Domain	Attribute	Max Score	Response Type	Scoring
Food and nutrition knowledge	Food Knowledge	5	Correct / Incorrect	Correct = 1 point Incorrect = 0 point
	Nutrition Knowledge	5	Correct / Incorrect	Correct = 1 point Incorrect = 0 point
	Food and Nutrition Language	3	Correct / Incorrect	Correct = 1 point Incorrect = 0 point
Food Skills	Food Skills	3	Correct / Incorrect	Correct = 1 point Incorrect = 0 point
Self-efficacy and confidence	Nutrition Literacy	3	Correct / Incorrect	Correct = 1 point Incorrect = 0 point
	Food and Nutrition Self-efficacy	4	Confidence scale (Not at all confident, Not very confident, Somewhat confident, Very confident)	somewhat confident/very confident = 1 point Not at all confident/Not very confident = 0 points
	Cooking Self-efficacy	11	Confidence scale (Not at all confident, Not very confident, Somewhat confident, Very confident)	somewhat confident/very confident = 1 point Not at all confident/Not very confident = 0 points
	Food Attitude and Dietary Behaviour	8	Agreement scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree)	agree/strongly agree = 1 point strongly disagree/ disagree/ neutral = 0 points
Ecological Factors	Food Systems	3	Agreement scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree)	agree/strongly agree = 1 point strongly disagree/ disagree/ neutral = 0 points
	Socio-cultural and Social Determinants of Health	5	Agreement scale (Strongly disagree, Disagree, Neutral, Agree, Strongly agree)	agree/strongly agree = 1 point strongly disagree/ disagree/ neutral = 0 points

The food literacy measures generate continuous scores. There is no known threshold, or cut-off, at which individuals have adequate food literacy or inadequate food literacy.

As the measure is used for different purposes, data will accrue regarding the average, or mean, and range of scores in different groups. Average scores observed among the young adults that participated in the studies to evaluate and refine the draft measure were 38/57 and 31/51 (the measure was subsequently refined to include 50 items). The mean score in the study of post-secondary students was 42/49 (one item was inadvertently omitted from the measure administered in the study, resulting in a total score of 49 rather than 50).

> The average score among all the participants in the development and validation studies was 41/49.

For the two domains from the 50-item measure that showed acceptable validity for use as standalone measures, the average scores were 11/13 for food and nutrition knowledge and 20/25 for self-efficacy and confidence.

> The predicted average score on the FLit16 based on data from the evaluation studies was 12/16.

For contexts in which scores on the food literacy measures are being used to assess relationships between food literacy and other variables, such as gender identity or household food security status, continuous food literacy scores should be used. Categorizing scores requires the use of arbitrary thresholds and results in the loss of information, as well as potential misclassification.

> For practitioners aiming to report the results of food literacy assessments, we advise presenting the mean (average) score from your sample, along with the observed minimum and maximum scores.

This approach enables meaningful comparisons between the mean score of your current sample and the benchmark mean score of 41 for the FLit50 or 12 for the FLit16. It is important to recognize that these mean scores are subject to variation with continued application of the FLit measures to different populations and should not be interpreted as rigid thresholds.

The use of non-stigmatizing language is encouraged when describing food literacy. For example, referring to levels of food literacy, such as higher versus lower food literacy, is preferred over labels such as food literate or illiterate.

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APPENDIX A:
FOOD LITERACY DOMAINS AND ATTRIBUTES

CATEGORIES	ATTRIBUTES
FOOD AND NUTRITION KNOWLEDGE	**FOOD KNOWLEDGE** To understand the variety of foods within all food groups. To know where food comes from and what is in it. **NUTRITION KNOWLEDGE** To understand the nutrients in food and how these can affect health and wellbeing. **FOOD AND NUTRITION LANGUAGE** To understand commonly used words to describe characteristics of nutrition in food (e.g., high fibre, low sodium) and preparation of food (e.g., sauté, fold).
FOOD SKILLS	**FOOD SKILLS** To be able to prepare meals throughout the life span using basic skills like chopping, measuring, cooking, reading recipes, and food safety.
SELF-EFFICACY AND CONFIDENCE	**NUTRITION LITERACY** To be able to distinguish between credible and false nutrition information. Knowing how to find reliable nutrition information and how to make sense of it (e.g., reading a food label). **FOOD AND NUTRITION SELF-EFFICACY** To believe in one's ability to apply food and nutrition-related knowledge to select, buy, and prepare food to make healthy choices in a complex food environment. **COOKING SELF-EFFICACY** To have confidence in one's ability to use cooking techniques and to prepare tasty meals with available food. **FOOD ATTITUDE** The desire to learn how to: prepare food; develop a healthy relationship toward food; have respect for food traditions and culture; and prepare and enjoy food to eat together with others.
ECOLOGIC (External) FACTORS	**FOOD SYSTEMS** The impact of the food system (e.g., growing, manufacturing, transportation, preparation, consumption and disposal of food products) on individual health, broader societal and economic wellbeing, and the environment. **SOCIAL DETERMINANTS OF HEALTH** Access to living wages, affordable housing, learning environments, healthy and adequate food, and cooking equipment. **SOCIO-CULTURAL INFLUENCES AND EATING PRACTICES** The influence of socio-cultural values, norms, and beliefs on food choices and eating practices; the social support to learn and share food skills; and the cultural and family food practices (e.g., eating together).
FOOD DECISIONS	**DIETARY BEHAVIOUR** To make healthy food choices.

APPENDIX B:
RESOURCES FOR ASSESSING DIETARY INTAKE AND HOUSEHOLD FOOD SECURITY STATUS

As described, the food literacy measures do not assess dietary intake or household food security status. The resources below provide information on assessing these constructs.

DIETARY INTAKE

There are various methods for assessing dietary intake, with variation in burden for the individuals collecting and providing the data, in accuracy and precision, and in the complexity of the coding and analyses required.

The National Cancer Institute's Dietary Assessment Primer provides an overview of different methods and how they can be used.

Practitioners and researchers may be interested in comparing alignment of dietary intakes with the most recent food-based dietary guidance in Canada, the 2019 Canada's Food Guide. Health Canada provides an overview of tools that can be used for this purpose. These include short screeners that can be administered in less than five minutes.

HOUSEHOLD FOOD SECURITY STATUS

The Household Food Security Survey Module is used nationally to measure food security at the household level. The module is a component of the Canadian Income Survey, and in research. Health Canada provides an overview of the Module.

APPENDIX C:

PROPERTIES ASSESSED IN THE EVALUATION OF THE FOOD LITERACY MEASURES

Property assessed	Description	Sample
Face validity[1]	The degree to which a measure appears to capture the construct of interest.	Experts in the field of food literacy
Content validity[1]	The degree to which a measure covers the entire conceptual domain of what is being measured (i.e., all the attributes of food literacy).	
Cognitive Validity[1]	The relationship between what a measure aims to measure and what it elicits from test takers, including item interpretation and response rationale.	Youth, ages 16 to 19 years Young pregnant individuals and parents, ages 16 to 25 years
Test-retest reliability[2]	The consistency of results based on the same sample when the measure is administered at multiple points in time.	
Known group validity (an indicator of construct validity)	The extent to which a measure can discriminate between two groups known to differ on the variable of interest.	Post-secondary students
Convergent validity (an indicator of construct validity)	The extent to which a measure is related to other measures of the same (or similar) constructs.	
Hypothesis validity (an indicator of construct validity)	The extent to which data from a measure reflect theoretically derived predictions about the relations with the construct of interest, e.g., differences in food literacy scores between students in food and nutrition programs and those in other programs.	

[1]These aspects of validity were assessed for the FLit50 and inferred for the FLit16.
[2]The test-retest reliability of the FLit16 has not yet been assessed.

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APPENDIX 8 – CHAPTER 5 SUPPLEMENTAL TABLES

Supplemental Table 1: Multiple pair-wise comparisons of differences in mean food literacy scores between variable group categories using Dunn's Test with Bonferroni adjustments

Variable	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj.signif	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon^2)
Food Program	Student of non-food program	Student of food program	341	116	40.5	(40.08, 41.02)	4.4	45.1	(44.4, 45.87)	4.0	10.40	0.00	0.00	****	0.87	-4.59	(-5.46, -3.72)	0.023
Age	18	19	5	76	43.4	(38.05, 48.75)	6.1	41.3	(40.16, 42.48)	5.2	-1.16	0.25	1	ns	5.48	2.08	(-3.39, 7.56)	-0.015
	18	20	5	96	43.4	(38.05, 48.75)	6.1	41.0	(40.05, 42.01)	4.9	-1.32	0.19	1	ns	5.44	2.37	(-3.07, 7.81)	-0.013
	18	21	5	110	43.4	(38.05, 48.75)	6.1	42.2	(41.32, 43.03)	4.6	-0.82	0.41	1	ns	5.42	1.23	(-4.19, 6.65)	-0.007
	18	22	5	64	43.4	(38.05, 48.75)	6.1	42.1	(40.9, 43.26)	4.8	-0.82	0.41	1	ns	5.48	1.32	(-4.16, 6.8)	-0.012
	18	23	5	46	43.4	(38.05, 48.75)	6.1	41.7	(40.32, 43.03)	4.7	-1.04	0.30	1	ns	5.52	1.73	(-3.8, 7.25)	-0.021
	18	24	5	18	43.4	(38.05, 48.75)	6.1	41.4	(39.53, 43.25)	4.0	-1.21	0.23	1	ns	5.67	2.01	(-3.66, 7.68)	-0.055
	18	25	5	34	43.4	(38.05, 48.75)	6.1	42.0	(40.38, 43.62)	4.8	-0.81	0.42	1	ns	5.59	1.40	(-4.19, 6.99)	-0.021

	19	20	76	96	41.3	(40.16, 42.48)	5.2	41.0	(40.05, 42.01)	4.9	-0.44	0.66	1	ns	1.52	0.28	(-1.23, 1.8)	-0.003
	19	21	76	110	41.3	(40.16, 42.48)	5.2	42.2	(41.32, 43.03)	4.6	1.07	0.28	1	ns	1.44	-0.86	(-2.3, 0.58)	0.006
	19	22	76	64	41.3	(40.16, 42.48)	5.2	42.1	(40.9, 43.26)	4.8	0.92	0.36	1	ns	1.65	-0.76	(-2.41, 0.89)	0.007
	19	23	76	46	41.3	(40.16, 42.48)	5.2	41.7	(40.32, 43.03)	4.7	0.24	0.81	1	ns	1.78	-0.36	(-2.14, 1.42)	0.002
	19	24	76	18	41.3	(40.16, 42.48)	5.2	41.4	(39.53, 43.25)	4.0	-0.28	0.78	1	ns	2.19	-0.07	(-2.27, 2.12)	-0.003
	19	25	76	34	41.3	(40.16, 42.48)	5.2	42.0	(40.38, 43.62)	4.8	0.72	0.47	1	ns	1.99	-0.68	(-2.67, 1.31)	0.007
	20	21	96	110	41.0	(40.05, 42.01)	4.9	42.2	(41.32, 43.03)	4.6	1.63	0.10	1	ns	1.30	-1.14	(-2.44, 0.16)	0.008
	20	22	96	64	41.0	(40.05, 42.01)	4.9	42.1	(40.9, 43.26)	4.8	1.38	0.17	1	ns	1.53	-1.05	(-2.58, 0.48)	0.009
	20	23	96	46	41.0	(40.05, 42.01)	4.9	41.7	(40.32, 43.03)	4.7	0.63	0.53	1	ns	1.67	-0.64	(-2.31, 1.03)	0.004
	20	24	96	18	41.0	(40.05, 42.01)	4.9	41.4	(39.53, 43.25)	4.0	-0.02	0.98	1	ns	2.10	-0.36	(-2.46, 1.75)	0.000
	20	25	96	34	41.0	(40.05, 42.01)	4.9	42.0	(40.38, 43.62)	4.8	1.08	0.28	1	ns	1.89	-0.97	(-2.86, 0.92)	0.008
	21	22	110	64	42.2	(41.32, 43.03)	4.6	42.1	(40.9, 43.26)	4.8	-0.03	0.98	1	ns	1.45	0.09	(-1.36, 1.55)	0.000
	21	23	110	46	42.2	(41.32, 43.03)	4.6	41.7	(40.32, 43.03)	4.7	-0.66	0.51	1	ns	1.60	0.50	(-1.1, 2.1)	-0.004

	21	24	110	18	42.2	(41.32, 43.03)	4.6	41.4	(39.53, 43.25)	4.0	-0.92	0.36	1	ns	2.05	0.78	(-1.26, 2.83)	-0.007
	21	25	110	34	42.2	(41.32, 43.03)	4.6	42.0	(40.38, 43.62)	4.8	-0.06	0.96	1	ns	1.83	0.17	(-1.66, 2)	0.000
	22	23	64	46	42.1	(40.9, 43.26)	4.8	41.7	(40.32, 43.03)	4.7	-0.57	0.57	1	ns	1.79	0.40	(-1.39, 2.2)	-0.005
	22	24	64	18	42.1	(40.9, 43.26)	4.8	41.4	(39.53, 43.25)	4.0	-0.86	0.39	1	ns	2.20	0.69	(-1.51, 2.89)	-0.011
	22	25	64	34	42.1	(40.9, 43.26)	4.8	42.0	(40.38, 43.62)	4.8	-0.03	0.98	1	ns	2.00	0.08	(-1.92, 2.08)	0.000
	23	24	46	18	41.7	(40.32, 43.03)	4.7	41.4	(39.53, 43.25)	4.0	-0.43	0.67	1	ns	2.30	0.29	(-2.02, 2.59)	-0.007
	23	25	46	34	41.7	(40.32, 43.03)	4.7	42.0	(40.38, 43.62)	4.8	0.46	0.65	1	ns	2.11	-0.33	(-2.43, 1.78)	0.006
	24	25	18	34	41.4	(39.53, 43.25)	4.0	42.0	(40.38, 43.62)	4.8	0.76	0.45	1	ns	2.47	-0.61	(-3.08, 1.86)	0.015
Gender	Men	Women	103	343	39.0	(38.1, 39.87)	4.6	42.6	(42.11, 43.06)	4.5	7.01	0.00	0.00	****	1.01	-3.60	(-4.61, -2.6)	0.016
Health literacy	High likelihood of limited literacy	Possibility of limited literacy	5	51	38.0	(36.61 - 39.39)	1.6	38.9	(37.33 - 40.4)	5.6	1.02	0.31	0.92	ns	2.07	-0.86	(-2.93, 1.2)	0.019
	High likelihood of limited literacy	Adequate literacy	5	401	38.0	(36.61 - 39.39)	1.6	42.1	(41.68 - 42.57)	4.6	2.37	0.02	0.05	ns	1.46	-4.12	(-5.58, -2.67)	0.006
	Possibility of limited literacy	Adequate literacy	51	401	38.9	(37.33 - 40.4)	5.6	42.1	(41.68 - 42.57)	4.6	3.96	0.00	0.00	***	1.60	-3.26	(-4.86, -1.66)	0.009
General health status	Poor	Fair	23	116	38.0	(35.88, 40.12)	5.2	39.9	(39.08, 40.82)	4.8	1.39	0.16	1	ns	2.30	-1.95	(-4.24, 0.35)	0.010

	Poor	Good	23	172	38.0	(35.88, 40.12)	5.2	42.2	(41.53, 42.84)	4.4	3.60	0.00	0.00	**	2.22	-4.19	(-6.41, -1.96)	0.019
	Poor	Very good	23	121	38.0	(35.88, 40.12)	5.2	43.3	(42.54, 43.97)	4.0	4.56	0.00	0.00	****	2.24	-5.26	(-7.5, -3.01)	0.032
	Poor	Excellent	23	22	38.0	(35.88, 40.12)	5.2	44.2	(42.74, 45.71)	3.6	4.11	0.00	0.00	***	2.59	-6.23	(-8.82, -3.63)	0.093
	Fair	Good	116	172	39.9	(39.08, 40.82)	4.8	42.2	(41.53, 42.84)	4.4	4.01	0.00	0.00	***	1.09	-2.24	(-3.33, -1.14)	0.014
	Fair	Very good	116	121	39.9	(39.08, 40.82)	4.8	43.3	(42.54, 43.97)	4.0	5.53	0.00	0.00	****	1.13	-3.31	(-4.44, -2.18)	0.023
	Fair	Excellent	116	22	39.9	(39.08, 40.82)	4.8	44.2	(42.74, 45.71)	3.6	3.90	0.00	0.00	***	1.72	-4.28	(-6, -2.55)	0.028
	Good	Very good	172	121	42.2	(41.53, 42.84)	4.4	43.3	(42.54, 43.97)	4.0	2.00	0.05	0.45	ns	0.97	-1.07	(-2.04, -0.1)	0.007
	Good	Excellent	172	22	42.2	(41.53, 42.84)	4.4	44.2	(42.74, 45.71)	3.6	1.88	0.06	0.60	ns	1.63	-2.04	(-3.67, -0.41)	0.010
	Very good	Excellent	121	22	43.3	(42.54, 43.97)	4.0	44.2	(42.74, 45.71)	3.6	0.81	0.42	1	ns	1.65	-0.97	(-2.62, 0.68)	0.006
Mental health status	Poor	Fair	94	139	40.8	(39.72, 41.81)	5.2	40.9	(40.13, 41.7)	4.7	0.06	0.95	1	ns	1.30	-0.15	(-1.45, 1.15)	0.000
	Poor	Good	94	149	40.8	(39.72, 41.81)	5.2	42.8	(42.01, 43.49)	4.6	3.21	0.00	0.01	*	1.28	-1.99	(-3.26, -0.71)	0.013
	Poor	Very good	94	64	40.8	(39.72, 41.81)	5.2	42.4	(41.34, 43.47)	4.3	1.99	0.05	0.46	ns	1.49	-1.64	(-3.13, -0.15)	0.013
	Poor	Excellent	94	10	40.8	(39.72, 41.81)	5.2	42.6	(40.08, 45.12)	4.1	0.93	0.35	1	ns	2.72	-1.83	(-4.56, 0.89)	0.009

	Fair	Good	139	149	40.9	(40.13, 41.7)	4.7	42.8	(42.01, 43.49)	4.6	3.52	0.00	0.00	**	1.07	-1.84	(-2.91, -0.76)	0.012
	Fair	Very good	139	64	40.9	(40.13, 41.7)	4.7	42.4	(41.34, 43.47)	4.3	2.08	0.04	0.37	ns	1.32	-1.49	(-2.81, -0.17)	0.010
	Fair	Excellent	139	10	40.9	(40.13, 41.7)	4.7	42.6	(40.08, 45.12)	4.1	0.92	0.36	1	ns	2.64	-1.69	(-4.32, 0.95)	0.006
	Good	Very good	149	64	42.8	(42.01, 43.49)	4.6	42.4	(41.34, 43.47)	4.3	-0.67	0.50	1	ns	1.29	0.35	(-0.95, 1.64)	-0.003
	Good	Excellent	149	10	42.8	(42.01, 43.49)	4.6	42.6	(40.08, 45.12)	4.1	-0.35	0.73	1	ns	2.62	0.15	(-2.47, 2.77)	-0.002
	Very good	Excellent	64	10	42.4	(41.34, 43.47)	4.3	42.6	(40.08, 45.12)	4.1	-0.04	4 0.969	1	ns	2.73	-0.19	(-2.93, 2.54)	-0.001
	Very easy	Easy	71	95	42.6	(41.57, 43.62)	4.4	41.3	(40.3, 42.22)	4.8	-1.83	0.07	0.67	ns	1.40	1.33	(-0.08, 2.73)	-0.011
	Very easy	Neither easy nor difficult	71	200	42.6	(41.57, 43.62)	4.4	41.7	(41.06, 42.38)	4.7	-1.33	0.19	1	ns	1.22	0.87	(-0.35, 2.09)	-0.005
	Very easy	Difficult	71	58	42.6	(41.57, 43.62)	4.4	41.4	(40.07, 42.76)	5.2	-1.41	0.16	1	ns	1.69	1.18	(-0.52, 2.87)	-0.011
Income adequacy	Very easy	Very difficult	71	11	42.6	(41.57, 43.62)	4.4	40.0	(36.32, 43.68)	6.2	-1.27	0.20	1	ns	3.82	2.59	(-1.23, 6.41)	-0.016
	Easy	Neither easy nor difficult	95	200	41.3	(40.3, 42.22)	4.8	41.7	(41.06, 42.38)	4.7	0.84	0.40	1	ns	1.16	-0.46	(-1.62, 0.71)	0.003
	Easy	Difficult	95	58	41.3	(40.3, 42.22)	4.8	41.4	(40.07, 42.76)	5.2	0.23	0.82	1	ns	1.65	-0.15	(-1.81, 1.5)	0.002
	Easy	Very difficult	95	11	41.3	(40.3, 42.22)	4.8	40.0	(36.32, 43.68)	6.2	-0.39	0.70	1	ns	3.80	1.26	(-2.54, 5.07)	-0.004

	Neither easy nor difficult	Difficult	200	58	41.7	(41.06, 42.38)	4.7	41.4	(40.07, 42.76)	5.2	-0.44	0.66	1	ns	1.50	0.31	(-1.19, 1.81)	-0.002
	Neither easy nor difficult	Very difficult	200	11	41.7	(41.06, 42.38)	4.7	40.0	(36.32, 43.68)	6.2	-0.74	0.46	1	ns	3.74	1.72	(-2.02, 5.46)	-0.004
	Difficult	Very difficult	58	11	41.4	(40.07, 42.76)	5.2	40.0	(36.32, 43.68)	6.2	-0.49	0.62	1	ns	3.92	1.41	(-2.51, 5.33)	-0.007
Food security status	Food secure	Marginal food insecurity	273	67	42.5	(42.01, 43.06)	4.4	41.0	(39.87, 42.04)	4.5	-2.79	0.01	0.03	*	1.21	1.58	(0.37, 2.79)	-0.008
	Food secure	Moderate food insecurity	273	71	42.5	(42.01, 43.06)	4.4	39.8	(38.48, 41.04)	5.5	-4.07	0.00	0.00	***	1.38	2.77	(1.39, 4.16)	-0.012
	Food secure	Severe food insecurity	273	46	42.5	(42.01, 43.06)	4.4	41.0	(39.51, 42.4)	5.0	-2.08	0.04	0.23	ns	1.53	1.58	(0.04, 3.11)	-0.007
	Marginal food insecurity	Moderate food insecurity	67	71	41.0	(39.87, 42.04)	4.5	39.8	(38.48, 41.04)	5.5	-0.95	0.34	1	ns	1.68	1.19	(-0.48, 2.87)	-0.007
	Marginal food insecurity	Severe food insecurity	67	46	41.0	(39.87, 42.04)	4.5	41.0	(39.51, 42.4)	5.0	0.26	0.80	1	ns	1.81	0.00	(-1.81, 1.8)	0.002
	Moderate food insecurity	Severe food insecurity	71	46	39.8	(38.48, 41.04)	5.5	41.0	(39.51, 42.4)	5.0	1.11	0.27	1	ns	1.93	-1.20	(-3.12, 0.73)	0.010

Supplemental Table 2: Results of the Kruskal Wallis Analysis of Variance evaluation of mean food literacy domain scores among subgroups with hypothesized differences among study participants.

			Food & Nutrition Knowledge score				Food Skills score				Self Efficacy & Confidence score				Ecological Factors score			
Characteristic	n (%)	df	Mean Score (SD)	Median Score (IQR)	KW statistic	p values[1]	Mean Score (SD)	Median Score (IQR)	KW statistic	p values[1]	Mean Score (SD)	Median Score (IQR)	KW statistic	p values[1]	Mean Score (SD)	Median Score (IQR)	KW statistic	p values[1]
Food Program	**457**	**1**	**10.9 (1.7)**	**11 (2)**	**76.4**	**< 0.001**	**1.7 (0.4)**	**3 (0)**	**0.143**	**0.705**	**20.4 (3.3)**	**21 (4)**	**100**	**< 0.001**	**7.7 (0.8)**	**8 (0)**	**2.04**	**0.156**
Yes	116 (25%)		11.6 (1.6)	12 (1)			2.8 (0.4)	3 (0)			22.8 (2.3)	23 (2)			7.7 (0.9)	8 (0)		
No	341 (75)		10.5 (1.6)	11 (2)			2.8 (0.4)	3 (0)			19.5 (3.2)	20 (4)			7.7 (0.7)	8 (0)		
Gender[2]	**446**	**1**	**10.9 (1.7)**	**11 (2)**	**28.5**	**< 0.001**	**1.7 (0.4)**	**3 (0)**	**8.86**	**0.003**	**20.4 (3.3)**	**21 (4)**	**28.2**	**< 0.001**	**7.7 (0.8)**	**8 (0)**	**29.6**	**< 0.001**
Man	103 (23%)		10 (1.9)	10 (2)			2.7 (0.5)	3 (1)			19 (3.3)	19 (4)			7.3 (1.2)	8 (1)		
Women	343 (75)		11.1 (1.6)	11 (2)			2.8 (0.4)	3 (0)			20.8 (3.2)	22 (4)			7.8 (0.6)	8 (0)		
Age[3]	**449**	**7**	**10.9 (1.7)**	**11 (2)**	**8.32**	**0.305**	**1.7 (0.4)**	**3 (0)**	**14.5**	**0.043**	**20.3 (3.3)**	**21 (4)**	**4.68**	**0.699**	**7.7 (0.8)**	**8 (0)**	**14.4**	**0.045**
18	5 (1%)		10.4 (2.8)	11 (0)			2.8 (0.4)	3 (0)			22.4 (2.7)	23 (2)			7.8 (0.4)	8 (0)		
19	76 (17)		10.7 (1.9)	11 (2)			2.8 (0.5)	3 (0)			20.2 (3.6)	21 (5)			7.6 (0.8)	8 (1)		
20	96 (21)		10.5 (1.7)	11 (2)			2.8 (0.5)	3 (0)			20.3 (3.0)	21 (4)			7.4 (1.2)	8 (1)		
21	110 (24)		11.1 (1.5)	12 (2)			2.8 (0.4)	3 (0)			20.4 (3.5)	21 (4)			7.8 (0.5)	8 (0)		
22	64 (14)		10.9 (1.8)	11 (2)			2.9 (0.3)	3 (0)			20.7 (3.4)	21 (4.25)			7.6 (0.7)	8 (1)		
23	46 (10)		11 (1.6)	11 (2.75)			2.7 (0.5)	3 (1)			20.3 (3.2)	21 (3.75)			7.7 (0.7)	8 (0)		
24	18 (4)		11.2 (1.2)	12 (1.75)			2.9 (0.2)	3 (0)			19.4 (3.6)	19 (4.75)			7.8 (0.4)	8 (0)		
25	34 (7)		11.1 (1.6)	11 (1)			2.8 (0.4)	3 (0)			20.3 (3.4)	21 (3)			7.9 (0.5)	8 (0)		
Health literacy	**457**	**2**	**10.9 (1.7)**	**11 (2)**	**29**	**< 0.001**	**1.7 (0.4)**	**3 (0)**	**1.68**	**0.431**	**20.4 (3.3)**	**21 (4)**	**6.2**	**0.045**	**7.7 (0.8)**	**8 (0)**	**18.1**	**< 0.001**
High likelihood of limited literacy	5 (1%)		9.2 (2.0)	9 (2)			2.8 (0.4)	3 (0)			19 (2.8)	21 (4)			7 (1.2)	7 (1)		
Possibility of limited literacy	51 (11)		9.4 (2.0)	10 (2.5)			2.7 (0.5)	3 (0)			19.3 (3.8)	20 (4)			7.2 (1.4)	8 (1)		
Adequate health literacy	401 (88)		11.1 (1.6)	11 (2)			2.8 (0.4)	3 (0)			20.5 (3.3)	21 (4)			7.7 (0.7)	8 (0)		
Perceived income adequacy[4]	**435**	**4**	**10.9 (1.7)**	**11 (2)**	**5.37**	**0.252**	**1.7 (0.4)**	**3 (0)**	**3.71**	**0.446**	**20.4 (3.3)**	**21 (4)**	**1.48**	**0.831**	**7.7 (0.8)**	**8 (0)**	**6.5**	**0.165**
Very difficult	71 (16%)		10.2 (2.0)	11 (2)			2.8 (0.4)	3 (0)			19.9 (3.5)	21 (4)			7.1 (1.9)	8 (0)		
Difficult	95 (21)		10.6 (2.0)	11 (2)			2.8 (0.4)	3 (0)			20.4 (3.2)	21 (4)			7.6 (0.7)	8 (1)		
Neither easy nor difficult	200 (44)		10.9 (1.6)	11 (2)			2.8 (0.4)	3 (0)			20.3 (3.5)	21 (5)			7.7 (0.7)	8 (0)		
Easy	58 (13)		10.7 (1.8)	11 (2)			2.7 (0.5)	3 (0)			20.3 (3.3)	21 (3)			7.6 (0.9)	8 (1)		
Very easy	11 (2)		11.2 (1.5)	11 (1.5)			2.9 (0.4)	3 (0)			20.8 (3.1)	20 (5.5)			7.7 (0.8)	8 (0.5)		
General Health[5]	**454**	**4**	**10.9 (1.7)**	**11 (2)**	**25.1**	**< 0.001**	**1.7 (0.4)**	**3 (0)**	**1.86**	**0.761**	**20.4 (3.3)**	**21 (4)**	**45.6**	**< 0.001**	**7.7 (0.8)**	**8 (0)**	**7.89**	**0.095**
Poor	23 (5%)		9.3 (2.2)	10 (3.5)			2.7 (0.6)	3 (0.5)			18.7 (3.8)	19 (6)			7.3 (1.0)	8 (1)		
Fair	116 (25)		10.7 (1.6)	11 (2)			2.8 (0.4)	3 (0)			18.9 (3.6)	19 (5)			7.5 (1.1)	8 (1)		
Good	172 (38)		10.9 (1.6)	11 (2)			2.8 (0.4)	3 (0)			20.7 (3.0)	21 (4)			7.7 (0.6)	8 (0)		
Very good	121 (26)		11.3 (1.5)	11 (1)			2.8 (0.4)	3 (0)			21.4 (2.8)	22 (4)			7.7 (0.6)	8 (0)		
Excellent	22 (5)		11.5 (1.4)	12 (2.75)			2.9 (0.4)	3 (0)			22.1 (2.3)	21.5 (3)			7.8 (0.5)	8 (0)		
Mental Health[6]	**456**	**4**	**10.9 (1.7)**	**11 (2)**	**8.23**	**0.0834**	**1.7 (0.4)**	**3 (0)**	**1.65**	**0.799**	**20.4 (3.3)**	**21 (4)**	**17.9**	**0.001**	**7.7 (0.8)**	**8 (0)**	**2.79**	**0.594**
Poor	94 (21%)		10.6 (2.0)	11 (2)			2.8 (0.5)	3 (0)			19.8 (3.6)	20 (5)			7.5 (1.1)	8 (1)		
Fair	139 (30)		10.7 (1.7)	11 (2)			2.8 (0.4)	3 (0)			19.8 (3.2)	20 (4)			7.7 (0.7)	8 (0)		
Good	149 (33)		11.1 (1.6)	12 (2)			2.8 (0.4)	3 (0)			21.1 (3.3)	22 (5)			7.7 (0.7)	8 (0)		
Very good	64 (14)		11.1 (1.4)	11 (2)			2.9 (0.3)	3 (0)			20.7 (3.1)	21 (4)			7.7 (0.8)	8 (0)		

Excellent	10 (2)		11 (1.6)	11 (1.75)			2.8 (0.4)	3 (0)			21 (2.6)	20.5 (3.25)			7.8 (0.4)	8 (0)		
Food security level	**457**	**3**	**10.9 (1.7)**	**11 (2)**	**23.3**	**< 0.001**	**1.7 (0.4)**	**3 (0)**	**1.22**	**0.749**	**20.4 (3.3)**	**21 (4)**	**14.4**	**0.002**	**7.7 (0.8)**	**8 (0)**	**9.41**	**0.024**
Food secure	273 (60%)		11.2 (1.5)	11 (2)			2.8 (0.4)	3 (0)			20.8 (3.2)	21 (4)			7.7 (0.7)	8 (0)		
Marginal food insecurity	67 (15)		10.6 (1.6)	11 (2)			2.9 (0.4)	3 (0)			19.7 (3.5)	20 (4)			7.8 90.4)	8 (0)		
Moderate food insecurity	71 (16)		10.2 (1.9)	10 (3)			2.8 (0.4)	3 (0)			19.4 (3.7)	19 (4)			7.4 (1.2)	8 (1)		
Severe food insecurity	46 (10)		10.3 (2.1)	11 (3)			2.7 (0.6)	3 (0)			20.3 (2.6)	20 (3)			7.6 (1.0)	8 (0.75)		

Supplemental Table 3: Multiple pair-wise comparisons across variable group levels of food literacy domain scores using Dunn's Test with Bonferroni adjustments

Food and Nutrition Knowledge Domain

Variable	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj significance	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon^2)
Food Program	Student of non-food program	Student of food program	341	116	10.5	(10.37, 10.71)	1.6	11.9	(11.57, 12.14)	1.6	8.74	0.00	0.00	****	0.33	-1.31	(-1.65, -0.98)	0.020
Age	18	19	5	76	10.4	(8.11, 12.69)	2.6	10.7	(10.29, 11.15)	1.9	0.161 0	0.87	1	ns	2.33	-0.32	(-2.65, 2)	0.002
	18	20	5	96	10.4	(8.11, 12.69)	2.6	10.5	(10.19, 10.87)	1.7	-0.22	0.83	1	ns	2.31	-0.13	(-2.44, 2.18)	-0.002
	18	21	5	110	10.4	(8.11, 12.69)	2.6	11.1	(10.86, 11.43)	1.5	0.58	0.56	1	ns	2.30	-0.75	(-3.05, 1.56)	0.005
	18	22	5	64	10.4	(8.11, 12.69)	2.6	10.9	(10.49, 11.39)	1.8	0.42	0.67	1	ns	2.33	-0.54	(-2.87, 1.79)	0.006
	18	23	5	46	10.4	(8.11, 12.69)	2.6	11.0	(10.52, 11.48)	1.6	0.37	0.71	1	ns	2.33	-0.60	(-2.93, 1.73)	0.007
	18	24	5	18	10.4	(8.11, 12.69)	2.6	11.2	(10.59, 11.74)	1.2	0.49	0.63	1	ns	2.36	-0.77	(-3.12, 1.59)	0.022
	18	25	5	34	10.4	(8.11, 12.69)	2.6	11.1	(10.54, 11.58)	1.6	0.45	0.65	1	ns	2.34	-0.66	(-3, 1.69)	0.012
	19	20	76	96	10.7	(10.29, 11.15)	1.9	10.5	(10.19, 10.87)	1.7	-1.14	0.26	1	ns	0.55	0.19	(-0.36, 0.74)	-0.007

19	21	76	110	10.7	(10.29, 11.15)	1.9	11.1	(10.86, 11.43)	1.5	1.29	0.20	1	ns	0.51	-0.42	(-0.94, 0.09)	0.007
19	22	76	64	10.7	(10.29, 11.15)	1.9	10.9	(10.49, 11.39)	1.8	0.71	0.48	1	ns	0.62	-0.21	(-0.84, 0.41)	0.005
19	23	76	46	10.7	(10.29, 11.15)	1.9	11.0	(10.52, 11.48)	1.6	0.53	0.60	1	ns	0.64	-0.28	(-0.92, 0.36)	0.004
19	24	76	18	10.7	(10.29, 11.15)	1.9	11.2	(10.59, 11.74)	1.2	0.65	0.51	1	ns	0.72	-0.44	(-1.16, 0.28)	0.007
19	25	76	34	10.7	(10.29, 11.15)	1.9	11.1	(10.54, 11.58)	1.6	0.68	0.49	1	ns	0.68	-0.34	(-1.01, 0.34)	0.006
20	21	96	110	10.5	(10.19, 10.87)	1.7	11.1	(10.86, 11.43)	1.5	2.63	0.01	0.24	ns	0.44	-0.61	(-1.06, -0.17)	0.013
20	22	96	64	10.5	(10.19, 10.87)	1.7	10.9	(10.49, 11.39)	1.8	1.83	0.07	1	ns	0.57	-0.41	(-0.97, 0.16)	0.012
20	23	96	46	10.5	(10.19, 10.87)	1.7	11.0	(10.52, 11.48)	1.6	1.52	0.13	1	ns	0.59	-0.47	(-1.06, 0.12)	0.011
20	24	96	18	10.5	(10.19, 10.87)	1.7	11.2	(10.59, 11.74)	1.2	1.35	0.18	1	ns	0.67	-0.64	(-1.31, 0.04)	0.012
20	25	96	34	10.5	(10.19, 10.87)	1.7	11.1	(10.54, 11.58)	1.6	1.58	0.11	1	ns	0.63	-0.53	(-1.15, 0.1)	0.012
21	22	110	64	11.1	(10.86, 11.43)	1.5	10.9	(10.49, 11.39)	1.8	-0.46	0.65	1	ns	0.53	0.21	(-0.32, 0.74)	-0.003
21	23	110	46	11.1	(10.86, 11.43)	1.5	11.0	(10.52, 11.48)	1.6	-0.54	0.59	1	ns	0.55	0.15	(-0.41, 0.7)	-0.003
21	24	110	18	11.1	(10.86, 11.43)	1.5	11.2	(10.59, 11.74)	1.2	-0.09	0.93	1	ns	0.64	-0.02	(-0.66, 0.62)	-0.001

	21	25	110	34	11.1	(10.86, 11.43)	1.5	11.1	(10.54, 11.58)	1.6	-0.26	0.79	1	ns	0.59	0.09	(-0.51, 0.68)	-0.002
	22	23	64	46	10.9	(10.49, 11.39)	1.8	11.0	(10.52, 11.48)	1.6	-0.12	0.91	1	ns	0.66	-0.06	(-0.72, 0.59)	-0.001
	22	24	64	18	10.9	(10.49, 11.39)	1.8	11.2	(10.59, 11.74)	1.2	0.19	0.85	1	ns	0.73	-0.23	(-0.96, 0.5)	0.002
	22	25	64	34	10.9	(10.49, 11.39)	1.8	11.1	(10.54, 11.58)	1.6	0.09	0.93	1	ns	0.69	-0.12	(-0.81, 0.57)	0.001
	23	24	46	18	11.0	(10.52, 11.48)	1.6	11.2	(10.59, 11.74)	1.2	0.26	0.80	1	ns	0.75	-0.17	(-0.91, 0.58)	0.004
	23	25	46	34	11.0	(10.52, 11.48)	1.6	11.1	(10.54, 11.58)	1.6	0.19	0.85	1	ns	0.71	-0.06	(-0.77, 0.65)	0.002
	24	25	18	34	11.2	(10.59, 11.74)	1.2	11.1	(10.54, 11.58)	1.6	-0.10	0.92	1	ns	0.78	0.11	(-0.67, 0.89)	-0.002
Gender	Men	Women	103	343	10.0	(9.68, 10.41)	1.9	11.1	(10.96, 11.29)	1.6	5.33	0.00	0.00	****	0.40	-1.08	(-1.48, -0.68)	0.012
Health literacy	High likelihood of limited literacy	Possibility of limited literacy	5	51	9.2	(7.4, 11)	2.0	9.6	(9.1, 10.19)	2.0	0.54	0.59	1	ns	1.88	-0.45	(-2.32, 1.43)	0.010
	High likelihood of limited literacy	Adequate literacy	5	401	9.2	(7.4, 11)	2.0	11.1	(10.9, 11.21)	1.6	2.21	0.03	0.08	ns	1.80	-1.85	(-3.66, -0.05)	0.005
	Possibility of limited literacy	Adequate literacy	51	401	9.6	(9.1, 10.19)	2.0	11.1	(10.9, 11.21)	1.6	4.99	0.00	0.00	****	0.57	-1.41	(-1.97, -0.84)	0.011
Income adequacy	Very easy	Easy	71	95	11.2	(10.84, 11.55)	1.5	10.7	(10.36, 11.07)	1.8	-1.72	0.09	0.86	ns	0.51	0.48	(-0.03, 0.99)	-0.010
	Very easy	Neither easy nor difficult	71	200	11.2	(10.84, 11.55)	1.5	10.9	(10.71, 11.15)	1.6	-1.10	0.27	1	ns	0.42	0.27	(-0.15, 0.69)	-0.004

	Very easy	Difficult	71	58	11.2	(10.84, 11.55)	1.5	10.6	(10.06, 11.11)	2.0	-1.66	0.10	0.972	ns	0.63	0.61	(-0.02, 1.25)	-0.013
	Very easy	Very difficult	71	11	11.2	(10.84, 11.55)	1.5	10.2	(9.01, 11.36)	2.0	-1.66	0.10	0.98	ns	1.23	1.02	(-0.21, 2.24)	-0.020
	Easy	Neither easy nor difficult	95	200	10.7	(10.36, 11.07)	1.8	10.9	(10.71, 11.15)	1.6	0.94	0.35	1	ns	0.42	-0.21	(-0.64, 0.21)	0.003
	Easy	Difficult	95	58	10.7	(10.36, 11.07)	1.8	10.6	(10.06, 11.11)	2.0	-0.14	0.89	1	ns	0.63	0.13	(-0.51, 0.76)	-0.001
	Easy	Very difficult	95	11	10.7	(10.36, 11.07)	1.8	10.2	(9.01, 11.36)	2.0	-0.84	0.40	1	ns	1.23	0.53	(-0.7, 1.76)	-0.008
	Neither easy nor difficult	Difficult	200	58	10.9	(10.71, 11.15)	1.6	10.6	(10.06, 11.11)	2.0	-0.95	0.34	1	ns	0.57	0.34	(-0.23, 0.91)	-0.004
	Neither easy nor difficult	Very difficult	200	11	10.9	(10.71, 11.15)	1.6	10.2	(9.01, 11.36)	2.0	-1.24	0.21	1	ns	1.20	0.75	(-0.45, 1.95)	-0.006
	Difficult	Very difficult	58	11	10.6	(10.06, 11.11)	2.0	10.2	(9.01, 11.36)	2.0	-0.74	0.46	1	ns	1.29	0.40	(-0.88, 1.69)	-0.011
General health	Poor	Fair	23	116	9.3	(8.41, 10.2)	2.2	10.7	(10.39, 10.98)	1.6	2.74	0.01	0.06	ns	0.94	-1.38	(-2.32, -0.44)	0.020
	Poor	Good	23	172	9.3	(8.41, 10.2)	2.2	10.9	(10.69, 11.18)	1.6	3.60	0.00	0.00	**	0.92	-1.63	(-2.56, -0.71)	0.019
	Poor	Very good	23	121	9.3	(8.41, 10.2)	2.2	11.3	(11.01, 11.54)	1.5	4.41	0.00	0.00	***	0.93	-1.97	(-2.9, -1.04)	0.031
	Poor	Excellent	23	22	9.3	(8.41, 10.2)	2.2	11.5	(10.88, 12.03)	1.4	3.69	0.00	0.00	**	1.06	-2.15	(-3.21, -1.09)	0.084
	Fair	Good	116	172	10.7	(10.39, 10.98)	1.6	10.9	(10.69, 11.18)	1.6	1.44	0.15	1	ns	0.38	-0.26	(-0.64, 0.13)	0.005

	Fair	Very good	116	121	10.7	(10.39, 10.98)	1.6	11.3	(11.01, 11.54)	1.5	2.90	0.00	0.04	*	0.40	-0.59	(-0.99, -0.19)	0.012
	Fair	Excellent	116	22	10.7	(10.39, 10.98)	1.6	11.5	(10.88, 12.03)	1.4	2.04	0.04	0.41	ns	0.64	-0.77	(-1.42, -0.13)	0.015
	Good	Very good	172	121	10.9	(10.69, 11.18)	1.6	11.3	(11.01, 11.54)	1.5	1.72	0.09	0.85	ns	0.36	-0.34	(-0.7, 0.02)	0.006
	Good	Excellent	172	22	10.9	(10.69, 11.18)	1.6	11.5	(10.88, 12.03)	1.4	1.34	0.18	1	ns	0.62	-0.52	(-1.14, 0.1)	0.007
	Very good	Excellent	121	22	11.3	(11.01, 11.54)	1.5	11.5	(10.88, 12.03)	1.4	0.42	4 0.672	1	ns	0.63	-0.18	(-0.81, 0.45)	0.003
Mental Health	Poor	Fair	94	139	10.6	(10.23, 11.02)	2.0	10.7	(10.38, 10.94)	1.7	-0.40	0.69	1	ns	0.48	-0.03	(-0.52, 0.45)	-0.002
	Poor	Good	94	149	10.6	(10.23, 11.02)	2.0	11.1	(10.87, 11.4)	1.6	1.93	0.05	0.54	ns	0.48	-0.51	(-0.98, -0.03)	0.008
	Poor	Very good	94	64	10.6	(10.23, 11.02)	2.0	11.1	(10.76, 11.46)	1.4	1.14	0.25	1	ns	0.53	-0.48	(-1.01, 0.05)	0.007
	Poor	Excellent	94	10	10.6	(10.23, 11.02)	2.0	11.0	(9.99, 12.01)	1.6	0.42	0.68	1	ns	1.09	-0.37	(-1.46, 0.71)	0.004
	Fair	Good	139	149	10.7	(10.38, 10.94)	1.7	11.1	(10.87, 11.4)	1.6	2.61	0.01	0.09	ns	0.38	-0.47	(-0.85, -0.09)	0.009
	Fair	Very good	139	64	10.7	(10.38, 10.94)	1.7	11.1	(10.76, 11.46)	1.4	1.58	0.11	1	ns	0.45	-0.45	(-0.89, 0)	0.008
	Fair	Excellent	139	10	10.7	(10.38, 10.94)	1.7	11.0	(9.99, 12.01)	1.6	0.59	0.56	1	ns	1.05	-0.34	(-1.39, 0.71)	0.004
	Good	Very good	149	64	11.1	(10.87, 11.4)	1.6	11.1	(10.76, 11.46)	1.4	-0.46	0.65	1	ns	0.44	0.02	(-0.41, 0.46)	-0.002

	Good	Excellent	149	10	11.1	(10.87, 11.4)	1.6	11.0	(9.99, 12.01)	1.6	-0.35	0.72	1	ns	1.05	0.13	(-0.91, 1.18)	-0.002
	Very good	Excellent	64	10	11.1	(10.76, 11.46)	1.4	11.0	(9.99, 12.01)	1.6	-0.14	0.89	1	ns	1.07	0.11	(-0.96, 1.18)	-0.002
Food security status	Food secure	Marginal food insecurity	273	67	11.2	(11.03, 11.38)	1.5	10.6	(10.23, 11.02)	1.6	-2.67	0.01	0.05	*	0.43	0.58	(0.15, 1.01)	-0.008
	Food secure	Moderate food insecurity	273	71	11.2	(11.03, 11.38)	1.5	10.2	(9.74, 10.63)	1.9	-4.14	0.00	0.00	***	0.48	1.02	(0.54, 1.5)	-0.012
	Food secure	Severe food insecurity	273	46	11.2	(11.03, 11.38)	1.5	10.3	(9.73, 10.96)	2.1	-2.55	0.01	0.06	ns	0.64	0.86	(0.22, 1.5)	-0.008
	Marginal food insecurity	Moderate food insecurity	67	71	10.6	(10.23, 11.02)	1.6	10.2	(9.74, 10.63)	1.9	-1.11	0.27	1	ns	0.59	0.44	(-0.15, 1.04)	-0.008
	Marginal food insecurity	Severe food insecurity	67	46	10.6	(10.23, 11.02)	1.6	10.3	(9.73, 10.96)	2.1	-0.23	0.82	1	ns	0.73	0.28	(-0.45, 1.01)	-0.002
	Moderate food insecurity	Severe food insecurity	71	46	10.2	(9.74, 10.63)	1.9	10.3	(9.73, 10.96)	2.1	0.77	0.44	1	ns	0.76	-0.16	(-0.92, 0.59)	0.007

Food Skills Domain

Variable	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj. significance	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon²)
Food Program	Student of non-food program	Student of food program	341	116	2.8	(2.76, 2.85)	0.4	2.8	(2.75, 2.9)	0.4	0.38	0.71	0.71	ns	0.09	-0.02	(-0.1, 0.07)	0.001
Age	18	19	5	76	2.8	(2.41, 3.19)	0.4	2.8	(2.67, 2.88)	0.5	-0.01	0.99	1	ns	0.41	0.02	(-0.38, 0.43)	0.000

18	20	5	96	2.8	(2.41, 3.19)	0.4	2.8	(2.7, 2.89)	0.5	0.10	0.92	1	ns	0.40	0.01	(-0.4, 0.41)	0.001
18	21	5	110	2.8	(2.41, 3.19)	0.4	2.8	(2.78, 2.91)	0.4	0.26	0.80	1	ns	0.40	-0.05	(-0.44, 0.35)	0.002
18	22	5	64	2.8	(2.41, 3.19)	0.4	2.9	(2.83, 2.98)	0.3	0.59	0.56	1	ns	0.40	-0.11	(-0.5, 0.29)	0.009
18	23	5	46	2.8	(2.41, 3.19)	0.4	2.7	(2.51, 2.79)	0.5	-0.81	0.42	1	ns	0.42	0.15	(-0.27, 0.56)	-0.016
18	24	5	18	2.8	(2.41, 3.19)	0.4	2.9	(2.84, 3.05)	0.2	0.74	0.46	1	ns	0.41	-0.14	(-0.55, 0.26)	0.033
18	25	5	34	2.8	(2.41, 3.19)	0.4	2.8	(2.66, 2.93)	0.4	-0.03	0.98	1	ns	0.42	0.01	(-0.41, 0.42)	-0.001
19	20	76	96	2.8	(2.67, 2.88)	0.5	2.8	(2.7, 2.89)	0.5	0.33	0.75	1	ns	0.14	-0.02	(-0.16, 0.13)	0.002
19	21	76	110	2.8	(2.67, 2.88)	0.5	2.8	(2.78, 2.91)	0.4	0.82	0.41	1	ns	0.13	-0.07	(-0.2, 0.06)	0.004
19	22	76	64	2.8	(2.67, 2.88)	0.5	2.9	(2.83, 2.98)	0.3	1.65	0.10	1	ns	0.13	-0.13	(-0.26, 0)	0.012
19	23	76	46	2.8	(2.67, 2.88)	0.5	2.7	(2.51, 2.79)	0.5	-2.01	0.04	1	ns	0.18	0.12	(-0.05, 0.3)	-0.017
19	24	76	18	2.8	(2.67, 2.88)	0.5	2.9	(2.84, 3.05)	0.2	1.44	0.15	1	ns	0.15	-0.17	(-0.32, -0.02)	0.016
19	25	76	34	2.8	(2.67, 2.88)	0.5	2.8	(2.66, 2.93)	0.4	-0.05	0.96	1	ns	0.17	-0.02	(-0.19, 0.16)	0.000
20	21	96	110	2.8	(2.7, 2.89)	0.5	2.8	(2.78, 2.91)	0.4	0.52	0.60	1	ns	0.12	-0.05	(-0.17, 0.06)	0.003

20	22	96	64	2.8	(2.7, 2.89)	0.5	2.9	(2.83, 2.98)	0.3	1.42	0.16	1	ns	0.12	-0.11	(-0.23, 0.01)	0.009
20	23	96	46	2.8	(2.7, 2.89)	0.5	2.7	(2.51, 2.79)	0.5	-2.37	0.02	0.49	ns	0.17	0.14	(-0.03, 0.31)	-0.017
20	24	96	18	2.8	(2.7, 2.89)	0.5	2.9	(2.84, 3.05)	0.2	1.28	0.20	1	ns	0.15	-0.15	(-0.3, -0.01)	0.011
20	25	96	34	2.8	(2.7, 2.89)	0.5	2.8	(2.66, 2.93)	0.4	-0.30	0.77	1	ns	0.17	0.00	(-0.17, 0.17)	-0.002
21	22	110	64	2.8	(2.78, 2.91)	0.4	2.9	(2.83, 2.98)	0.3	1.00	0.32	1	ns	0.10	-0.06	(-0.16, 0.04)	0.006
21	23	110	46	2.8	(2.78, 2.91)	0.4	2.7	(2.51, 2.79)	0.5	-2.84	0.00	0.13	ns	0.15	0.19	(0.04, 0.35)	-0.018
21	24	110	18	2.8	(2.78, 2.91)	0.4	2.9	(2.84, 3.05)	0.2	1.00	0.32	1	ns	0.13	-0.10	(-0.23, 0.03)	0.008
21	25	110	34	2.8	(2.78, 2.91)	0.4	2.8	(2.66, 2.93)	0.4	-0.68	0.50	1	ns	0.15	0.05	(-0.1, 0.21)	-0.005
22	23	64	46	2.9	(2.83, 2.98)	0.3	2.7	(2.51, 2.79)	0.5	-3.39	0.00	0.02	*	0.16	0.25	(0.1, 0.41)	-0.031
22	24	64	18	2.9	(2.83, 2.98)	0.3	2.9	(2.84, 3.05)	0.2	0.37	0.71	1	ns	0.13	-0.04	(-0.17, 0.09)	0.005
22	25	64	34	2.9	(2.83, 2.98)	0.3	2.8	(2.66, 2.93)	0.4	-1.36	0.17	1	ns	0.16	0.11	(-0.04, 0.27)	-0.014
23	24	46	18	2.7	(2.51, 2.79)	0.5	2.9	(2.84, 3.05)	0.2	2.71	0.01	0.19	ns	0.18	-0.29	(-0.47, -0.12)	0.043
23	25	46	34	2.7	(2.51, 2.79)	0.5	2.8	(2.66, 2.93)	0.4	1.62	0.11	1	ns	0.20	-0.14	(-0.34, 0.05)	0.020

	24	25	18	34	2.9	(2.84, 3.05)	0.2	2.8	(2.66, 2.93)	0.4	-1.33	0.18	1	ns	0.18	0.15	(-0.03, 0.33)	-0.026
Gender	Men	Women	103	343	2.7	(2.61, 2.8)	0.5	2.8	(2.81, 2.89)	0.4	2.98	0.00	0.00	**	0.10	-0.14	(-0.24, -0.04)	0.007
Income adequacy	Very easy	Easy	71	95	2.9	(2.78, 2.94)	0.4	2.7	(2.64, 2.84)	0.5	-1.72	0.09	0.85	ns	0.13	0.12	(-0.01, 0.25)	-0.010
	Very easy	Neither easy nor difficult	71	200	2.9	(2.78, 2.94)	0.4	2.8	(2.76, 2.88)	0.4	-0.58	0.56	1	ns	0.10	0.04	(-0.06, 0.14)	-0.002
	Very easy	Difficult	71	58	2.9	(2.78, 2.94)	0.4	2.8	(2.72, 2.94)	0.4	-0.25	0.80	1	ns	0.14	0.03	(-0.1, 0.17)	-0.002
	Very easy	Very difficult	71	11	2.9	(2.78, 2.94)	0.4	2.8	(2.58, 3.06)	0.4	-0.33	0.75	1	ns	0.25	0.04	(-0.21, 0.29)	-0.004
	Easy	Neither easy nor difficult	95	200	2.7	(2.64, 2.84)	0.5	2.8	(2.76, 2.88)	0.4	1.53	0.13	1	ns	0.11	-0.08	(-0.2, 0.03)	0.005
	Easy	Difficult	95	58	2.7	(2.64, 2.84)	0.5	2.8	(2.72, 2.94)	0.4	1.35	0.18	1	ns	0.15	-0.09	(-0.24, 0.06)	0.009
	Easy	Very difficult	95	11	2.7	(2.64, 2.84)	0.5	2.8	(2.58, 3.06)	0.4	0.52	0.61	1	ns	0.26	-0.08	(-0.34, 0.18)	0.005
	Neither easy nor difficult	Difficult	200	58	2.8	(2.76, 2.88)	0.4	2.8	(2.72, 2.94)	0.4	0.23	0.82	1	ns	0.12	-0.01	(-0.13, 0.12)	0.001
	Neither easy nor difficult	Very difficult	200	11	2.8	(2.76, 2.88)	0.4	2.8	(2.58, 3.06)	0.4	-0.08	0.93	1	ns	0.25	0.00	(-0.24, 0.25)	0.000
	Difficult	Very difficult	58	11	2.8	(2.72, 2.94)	0.4	2.8	(2.58, 3.06)	0.4	-0.18	0.85	1	ns	0.26	0.01	(-0.25, 0.27)	-0.003
Health literacy	High likelihood of limited literacy	Possibility of limited literacy	5	51	2.8	(2.41, 3.19)	0.4	2.7	(2.58, 2.87)	0.5	-0.23	0.82	1	ns	0.42	0.07	(-0.34, 0.49)	-0.004

	High likelihood of limited literacy	Adequate literacy	5	401	2.8	(2.41, 3.19)	0.4	2.8	(2.79, 2.86)	0.4	0.18	0.86	1	ns	0.39	-0.03	(-0.42, 0.37)	0.000
	Possibility of limited literacy	Adequate literacy	51	401	2.7	(2.58, 2.87)	0.5	2.8	(2.79, 2.86)	0.4	1.29	0.20	0.59	ns	0.15	-0.10	(-0.25, 0.05)	0.003
General health	Poor	Fair	23	116	2.7	(2.47, 2.92)	0.6	2.8	(2.75, 2.9)	0.4	1.19	0.24	1	ns	0.24	-0.13	(-0.37, 0.11)	0.009
	Poor	Good	23	172	2.7	(2.47, 2.92)	0.6	2.8	(2.77, 2.89)	0.4	1.24	0.22	1	ns	0.24	-0.14	(-0.37, 0.1)	0.006
	Poor	Very good	23	121	2.7	(2.47, 2.92)	0.6	2.8	(2.75, 2.89)	0.4	1.00	0.32	1	ns	0.24	-0.12	(-0.36, 0.12)	0.007
	Poor	Excellent	23	22	2.7	(2.47, 2.92)	0.6	2.9	(2.72, 3.01)	0.4	1.16	0.24	1	ns	0.27	-0.17	(-0.44, 0.1)	0.026
	Fair	Good	116	172	2.8	(2.75, 2.9)	0.4	2.8	(2.77, 2.89)	0.4	0.03	0.97	1	ns	0.09	0.00	(-0.1, 0.09)	0.000
	Fair	Very good	116	121	2.8	(2.75, 2.9)	0.4	2.8	(2.75, 2.89)	0.4	-0.34	0.74	1	ns	0.10	0.01	(-0.09, 0.11)	-0.001
	Fair	Excellent	116	22	2.8	(2.75, 2.9)	0.4	2.9	(2.72, 3.01)	0.4	0.33	0.74	1	ns	0.16	-0.04	(-0.2, 0.13)	0.002
	Good	Very good	172	121	2.8	(2.77, 2.89)	0.4	2.8	(2.75, 2.89)	0.4	-0.40	0.69	1	ns	0.09	0.01	(-0.08, 0.1)	-0.001
	Good	Excellent	172	22	2.8	(2.77, 2.89)	0.4	2.9	(2.72, 3.01)	0.4	0.32	0.75	1	ns	0.16	-0.03	(-0.19, 0.13)	0.002
	Very good	Excellent	121	22	2.8	(2.75, 2.89)	0.4	2.9	(2.72, 3.01)	0.4	0.52	0.61	1	ns	0.16	-0.05	(-0.21, 0.12)	0.004
Mental Health	Poor	Fair	94	139	2.8	(2.69, 2.88)	0.5	2.8	(2.73, 2.87)	0.4	0.11	0.91	1	ns	0.12	-0.01	(-0.13, 0.11)	0.000

	Poor	Good	94	149	2.8	(2.69, 2.88)	0.5	2.8	(2.77, 2.89)	0.4	0.54	0.59	1	ns	0.11	-0.04	(-0.16, 0.07)	0.002
	Poor	Very good	94	64	2.8	(2.69, 2.88)	0.5	2.9	(2.79, 2.96)	0.3	1.13	0.26	1	ns	0.12	-0.09	(-0.21, 0.04)	0.007
	Poor	Excellent	94	10	2.8	(2.69, 2.88)	0.5	2.8	(2.54, 3.06)	0.4	-0.04	0.97	1	ns	0.28	-0.01	(-0.29, 0.26)	0.000
	Fair	Good	139	149	2.8	(2.73, 2.87)	0.4	2.8	(2.77, 2.89)	0.4	0.48	0.63	1	ns	0.09	-0.03	(-0.13, 0.06)	0.002
	Fair	Very good	139	64	2.8	(2.73, 2.87)	0.4	2.9	(2.79, 2.96)	0.3	1.12	0.26	1	ns	0.11	-0.08	(-0.19, 0.03)	0.006
	Fair	Excellent	139	10	2.8	(2.73, 2.87)	0.4	2.8	(2.54, 3.06)	0.4	-0.08	0.93	1	ns	0.27	0.00	(-0.27, 0.27)	-0.001
	Good	Very good	149	64	2.8	(2.77, 2.89)	0.4	2.9	(2.79, 2.96)	0.3	0.75	0.45	1	ns	0.10	-0.04	(-0.14, 0.06)	0.004
	Good	Excellent	149	10	2.8	(2.77, 2.89)	0.4	2.8	(2.54, 3.06)	0.4	-0.26	0.80	1	ns	0.27	0.03	(-0.24, 0.3)	-0.002
	Very good	Excellent	64	10	2.9	(2.79, 2.96)	0.3	2.8	(2.54, 3.06)	0.4	-0.58	0.56	1	ns	0.27	0.08	(-0.2, 0.35)	-0.008
Food security status	Food secure	Marginal food insecurity	273	67	2.8	(2.77, 2.87)	0.4	2.9	(2.76, 2.94)	0.4	0.53	0.60	1	ns	0.10	-0.03	(-0.13, 0.06)	0.002
	Food secure	Moderate food insecurity	273	71	2.8	(2.77, 2.87)	0.4	2.8	(2.74, 2.92)	0.4	0.16	0.87	1	ns	0.10	-0.01	(-0.11, 0.09)	0.000
	Food secure	Severe food insecurity	273	46	2.8	(2.77, 2.87)	0.4	2.7	(2.55, 2.89)	0.6	-0.84	0.40	1	ns	0.18	0.10	(-0.08, 0.27)	-0.003
	Marginal food insecurity	Moderate food insecurity	67	71	2.9	(2.76, 2.94)	0.4	2.8	(2.74, 2.92)	0.4	-0.30	0.76	1	ns	0.12	0.02	(-0.1, 0.14)	-0.002

	Marginal food insecurity	Severe food insecurity	67	46	2.9	(2.76, 2.94)	0.4	2.7	(2.55, 2.89)	0.6	-1.08	0.28	1	ns	0.19	0.13	(-0.06, 0.32)	-0.010
	Moderate food insecurity	Severe food insecurity	71	46	2.8	(2.74, 2.92)	0.4	2.7	(2.55, 2.89)	0.6	-0.82	0.41	1	ns	0.19	0.11	(-0.08, 0.3)	-0.007

Self-efficacy and Confidence Domain

Variable	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj. significance	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon²)
Food Program	Student of non-food program	Student of food program	341	116	19.5	(19.2, 19.89)	3.2	22.8	(22.35, 23.19)	2.3	10.00	0.00	0.00	****	0.54	-3.22	(-3.76, -2.68)	0.022
Age	18	19	5	76	22.4	(20.03, 24.77)	2.7	20.2	(19.42, 21.03)	3.6	-1.44	0.15	1	ns	2.50	2.18	(-0.32, 4.68)	-0.018
	18	20	5	96	22.4	(20.03, 24.77)	2.7	20.3	(19.66, 20.86)	3.0	-1.55	0.12	1	ns	2.44	2.14	(-0.3, 4.58)	-0.016
	18	21	5	110	22.4	(20.03, 24.77)	2.7	20.4	(19.73, 21.04)	3.5	-1.36	0.18	1	ns	2.46	2.02	(-0.44, 4.48)	-0.012
	18	22	5	64	22.4	(20.03, 24.77)	2.7	20.7	(19.83, 21.48)	3.4	-1.20	0.23	1	ns	2.51	1.74	(-0.76, 4.25)	-0.018
	18	23	5	46	22.4	(20.03, 24.77)	2.7	20.3	(19.39, 21.22)	3.2	-1.47	0.14	1	ns	2.54	2.10	(-0.44, 4.63)	-0.029
	18	24	5	18	22.4	(20.03, 24.77)	2.7	19.4	(17.76, 21.13)	3.6	-1.85	0.06	1	ns	2.91	2.96	(0.05, 5.86)	-0.084
	18	25	5	34	22.4	(20.03, 24.77)	2.7	20.3	(19.11, 21.42)	3.4	-1.39	0.16	1	ns	2.64	2.14	(-0.5, 4.77)	-0.037

19	20	76	96	20.2	(19.42, 21.03)	3.6	20.3	(19.66, 20.86)	3.0	-0.31	0.76	1	ns	1.01	-0.04	(-1.04, 0.97)	-0.002
19	21	76	110	20.2	(19.42, 21.03)	3.6	20.4	(19.73, 21.04)	3.5	0.29	0.77	1	ns	1.04	-0.16	(-1.2, 0.88)	0.002
19	22	76	64	20.2	(19.42, 21.03)	3.6	20.7	(19.83, 21.48)	3.4	0.62	0.54	1	ns	1.15	-0.43	(-1.58, 0.72)	0.004
19	23	76	46	20.2	(19.42, 21.03)	3.6	20.3	(19.39, 21.22)	3.2	-0.16	0.87	1	ns	1.22	-0.08	(-1.3, 1.14)	-0.001
19	24	76	18	20.2	(19.42, 21.03)	3.6	19.4	(17.76, 21.13)	3.6	-1.04	0.30	1	ns	1.87	0.78	(-1.09, 2.65)	-0.011
19	25	76	34	20.2	(19.42, 21.03)	3.6	20.3	(19.11, 21.42)	3.4	-0.01	0.99	1	ns	1.41	-0.04	(-1.45, 1.37)	0.000
20	21	96	110	20.3	(19.66, 20.86)	3.0	20.4	(19.73, 21.04)	3.5	0.65	0.51	1	ns	0.89	-0.12	(-1.01, 0.77)	0.003
20	22	96	64	20.3	(19.66, 20.86)	3.0	20.7	(19.83, 21.48)	3.4	0.94	0.35	1	ns	1.02	-0.40	(-1.42, 0.62)	0.006
20	23	96	46	20.3	(19.66, 20.86)	3.0	20.3	(19.39, 21.22)	3.2	0.10	0.92	1	ns	1.10	-0.04	(-1.14, 1.05)	0.001
20	24	96	18	20.3	(19.66, 20.86)	3.0	19.4	(17.76, 21.13)	3.6	-0.88	0.38	1	ns	1.79	0.82	(-0.97, 2.61)	-0.008
20	25	96	34	20.3	(19.66, 20.86)	3.0	20.3	(19.11, 21.42)	3.4	0.23	0.82	1	ns	1.31	0.00	(-1.31, 1.3)	0.002
21	22	110	64	20.4	(19.73, 21.04)	3.5	20.7	(19.83, 21.48)	3.4	0.39	0.70	1	ns	1.05	-0.27	(-1.33, 0.78)	0.002
21	23	110	46	20.4	(19.73, 21.04)	3.5	20.3	(19.39, 21.22)	3.2	-0.42	0.67	1	ns	1.13	0.08	(-1.05, 1.2)	-0.003

	21	24	110	18	20.4	(19.73, 21.04)	3.5	19.4	(17.76, 21.13)	3.6	-1.24	0.21	1	ns	1.81	0.94	(-0.87, 2.75)	-0.010
	21	25	110	34	20.4	(19.73, 21.04)	3.5	20.3	(19.11, 21.42)	3.4	-0.24	0.81	1	ns	1.33	0.12	(-1.21, 1.45)	-0.002
	22	23	64	46	20.7	(19.83, 21.48)	3.4	20.3	(19.39, 21.22)	3.2	-0.70	0.49	1	ns	1.23	0.35	(-0.88, 1.58)	-0.006
	22	24	64	18	20.7	(19.83, 21.48)	3.4	19.4	(17.76, 21.13)	3.6	-1.41	0.16	1	ns	1.88	1.21	(-0.66, 3.09)	-0.017
	22	25	64	34	20.7	(19.83, 21.48)	3.4	20.3	(19.11, 21.42)	3.4	-0.51	0.61	1	ns	1.42	0.39	(-1.03, 1.81)	-0.005
	23	24	46	18	20.3	(19.39, 21.22)	3.2	19.4	(17.76, 21.13)	3.6	-0.87	0.38	1	ns	1.92	0.86	(-1.06, 2.78)	-0.014
	23	25	46	34	20.3	(19.39, 21.22)	3.2	20.3	(19.11, 21.42)	3.4	0.12	0.90	1	ns	1.48	0.04	(-1.44, 1.52)	0.002
	24	25	18	34	19.4	(17.76, 21.13)	3.6	20.3	(19.11, 21.42)	3.4	0.93	0.35	1	ns	2.05	-0.82	(-2.87, 1.23)	0.018
Gender	Men	Women	103	343	19.0	(18.32, 19.59)	3.3	20.8	(20.48, 21.17)	3.2	5.31	0.00	0.00	****	0.72	-1.88	(-2.6, -1.15)	0.012
Income adequacy	Very easy	Easy	71	95	20.8	(20.1, 21.53)	3.1	20.3	(19.59, 20.92)	3.3	-1.04	0.30	1	ns	0.97	0.56	(-0.41, 1.54)	-0.006
	Very easy	Neither easy nor difficult	71	200	20.8	(20.1, 21.53)	3.1	20.3	(19.77, 20.73)	3.5	-1.07	0.28	1	ns	0.86	0.57	(-0.29, 1.43)	-0.004
	Very easy	Difficult	71	58	20.8	(20.1, 21.53)	3.1	20.4	(19.59, 21.24)	3.2	-0.74	0.46	1	ns	1.09	0.40	(-0.69, 1.5)	-0.006
	Very easy	Very difficult	71	11	20.8	(20.1, 21.53)	3.1	19.9	(17.82, 22)	3.5	-0.70	0.48	1	ns	2.21	0.91	(-1.3, 3.11)	-0.009

	Easy	Neither easy nor difficult	95	200	20.3	(19.59, 20.92)	3.3	20.3	(19.77, 20.73)	3.5	0.13	0.90	1	ns	0.82	0.00	(-0.82, 0.82)	0.000
	Easy	Difficult	95	58	20.3	(19.59, 20.92)	3.3	20.4	(19.59, 21.24)	3.2	0.20	0.84	1	ns	1.06	-0.16	(-1.22, 0.9)	0.001
	Easy	Very difficult	95	11	20.3	(19.59, 20.92)	3.3	19.9	(17.82, 22)	3.5	-0.20	0.84	1	ns	2.19	0.34	(-1.85, 2.54)	-0.002
	Neither easy nor difficult	Difficult	200	58	20.3	(19.77, 20.73)	3.5	20.4	(19.59, 21.24)	3.2	0.12	0.91	1	ns	0.96	-0.16	(-1.12, 0.79)	0.000
	Neither easy nor difficult	Very difficult	200	11	20.3	(19.77, 20.73)	3.5	19.9	(17.82, 22)	3.5	-0.26	0.80	1	ns	2.14	0.34	(-1.8, 2.48)	-0.001
	Difficult	Very difficult	58	11	20.4	(19.59, 21.24)	3.2	19.9	(17.82, 22)	3.5	-0.30	0.77	1	ns	2.25	0.50	(-1.74, 2.75)	-0.004
Health literacy	High likelihood of limited literacy	Possibility of limited literacy	5	51	19.0	(16.52, 21.48)	2.8	19.3	(18.23, 20.32)	3.8	0.46	0.65	1	ns	2.69	-0.27	(-2.96, 2.42)	0.008
	High likelihood of limited literacy	Adequate literacy	5	401	19.0	(16.52, 21.48)	2.8	20.5	(20.2, 20.84)	3.3	1.21	0.23	0.68	ns	2.50	-1.52	(-4.02, 0.98)	0.003
	Possibility of limited literacy	Adequate literacy	51	401	19.3	(18.23, 20.32)	3.8	20.5	(20.2, 20.84)	3.3	2.22	0.03	0.08	ns	1.09	-1.24	(-2.33, -0.15)	0.005
General health	Poor	Fair	23	116	18.7	(17.11, 20.19)	3.8	18.9	(18.26, 19.57)	3.6	0.18	0.86	1	ns	1.68	-0.26	(-1.94, 1.42)	0.001
	Poor	Good	23	172	18.7	(17.11, 20.19)	3.8	20.7	(20.23, 21.14)	3.0	2.45	0.01	0.14	ns	1.61	-2.03	(-3.64, -0.43)	0.013
	Poor	Very good	23	121	18.7	(17.11, 20.19)	3.8	21.4	(20.92, 21.92)	2.8	3.46	0.00	0.01	**	1.62	-2.77	(-4.39, -1.15)	0.024
	Poor	Excellent	23	22	18.7	(17.11, 20.19)	3.8	22.1	(21.18, 23.1)	2.3	3.34	0.00	0.01	**	1.82	-3.48	(-5.3, -1.67)	0.076

	Fair	Good	116	172	18.9	(18.26, 19.57)	3.6	20.7	(20.23, 21.14)	3.0	4.19	0.00	0.00	***	0.80	-1.77	(-2.57, -0.97)	0.015
	Fair	Very good	116	121	18.9	(18.26, 19.57)	3.6	21.4	(20.92, 21.92)	2.8	5.74	0.00	0.00	****	0.83	-2.51	(-3.34, -1.68)	0.024
	Fair	Excellent	116	22	18.9	(18.26, 19.57)	3.6	22.1	(21.18, 23.1)	2.3	4.11	0.00	0.00	***	1.16	-3.22	(-4.39, -2.06)	0.030
	Good	Very good	172	121	20.7	(20.23, 21.14)	3.0	21.4	(20.92, 21.92)	2.8	2.05	0.04	0.40	ns	0.67	-0.74	(-1.41, -0.06)	0.007
	Good	Excellent	172	22	20.7	(20.23, 21.14)	3.0	22.1	(21.18, 23.1)	2.3	2.00	0.05	0.46	ns	1.06	-1.45	(-2.51, -0.39)	0.010
	Very good	Excellent	121	22	21.4	(20.92, 21.92)	2.8	22.1	(21.18, 23.1)	2.3	0.90	1 0.367	1	ns	1.08	-0.71	(-1.8, 0.37)	0.006
	Poor	Fair	94	139	19.8	(19.1, 20.56)	3.6	19.8	(19.23, 20.3)	3.2	-0.41	0.68	1	ns	0.90	0.06	(-0.84, 0.96)	-0.002
	Poor	Good	94	149	19.8	(19.1, 20.56)	3.6	21.1	(20.56, 21.61)	3.3	3.01	0.00	0.03	*	0.90	-1.25	(-2.15, -0.35)	0.012
	Poor	Very good	94	64	19.8	(19.1, 20.56)	3.6	20.7	(19.97, 21.5)	3.1	1.59	0.11	1	ns	1.05	-0.90	(-1.96, 0.15)	0.010
Mental Health	Poor	Excellent	94	10	19.8	(19.1, 20.56)	3.6	21.0	(19.4, 22.6)	2.6	0.71	0.48	1	ns	1.76	-1.17	(-2.93, 0.59)	0.007
	Fair	Good	139	149	19.8	(19.23, 20.3)	3.2	21.1	(20.56, 21.61)	3.3	3.83	0.00	0.00	**	0.75	-1.31	(-2.06, -0.56)	0.013
	Fair	Very good	139	64	19.8	(19.23, 20.3)	3.2	20.7	(19.97, 21.5)	3.1	2.07	0.04	0.38	ns	0.93	-0.96	(-1.9, -0.03)	0.010
	Fair	Excellent	139	10	19.8	(19.23, 20.3)	3.2	21.0	(19.4, 22.6)	2.6	0.89	0.38	1	ns	1.69	-1.23	(-2.92, 0.46)	0.006

	Good	Very good	149	64	21.1	(20.56, 21.61)	3.3	20.7	(19.97, 21.5)	3.1	-0.93	0.35	1	ns	0.93	0.35	(-0.58, 1.27)	-0.004
	Good	Excellent	149	10	21.1	(20.56, 21.61)	3.3	21.0	(19.4, 22.6)	2.6	-0.49	0.62	1	ns	1.68	0.08	(-1.6, 1.76)	-0.003
	Very good	Excellent	64	10	20.7	(19.97, 21.5)	3.1	21.0	(19.4, 22.6)	2.6	-0.07	0.95	1	ns	1.77	-0.27	(-2.04, 1.51)	-0.001
Food security status	Food secure	Marginal food insecurity	273	67	20.8	(20.41, 21.18)	3.2	19.7	(18.84, 20.51)	3.5	-2.61	0.01	0.05	ns	0.92	1.12	(0.2, 2.04)	-0.008
	Food secure	Moderate food insecurity	273	71	20.8	(20.41, 21.18)	3.2	19.4	(18.54, 20.25)	3.7	-3.18	0.00	0.01	**	0.94	1.40	(0.46, 2.33)	-0.009
	Food secure	Severe food insecurity	273	46	20.8	(20.41, 21.18)	3.2	20.3	(19.57, 21.08)	2.6	-1.32	0.19	1	ns	0.85	0.47	(-0.39, 1.32)	-0.004
	Marginal food insecurity	Moderate food insecurity	67	71	19.7	(18.84, 20.51)	3.5	19.4	(18.54, 20.25)	3.7	-0.40	0.69	1	ns	1.19	0.28	(-0.92, 1.47)	-0.003
	Marginal food insecurity	Severe food insecurity	67	46	19.7	(18.84, 20.51)	3.5	20.3	(19.57, 21.08)	2.6	0.76	0.45	1	ns	1.13	-0.65	(-1.78, 0.47)	0.007
	Moderate food insecurity	Severe food insecurity	71	46	19.4	(18.54, 20.25)	3.7	20.3	(19.57, 21.08)	2.6	1.13	0.26	1	ns	1.14	-0.93	(-2.07, 0.21)	0.010

Ecological Factors Domain

Variable	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj. significance	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon2)
Food Program	Student of non-food program	Student of food program	341	116	7.7	(7.57, 7.73)	0.7	7.7	(7.52, 7.86)	0.9	1.42	0.16	0.16	ns	0.19	-0.04	(-0.23, 0.15)	0.003

	18	19	5	76	7.8	(7.41, 8.19)	0.4	7.6	(7.41, 7.77)	0.8	-0.51	0.61	1	ns	0.43	0.21	(-0.22, 0.64)	-0.006
	18	20	5	96	7.8	(7.41, 8.19)	0.4	7.4	(7.21, 7.69)	1.2	-0.46	0.65	1	ns	0.46	0.35	(-0.11, 0.81)	-0.005
	18	21	5	110	7.8	(7.41, 8.19)	0.4	7.8	(7.7, 7.9)	0.5	0.15	0.88	1	ns	0.40	0.00	(-0.4, 0.4)	0.001
	18	22	5	64	7.8	(7.41, 8.19)	0.4	7.6	(7.4, 7.75)	0.7	-0.64	0.53	1	ns	0.43	0.22	(-0.21, 0.65)	-0.009
	18	23	5	46	7.8	(7.41, 8.19)	0.4	7.7	(7.52, 7.92)	0.7	-0.03	0.97	1	ns	0.44	0.08	(-0.36, 0.52)	-0.001
	18	24	5	18	7.8	(7.41, 8.19)	0.4	7.8	(7.66, 8.01)	0.4	0.15	0.88	1	ns	0.43	-0.03	(-0.46, 0.4)	0.007
Age	18	25	5	34	7.8	(7.41, 8.19)	0.4	7.9	(7.7, 8.06)	0.5	0.62	0.54	1	ns	0.43	-0.08	(-0.51, 0.35)	0.016
	19	20	76	96	7.6	(7.41, 7.77)	0.8	7.4	(7.21, 7.69)	1.2	0.18	0.86	1	ns	0.30	0.14	(-0.16, 0.44)	0.001
	19	21	76	110	7.6	(7.41, 7.77)	0.8	7.8	(7.7, 7.9)	0.5	2.06	0.04	1	ns	0.21	-0.21	(-0.41, 0)	0.011
	19	22	76	64	7.6	(7.41, 7.77)	0.8	7.6	(7.4, 7.75)	0.7	-0.34	0.74	1	ns	0.25	0.01	(-0.24, 0.26)	-0.002
	19	23	76	46	7.6	(7.41, 7.77)	0.8	7.7	(7.52, 7.92)	0.7	1.19	0.24	1	ns	0.27	-0.13	(-0.39, 0.14)	0.010
	19	24	76	18	7.6	(7.41, 7.77)	0.8	7.8	(7.66, 8.01)	0.4	1.19	0.23	1	ns	0.25	-0.24	(-0.49, 0.01)	0.013
	19	25	76	34	7.6	(7.41, 7.77)	0.8	7.9	(7.7, 8.06)	0.5	2.59	0.01	0.27	ns	0.26	-0.29	(-0.55, -0.03)	0.024

20	21	96	110	7.4	(7.21, 7.69)	1.2	7.8	(7.7, 7.9)	0.5	2.00	0.05	1	ns	0.26	-0.35	(-0.61, -0.09)	0.010
20	22	96	64	7.4	(7.21, 7.69)	1.2	7.6	(7.4, 7.75)	0.7	-0.53	0.60	1	ns	0.30	-0.13	(-0.43, 0.17)	-0.003
20	23	96	46	7.4	(7.21, 7.69)	1.2	7.7	(7.52, 7.92)	0.7	1.08	0.28	1	ns	0.31	-0.27	(-0.58, 0.04)	0.008
20	24	96	18	7.4	(7.21, 7.69)	1.2	7.8	(7.66, 8.01)	0.4	1.10	0.27	1	ns	0.30	-0.39	(-0.68, -0.09)	0.010
20	25	96	34	7.4	(7.21, 7.69)	1.2	7.9	(7.7, 8.06)	0.5	2.54	0.01	0.31	ns	0.30	-0.43	(-0.73, -0.13)	0.020
21	22	110	64	7.8	(7.7, 7.9)	0.5	7.6	(7.4, 7.75)	0.7	-2.32	0.02	0.57	ns	0.20	0.22	(0.02, 0.42)	-0.013
21	23	110	46	7.8	(7.7, 7.9)	0.5	7.7	(7.52, 7.92)	0.7	-0.49	0.62	1	ns	0.22	0.08	(-0.14, 0.3)	-0.003
21	24	110	18	7.8	(7.7, 7.9)	0.5	7.8	(7.66, 8.01)	0.4	0.02	0.99	1	ns	0.20	-0.03	(-0.24, 0.17)	0.000
21	25	110	34	7.8	(7.7, 7.9)	0.5	7.9	(7.7, 8.06)	0.5	1.15	0.25	1	ns	0.21	-0.08	(-0.29, 0.12)	0.008
22	23	64	46	7.6	(7.4, 7.75)	0.7	7.7	(7.52, 7.92)	0.7	1.44	0.15	1	ns	0.26	-0.14	(-0.4, 0.12)	0.013
22	24	64	18	7.6	(7.4, 7.75)	0.7	7.8	(7.66, 8.01)	0.4	1.38	0.17	1	ns	0.25	-0.26	(-0.5, -0.01)	0.017
22	25	64	34	7.6	(7.4, 7.75)	0.7	7.9	(7.7, 8.06)	0.5	2.79	0.01	0.15	ns	0.25	-0.30	(-0.55, -0.05)	0.029
23	24	46	18	7.7	(7.52, 7.92)	0.7	7.8	(7.66, 8.01)	0.4	0.32	0.75	1	ns	0.27	-0.12	(-0.38, 0.15)	0.005

	23	25	46	34	7.7	(7.52, 7.92)	0.7	7.9	(7.7, 8.06)	0.5	1.38	0.17	1	ns	0.27	-0.16	(-0.43, 0.1)	0.018
	24	25	18	34	7.8	(7.66, 8.01)	0.4	7.9	(7.7, 8.06)	0.5	0.76	0.45	1	ns	0.25	-0.05	(-0.3, 0.2)	0.015
Gender	Men	Women	103	343	7.3	(7.04, 7.5)	1.2	7.8	(7.72, 7.84)	0.6	5.44	0.00	0.00	****	0.24	-0.51	(-0.74, -0.27)	0.012
Income adequacy	Very easy	Easy	71	95	7.7	(7.54, 7.9)	0.8	7.6	(7.37, 7.75)	0.9	-1.74	0.08	0.81	ns	0.26	0.16	(-0.1, 0.42)	-0.011
	Very easy	Neither easy nor difficult	71	200	7.7	(7.54, 7.9)	0.8	7.7	(7.63, 7.81)	0.7	-0.62	0.54	1	ns	0.20	0.00	(-0.21, 0.2)	-0.002
	Very easy	Difficult	71	58	7.7	(7.54, 7.9)	0.8	7.6	(7.41, 7.77)	0.7	-1.96	0.05	0.51	ns	0.26	0.13	(-0.12, 0.39)	-0.015
	Very easy	Very difficult	71	11	7.7	(7.54, 7.9)	0.8	7.1	(5.96, 8.23)	1.9	-1.04	0.30	1	ns	1.15	0.63	(-0.52, 1.78)	-0.013
	Easy	Neither easy nor difficult	95	200	7.6	(7.37, 7.75)	0.9	7.7	(7.63, 7.81)	0.7	1.51	0.13	1	ns	0.21	-0.16	(-0.37, 0.05)	0.005
	Easy	Difficult	95	58	7.6	(7.37, 7.75)	0.9	7.6	(7.41, 7.77)	0.7	-0.44	0.66	1	ns	0.26	-0.03	(-0.29, 0.23)	-0.003
	Easy	Very difficult	95	11	7.6	(7.37, 7.75)	0.9	7.1	(5.96, 8.23)	1.9	-0.20	0.84	1	ns	1.15	0.47	(-0.68, 1.62)	-0.002
	Neither easy nor difficult	Difficult	200	58	7.7	(7.63, 7.81)	0.7	7.6	(7.41, 7.77)	0.7	-1.75	0.08	0.80	ns	0.20	0.13	(-0.07, 0.34)	-0.007
	Neither easy nor difficult	Very difficult	200	11	7.7	(7.63, 7.81)	0.7	7.1	(5.96, 8.23)	1.9	-0.82	0.41	1	ns	1.14	0.63	(-0.51, 1.77)	-0.004
	Difficult	Very difficult	58	11	7.6	(7.41, 7.77)	0.7	7.1	(5.96, 8.23)	1.9	0.02	0.98	1	ns	1.15	0.50	(-0.65, 1.64)	0.000

	High likelihood of limited literacy	Possibility of limited literacy	5	51	7.0	(5.93, 8.07)	1.2	7.2	(6.84, 7.59)	1.4	0.96	0.34	1	ns	1.14	-0.22	(-1.35, 0.92)	0.017
Health literacy	High likelihood of limited literacy	Adequate literacy	5	401	7.0	(5.93, 8.07)	1.2	7.7	(7.66, 7.79)	0.7	2.23	0.03	0.08	ns	1.08	-0.73	(-1.8, 0.35)	0.005
	Possibility of limited literacy	Adequate literacy	51	401	7.2	(6.84, 7.59)	1.4	7.7	(7.66, 7.79)	0.7	3.71	0.00	0.00	***	0.38	-0.51	(-0.89, -0.13)	0.008
General health	Poor	Fair	23	116	7.3	(6.95, 7.75)	1.0	7.5	(7.33, 7.73)	1.1	1.42	0.16	1	ns	0.45	-0.18	(-0.63, 0.27)	0.010
	Poor	Good	23	172	7.3	(6.95, 7.75)	1.0	7.7	(7.64, 7.82)	0.6	2.24	0.02	0.25	ns	0.41	-0.38	(-0.8, 0.03)	0.012
	Poor	Very good	23	121	7.3	(6.95, 7.75)	1.0	7.7	(7.63, 7.86)	0.6	2.35	0.02	0.19	ns	0.42	-0.40	(-0.81, 0.02)	0.016
	Poor	Excellent	23	22	7.3	(6.95, 7.75)	1.0	7.8	(7.55, 7.99)	0.5	1.81	0.07	0.71	ns	0.46	-0.42	(-0.88, 0.03)	0.041
	Fair	Good	116	172	7.5	(7.33, 7.73)	1.1	7.7	(7.64, 7.82)	0.6	1.45	0.15	1	ns	0.22	-0.21	(-0.43, 0.01)	0.005
	Fair	Very good	116	121	7.5	(7.33, 7.73)	1.1	7.7	(7.63, 7.86)	0.6	1.62	0.11	1	ns	0.23	-0.22	(-0.45, 0.01)	0.007
	Fair	Excellent	116	22	7.5	(7.33, 7.73)	1.1	7.8	(7.55, 7.99)	0.5	0.93	0.35	1	ns	0.30	-0.25	(-0.54, 0.05)	0.007
	Good	Very good	172	121	7.7	(7.64, 7.82)	0.6	7.7	(7.63, 7.86)	0.6	0.30	0.76	1	ns	0.14	-0.01	(-0.16, 0.13)	0.001
	Good	Excellent	172	22	7.7	(7.64, 7.82)	0.6	7.8	(7.55, 7.99)	0.5	0.18	0.86	1	ns	0.24	-0.04	(-0.28, 0.2)	0.001
	Very good	Excellent	121	22	7.7	(7.63, 7.86)	0.6	7.8	(7.55, 7.99)	0.5	0.02	0.98	1	ns	0.25	-0.03	(-0.28, 0.22)	0.000

Mental Health	Poor	Fair	94	139	7.5	(7.3, 7.74)	1.1	7.7	(7.56, 7.8)	0.7	1.24	0.22	1	ns	0.25	-0.16	(-0.42, 0.09)	0.005
	Poor	Good	94	149	7.5	(7.3, 7.74)	1.1	7.7	(7.6, 7.81)	0.7	1.46	0.14	1	ns	0.25	-0.18	(-0.43, 0.06)	0.006
	Poor	Very good	94	64	7.5	(7.3, 7.74)	1.1	7.7	(7.5, 7.87)	0.8	1.35	0.18	1	ns	0.29	-0.17	(-0.46, 0.12)	0.009
	Poor	Excellent	94	10	7.5	(7.3, 7.74)	1.1	7.8	(7.54, 8.06)	0.4	0.70	0.49	1	ns	0.34	-0.28	(-0.62, 0.07)	0.007
	Fair	Good	139	149	7.7	(7.56, 7.8)	0.7	7.7	(7.6, 7.81)	0.7	0.23	0.82	1	ns	0.16	-0.02	(-0.18, 0.14)	0.001
	Fair	Very good	139	64	7.7	(7.56, 7.8)	0.7	7.7	(7.5, 7.87)	0.8	0.35	0.73	1	ns	0.22	0.00	(-0.22, 0.22)	0.002
	Fair	Excellent	139	10	7.7	(7.56, 7.8)	0.7	7.8	(7.54, 8.06)	0.4	0.20	0.84	1	ns	0.29	-0.12	(-0.4, 0.17)	0.001
	Good	Very good	149	64	7.7	(7.6, 7.81)	0.7	7.7	(7.5, 7.87)	0.8	0.17	0.87	1	ns	0.21	0.02	(-0.2, 0.23)	0.001
	Good	Excellent	149	10	7.7	(7.6, 7.81)	0.7	7.8	(7.54, 8.06)	0.4	0.12	0.91	1	ns	0.28	-0.10	(-0.38, 0.19)	0.001
	Very good	Excellent	64	10	7.7	(7.5, 7.87)	0.8	7.8	(7.54, 8.06)	0.4	0.04	0.97	1	ns	0.32	-0.11	(-0.43, 0.21)	0.001
Food security status	Food secure	Marginal food insecurity	273	67	7.7	(7.64, 7.8)	0.7	7.8	(7.7, 7.91)	0.4	0.41	0.69	1	ns	0.13	-0.08	(-0.21, 0.05)	0.001
	Food secure	Moderate food insecurity	273	71	7.7	(7.64, 7.8)	0.7	7.4	(7.07, 7.63)	1.2	-2.83	0.00	0.03	*	0.29	0.37	(0.08, 0.66)	-0.008
	Food secure	Severe food insecurity	273	46	7.7	(7.64, 7.8)	0.7	7.6	(7.26, 7.87)	1.0	-0.99	0.32	1	ns	0.31	0.16	(-0.16, 0.47)	-0.003

	Marginal food insecurity	Moderate food insecurity	67	71	7.8	(7.7, 7.91)	0.4	7.4	(7.07, 7.63)	1.2	-2.54	0.01	0.07	ns	0.30	0.45	(0.16, 0.75)	-0.019
	Marginal food insecurity	Severe food insecurity	67	46	7.8	(7.7, 7.91)	0.4	7.6	(7.26, 7.87)	1.0	-1.11	0.27	1	ns	0.32	0.24	(-0.08, 0.56)	-0.010
	Moderate food insecurity	Severe food insecurity	71	46	7.4	(7.07, 7.63)	1.2	7.6	(7.26, 7.87)	1.0	1.16	0.25	1	ns	0.41	-0.21	(-0.62, 0.2)	0.010

APPENDIX 9 – CHAPTER 6 SUPPLEMENTAL TABLES AND FIGURE

Supplemental Table 1: Pairwise comparisons across variable group levels of food literacy scores from the FLit16 measure using Dunn's Test with Bonferroni corrections

	Group 1	Group 2	Sample size of group 1	Sample size of group 2	Mean of group 1	Confidence Intervals of mean of group 1	Standard Deviation (SD) of group 1	Mean of group 2	Confidence Intervals of mean of group 2	Standard Deviation (SD) of group 2	Dunn's statistic	p	p.adj	p.adj. significance	Minimal detectable difference	Difference (mean1-mean2)	Confidence Intervals of difference in group means	Effect size (epsilon2)
Food Program	Student of non-food program	Student of food program	341	116	12.0	(-2.23, -1.74)	2.1	14.0	(14.23, 12.24)	1.7	9.21	0.00	0.0	****	0.25	-1.99	(-2.23, -1.74)	0.186
Age	18	19	5	76	13.6	(-0.38, 2.9)	2.8	12.3	(13.98, 15.24)	2.4	-1.43	0.15	1.0	ns	1.64	1.26	(-0.38, 2.9)	-0.003
	18	20	5	96	13.6	(-0.11, 3.14)	2.8	12.1	(13.71, 15.23)	2.2	-1.69	0.09	1.0	ns	1.63	1.52	(-0.11, 3.14)	-0.004
	18	21	5	110	13.6	(-0.68, 2.56)	2.8	12.7	(14.28, 15.22)	2.0	-1.18	0.24	1.0	ns	1.62	0.94	(-0.68, 2.56)	-0.003
	18	22	5	64	13.6	(-0.66, 2.61)	2.8	12.6	(14.26, 15.24)	2.2	-1.12	0.26	1.0	ns	1.64	0.98	(-0.66, 2.61)	-0.002
	18	23	5	46	13.6	(-0.84, 2.48)	2.8	12.8	(14.44, 15.26)	2.3	-0.93	0.35	1.0	ns	1.66	0.82	(-0.84, 2.48)	-0.002
	18	24	5	18	13.6	(-0.43, 2.96)	2.8	12.3	(14.03, 15.3)	1.9	-1.44	0.15	1.0	ns	1.70	1.27	(-0.43, 2.96)	-0.003
	18	25	5	34	13.6	(-0.77, 2.56)	2.8	12.7	(14.37, 15.26)	2.0	-1.01	0.31	1.0	ns	1.66	0.89	(-0.77, 2.56)	-0.002
	19	20	76	96	12.3	(-0.19, 0.71)	2.4	12.1	(12.53, 12.79)	2.2	-0.74	0.46	1.0	ns	0.45	0.26	(-0.19, 0.71)	-0.002
	19	21	76	110	12.3	(-0.75, 0.1)	2.4	12.7	(13.09, 12.77)	2.0	0.82	0.41	1.0	ns	0.43	-0.32	(-0.75, 0.1)	0.002

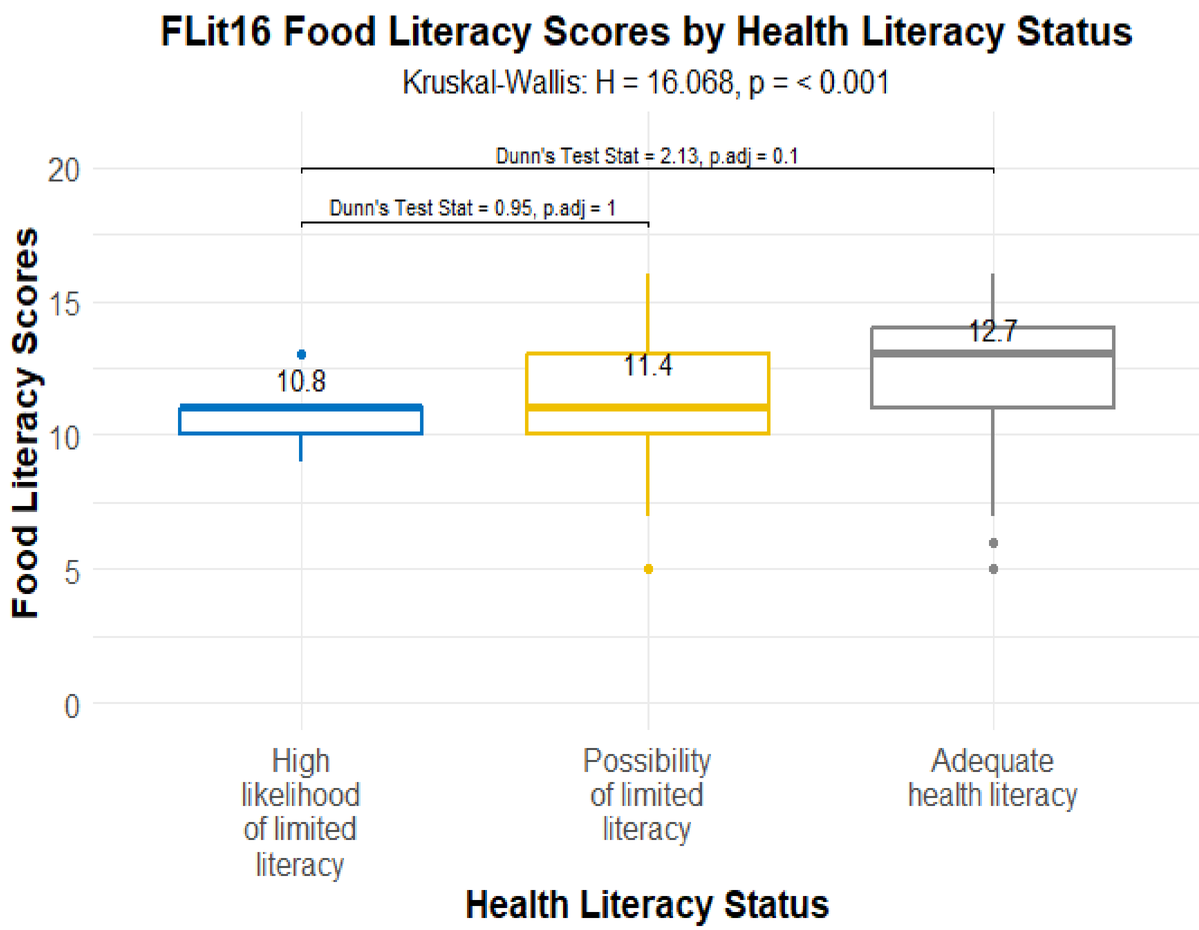
	19	22	76	64	12.3	(-0.78, 0.21)	2.4	12.6	(13.12, 12.84)	2.2	0.85	0.39	1.0	ns	0.49	-0.28	(-0.78, 0.21)	0.002
	19	23	76	46	12.3	(-1, 0.12)	2.4	12.8	(13.34, 12.9)	2.3	1.19	0.23	1.0	ns	0.56	-0.44	(-1, 0.12)	0.003
	19	24	76	18	12.3	(-0.66, 0.67)	2.4	12.3	(13, 13.01)	1.9	-0.26	0.80	1.0	ns	0.67	0.01	(-0.66, 0.67)	-0.001
	19	25	76	34	12.3	(-0.93, 0.2)	2.4	12.7	(13.27, 12.91)	2.0	0.86	0.39	1.0	ns	0.56	-0.36	(-0.93, 0.2)	0.002
	20	21	96	110	12.1	(-0.96, -0.21)	2.2	12.7	(13.04, 12.46)	2.0	1.69	0.09	1.0	ns	0.38	-0.58	(-0.96, -0.21)	0.004
	20	22	96	64	12.1	(-0.99, -0.09)	2.2	12.6	(13.08, 12.54)	2.2	1.60	0.11	1.0	ns	0.45	-0.54	(-0.99, -0.09)	0.004
	20	23	96	46	12.1	(-1.22, -0.17)	2.2	12.8	(13.31, 12.61)	2.3	1.88	0.06	1.0	ns	0.52	-0.70	(-1.22, -0.17)	0.004
	20	24	96	18	12.1	(-0.88, 0.38)	2.2	12.3	(12.97, 12.72)	1.9	0.18	0.86	1.0	ns	0.63	-0.25	(-0.88, 0.38)	0.000
	20	25	96	34	12.1	(-1.15, -0.1)	2.2	12.7	(13.23, 12.61)	2.0	1.46	0.14	1.0	ns	0.53	-0.62	(-1.15, -0.1)	0.003
	21	22	110	64	12.7	(-0.39, 0.47)	2.0	12.6	(13.05, 13.09)	2.2	0.14	0.89	1.0	ns	0.43	0.04	(-0.39, 0.47)	0.000
	21	23	110	46	12.7	(-0.62, 0.39)	2.0	12.8	(13.29, 13.17)	2.3	0.57	0.57	1.0	ns	0.51	-0.12	(-0.62, 0.39)	0.001
	21	24	110	18	12.7	(-0.29, 0.95)	2.0	12.3	(12.95, 13.28)	1.9	-0.74	0.46	1.0	ns	0.62	0.33	(-0.29, 0.95)	-0.002
	21	25	110	34	12.7	(-0.55, 0.47)	2.0	12.7	(13.21, 13.17)	2.0	0.29	0.78	1.0	ns	0.51	-0.04	(-0.55, 0.47)	0.001

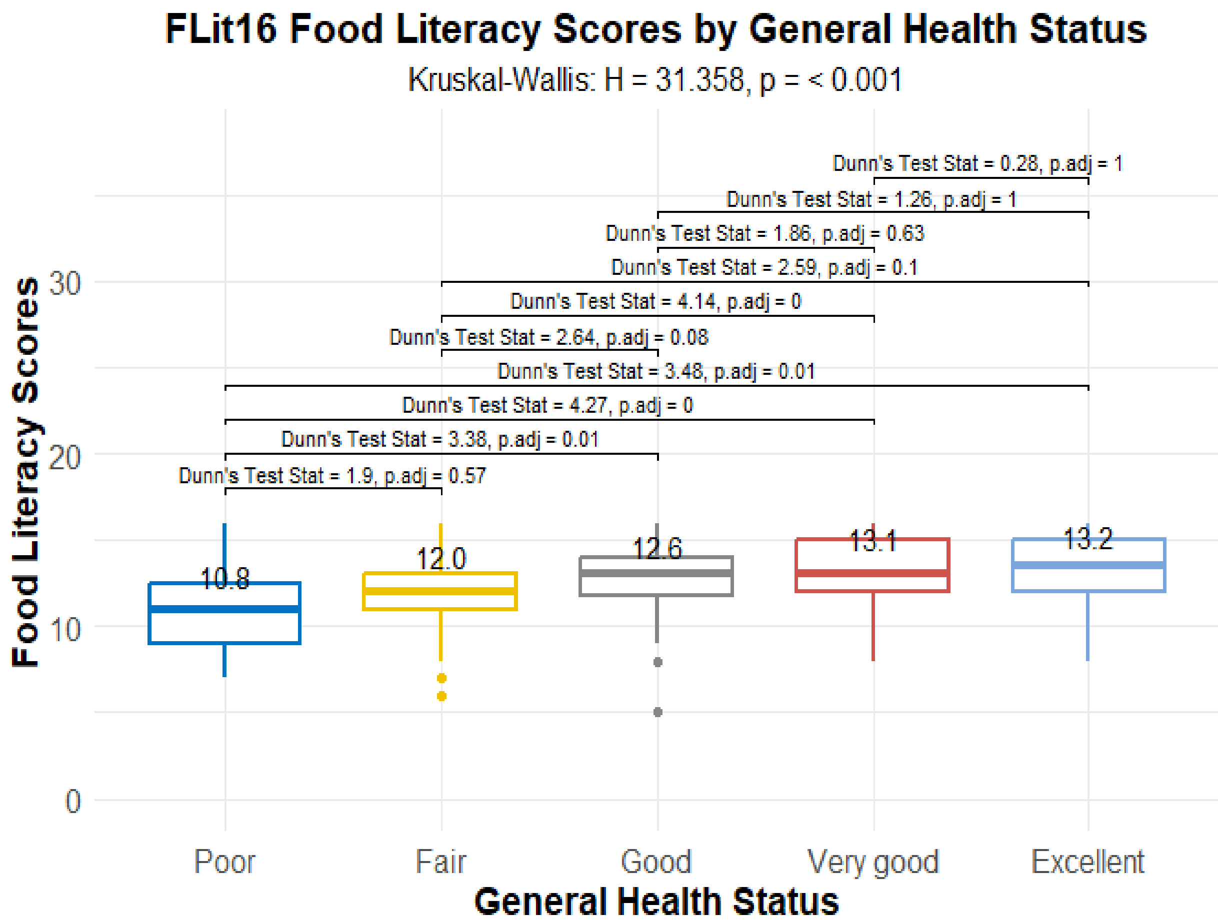
	22	23	64	46	12.6	(-0.72, 0.41)	2.2	12.8	(13.35, 13.19)	2.3	0.41	0.68	1.0	ns	0.57	-0.16	(-0.72, 0.41)	0.001
	22	24	64	18	12.6	(-0.38, 0.96)	2.2	12.3	(13, 13.29)	1.9	-0.79	0.43	1.0	ns	0.67	0.29	(-0.38, 0.96)	-0.002
	22	25	64	34	12.6	(-0.65, 0.49)	2.2	12.7	(13.27, 13.19)	2.0	0.16	0.87	1.0	ns	0.57	-0.08	(-0.65, 0.49)	0.000
	23	24	46	18	12.8	(-0.27, 1.17)	2.3	12.3	(13.05, 13.5)	1.9	-1.04	0.30	1.0	ns	0.72	0.45	(-0.27, 1.17)	-0.002
	23	25	46	34	12.8	(-0.55, 0.7)	2.3	12.7	(13.33, 13.41)	2.0	-0.20	0.84	1.0	ns	0.63	0.08	(-0.55, 0.7)	0.000
	24	25	18	34	12.3	(-1.09, 0.35)	1.9	12.7	(13.43, 13.05)	2.0	0.84	0.40	1.0	ns	0.72	-0.37	(-1.09, 0.35)	0.002
Gender	Men	Women	103	343	11.6	(-1.54, -0.93)	2.1	12.8	(13.1, 11.86)	2.1	5.41	0.00	0.0	****	0.30	-1.24	(-1.54, -0.93)	0.066
Health literacy	High likelihood of limited literacy	Possibility of limited literacy	5	51	10.8	(-1.55, 0.37)	1.5	11.4	(12.35, 11.76)	2.5	0.95	0.35	1.0	ns	0.96	-0.59	(-1.55, 0.37)	0.002
	High likelihood of limited literacy	Adequate literacy	5	401	10.8	(-2.72, -1)	1.5	12.7	(13.52, 11.66)	2.1	2.13	0.03	0.1	ns	0.86	-1.86	(-2.72, -1)	0.005
	Possibility of limited literacy	Adequate literacy	51	401	11.4	(-1.74, -0.8)	2.5	12.7	(13.13, 11.86)	2.1	3.47	0.00	0.0	**	0.47	-1.27	(-1.74, -0.8)	0.008
General health status	Poor	Fair	23	116	10.8	(-1.88, -0.45)	2.5	12.0	(12.7, 11.54)	2.0	1.90	0.06	0.6	ns	0.71	-1.17	(-1.88, -0.45)	0.004
	Poor	Good	23	172	10.8	(-2.5, -1.11)	2.5	12.6	(13.33, 11.52)	2.1	3.38	0.00	0.0	**	0.70	-1.81	(-2.5, -1.11)	0.007
	Poor	Very good	23	121	10.8	(-2.98, -1.57)	2.5	13.1	(13.81, 11.53)	2.0	4.27	0.00	0.0	***	0.71	-2.27	(-2.98, -1.57)	0.009

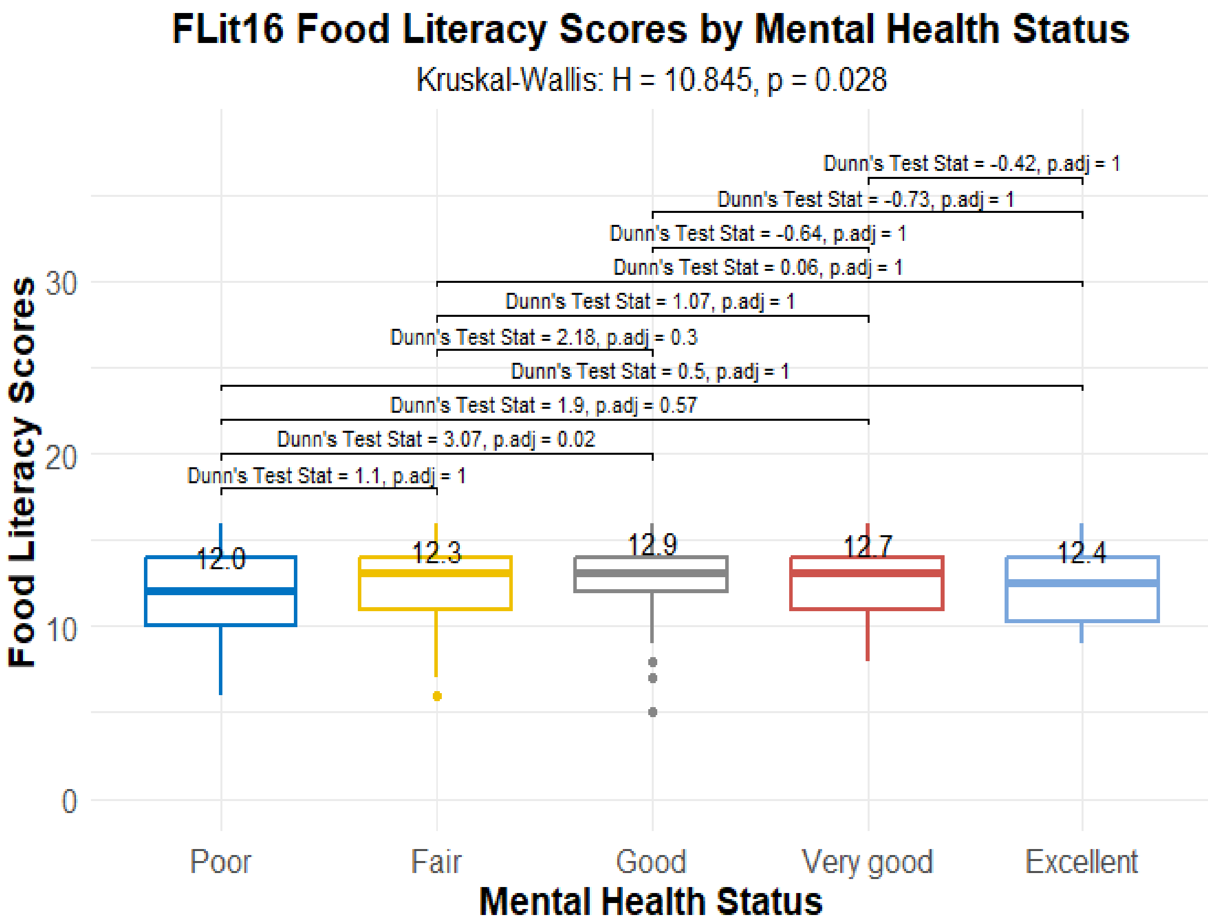
	Poor	Excellent	23	22	10.8	(-3.27, -1.44)	2.5	13.2	(14.1, 11.74)	2.3	3.48	0.00	0.0	**	0.91	-2.36	(-3.27, -1.44)	0.008
	Fair	Good	116	172	12.0	(-0.96, -0.33)	2.0	12.6	(12.95, 12.31)	2.1	2.64	0.01	0.1	ns	0.32	-0.64	(-0.96, -0.33)	0.006
	Fair	Very good	116	121	12.0	(-1.44, -0.77)	2.0	13.1	(13.44, 12.33)	2.0	4.14	0.00	0.0	***	0.34	-1.11	(-1.44, -0.77)	0.009
	Fair	Excellent	116	22	12.0	(-1.86, -0.52)	2.0	13.2	(13.85, 12.66)	2.3	2.59	0.01	0.1	ns	0.67	-1.19	(-1.86, -0.52)	0.006
	Good	Very good	172	121	12.6	(-0.77, -0.16)	2.1	13.1	(13.41, 12.94)	2.0	1.86	0.06	0.6	ns	0.31	-0.47	(-0.77, -0.16)	0.004
	Good	Excellent	172	22	12.6	(-1.2, 0.11)	2.1	13.2	(13.84, 13.29)	2.3	1.26	0.21	1.0	ns	0.66	-0.55	(-1.2, 0.11)	0.003
	Very good	Excellent	121	22	13.1	(-0.75, 0.58)	2.0	13.2	(13.85, 13.76)	2.3	0.28	0.78	1.0	ns	0.67	-0.08	(-0.75, 0.58)	0.001
Mental health status	Poor	Fair	94	139	12.0	(-0.7, 0.07)	2.4	12.3	(12.73, 12.41)	2.0	1.10	0.27	1.0	ns	0.38	-0.31	(-0.7, 0.07)	0.002
	Poor	Good	94	149	12.0	(-1.22, -0.46)	2.4	12.9	(13.25, 12.41)	2.1	3.07	0.00	0.0	*	0.38	-0.84	(-1.22, -0.46)	0.007
	Poor	Very good	94	64	12.0	(-1.14, -0.23)	2.4	12.7	(13.17, 12.48)	2.1	1.90	0.06	0.6	ns	0.45	-0.69	(-1.14, -0.23)	0.004
	Poor	Excellent	94	10	12.0	(-1.48, 0.74)	2.4	12.4	(13.51, 13.14)	2.6	0.50	0.62	1.0	ns	1.11	-0.37	(-1.48, 0.74)	0.001
	Fair	Good	139	149	12.3	(-0.84, -0.21)	2.0	12.9	(13.19, 12.66)	2.1	2.18	0.03	0.3	ns	0.31	-0.53	(-0.84, -0.21)	0.005
	Fair	Very good	139	64	12.3	(-0.77, 0.02)	2.0	12.7	(13.12, 12.74)	2.1	1.07	0.29	1.0	ns	0.40	-0.37	(-0.77, 0.02)	0.002

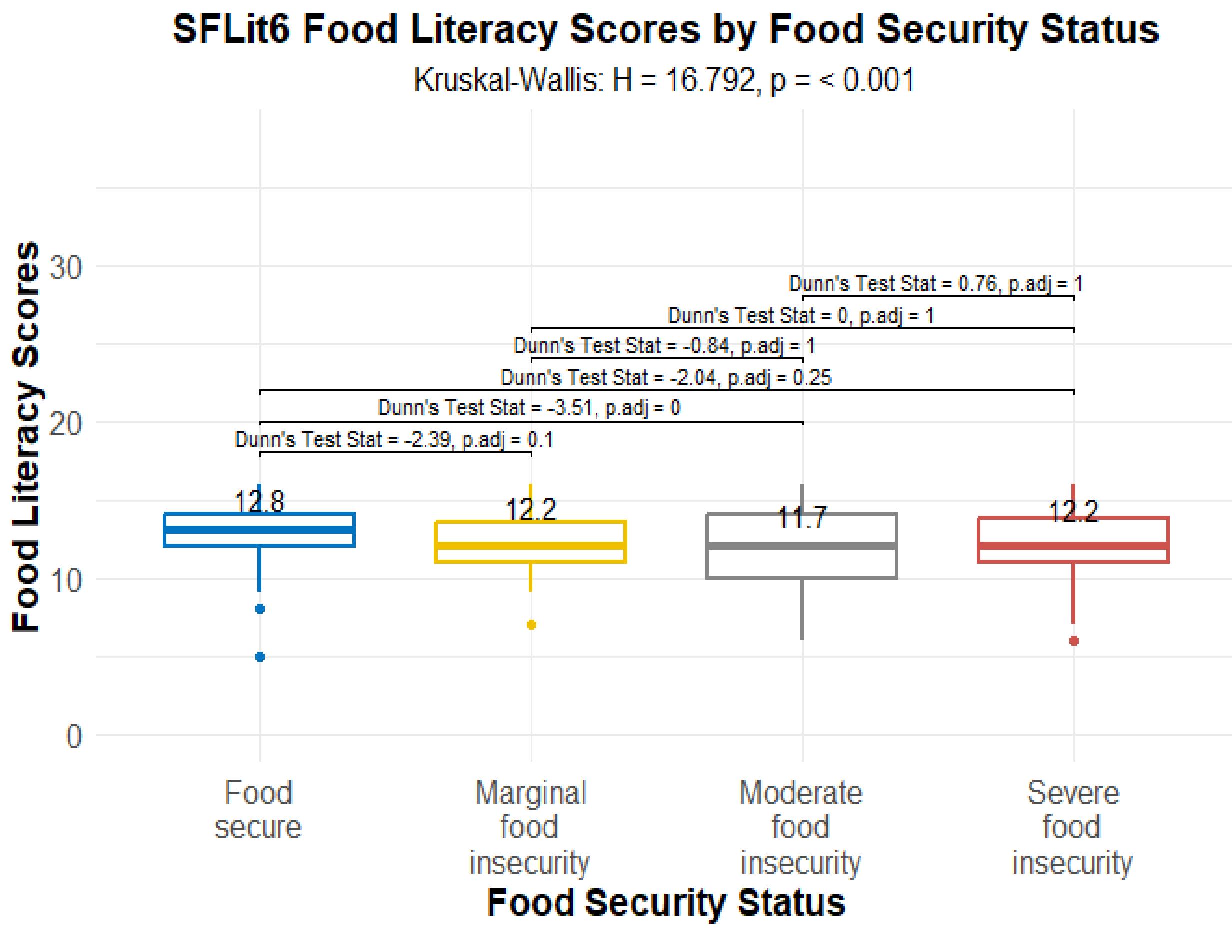
	Fair	Excellent	139	10	12.3	(-1.14, 1.04)	2.0	12.4	(13.49, 13.44)	2.6	0.06	0.95	1.0	ns	1.09	-0.05	(-1.14, 1.04)	0.000
	Good	Very good	149	64	12.9	(-0.24, 0.55)	2.1	12.7	(13.12, 13.27)	2.1	-0.64	0.52	1.0	ns	0.40	0.15	(-0.24, 0.55)	-0.001
	Good	Excellent	149	10	12.9	(-0.62, 1.56)	2.1	12.4	(13.49, 13.96)	2.6	-0.73	0.47	1.0	ns	1.09	0.47	(-0.62, 1.56)	-0.002
	Very good	Excellent	64	10	12.7	(-0.8, 1.44)	2.1	12.4	(13.52, 13.84)	2.6	-0.42	0.68	1.0	ns	1.12	0.32	(-0.8, 1.44)	-0.001
Income adequacy	Very easy	Easy	71	95	13.0	(0.2, 1)	1.8	12.4	(12.76, 13.36)	2.2	-1.65	0.10	1.0	ns	0.40	0.60	(0.2, 1)	-0.004
	Very easy	Neither easy nor difficult	71	200	13.0	(0.13, 0.81)	1.8	12.5	(12.83, 13.3)	2.2	-1.51	0.13	1.0	ns	0.34	0.47	(0.13, 0.81)	-0.003
	Very easy	Difficult	71	58	13.0	(0.07, 1.05)	1.8	12.4	(12.88, 13.44)	2.4	-1.28	0.20	1.0	ns	0.49	0.56	(0.07, 1.05)	-0.003
	Very easy	Very difficult	71	11	13.0	(0.25, 2.57)	1.8	11.5	(12.7, 14.12)	2.9	-1.47	0.14	1.0	ns	1.16	1.41	(0.25, 2.57)	-0.003
	Easy	Neither easy nor difficult	95	200	12.4	(-0.48, 0.22)	2.2	12.5	(12.84, 12.71)	2.2	0.40	0.69	1.0	ns	0.35	-0.13	(-0.48, 0.22)	0.001
	Easy	Difficult	95	58	12.4	(-0.53, 0.46)	2.2	12.4	(12.89, 12.85)	2.4	0.20	0.85	1.0	ns	0.49	-0.04	(-0.53, 0.46)	0
	Easy	Very difficult	95	11	12.4	(-0.35, 1.97)	2.2	11.5	(12.71, 13.52)	2.9	-0.69	0.49	1.0	ns	1.16	0.81	(-0.35, 1.97)	-0.002
	Neither easy nor difficult	Difficult	200	58	12.5	(-0.36, 0.53)	2.2	12.4	(12.84, 12.93)	2.4	-0.12	0.91	1.0	ns	0.45	0.09	(-0.36, 0.53)	0
	Neither easy nor difficult	Very difficult	200	11	12.5	(-0.2, 2.08)	2.2	11.5	(12.69, 13.63)	2.9	-0.87	0.39	1.0	ns	1.14	0.94	(-0.2, 2.08)	-0.002
	Difficult	Very difficult	58	11	12.4	(-0.34, 2.04)	2.4	11.5	(12.74, 13.59)	2.9	-0.76	0.45	1.0	ns	1.19	0.85	(-0.34, 2.04)	-0.002

Food security status	Food secure	Marginal food insecurity	273	67	12.8	(0.22, 0.94)	2.1	12.2	(12.6, 13.18)	2.0	-2.39	0.02	0.1	ns	0.358	0.58	(0.22, 0.94)	0.017
	Food secure	Moderate food insecurity	273	71	12.8	(0.67, 1.47)	2.1	11.7	(12.15, 13.22)	2.4	-3.51	0.00	0.0	**	0.401	1.07	(0.67, 1.47)	0.035
	Food secure	Severe food insecurity	273	46	12.8	(0.22, 1.12)	2.1	12.2	(12.6, 13.27)	2.2	-2.04	0.04	0.2	ns	0.449	0.67	(0.22, 1.12)	0.013
	Marginal food insecurity	Moderate food insecurity	67	71	12.2	(0, 0.98)	2.0	11.7	(12.23, 12.73)	2.4	-0.84	0.40	1.0	ns	0.488	0.49	(0, 0.98)	0.005
	Marginal food insecurity	Severe food insecurity	67	46	12.2	(-0.44, 0.61)	2.0	12.2	(12.68, 12.77)	2.2	0.00	1.00	1.0	ns	0.528	0.09	(-0.44, 0.61)	0
	Moderate food insecurity	Severe food insecurity	71	46	11.7	(-0.96, 0.15)	2.4	12.2	(12.71, 12.3)	2.2	0.76	0.45	1.0	ns	0.558	-0.41	(-0.96, 0.15)	0.005


FLit16 Food Literacy Scores by Health Literacy Status
Kruskal-Wallis: H = 16.068, p = < 0.001
Dunn's Test Stat = 2.13, p.adj = 0.1
Dunn's Test Stat = 0.95, p.adj = 1
Food Literacy Scores
20
15
10
5
0
10.8
11.4
12.7
High likelihood of limited literacy
Possibility of limited literacy
Adequate health literacy
Health Literacy Status


FLit16 Food Literacy Scores by General Health Status
Kruskal-Wallis: H = 31.358, p = < 0.001
Dunn's Test Stat = 0.28, p.adj = 1
Dunn's Test Stat = 1.26, p.adj = 1
Dunn's Test Stat = 1.86, p.adj = 0.63
Dunn's Test Stat = 2.59, p.adj = 0.1
Dunn's Test Stat = 4.14, p.adj = 0
Dunn's Test Stat = 2.64, p.adj = 0.08
Dunn's Test Stat = 3.48, p.adj = 0.01
Dunn's Test Stat = 4.27, p.adj = 0
Dunn's Test Stat = 3.38, p.adj = 0.01
Dunn's Test Stat = 1.9, p.adj = 0.57
10.8
12.0
12.6
13.1
13.2
Food Literacy Scores
0
10
20
30
Poor
Fair
Good
Very good
Excellent
General Health Status


FLit16 Food Literacy Scores by Mental Health Status
Kruskal-Wallis: H = 10.845, p = 0.028
Dunn's Test Stat = -0.42, p.adj = 1
Dunn's Test Stat = -0.73, p.adj = 1
Dunn's Test Stat = -0.64, p.adj = 1
Dunn's Test Stat = 0.06, p.adj = 1
Dunn's Test Stat = 1.07, p.adj = 1
Dunn's Test Stat = 2.18, p.adj = 0.3
Dunn's Test Stat = 0.5, p.adj = 1
Dunn's Test Stat = 1.9, p.adj = 0.57
Dunn's Test Stat = 3.07, p.adj = 0.02
Dunn's Test Stat = 1.1, p.adj = 1
12.0
12.3
12.9
12.7
12.4
Food Literacy Scores
0
10
20
30
Poor
Fair
Good
Very good
Excellent
Mental Health Status



Supplemental Figure 1: Box plots illustrating pairwise comparisons of FLit16 food literacy scores using Dunn's test and Bonferroni corrections for variables with significant Kruskal-Wallis ANOVA results and three or more group levels.

Supplemental Table 1: Difficulty and discrimination parameters for items in the FLit16 using a 2-parameter Item Response Theory model for food literacy. Response options are available in Appendix 1.

Item ID	Item text	Item discrimination (mean = 1.917)	Item difficulty (mean =-1.148)
Food Knowledge 4	Which of the following is a source of unsaturated fats?	0.996	0.102
Food Knowledge 5	A breakfast cereal lists "fortified" on its box. This means:	1.801	-0.896
Nutrition Knowledge 2	Which of the following is a healthier type of sugar?	0.334	3.052
Nutrition Knowledge 3	The foods that we eat may affect our mood.	2.453	-2.372
Food & Nutrition Language 1	If you are steaming vegetables, this means that you are:	2.371	-1.518
Food Skills 1	Fresh vegetables and fruit should be washed if:	0.971	-2.152
Nutrition Literacy 3	Is it safe to defrost frozen meat, poultry or fish in a dish on the kitchen counter?	0.376	-0.992
Nutrition Self-Efficacy 2	How confident are you in your ability to do each of the following? Choose the healthiest options from foods sold at restaurants.	1.465	-1.275
Nutrition Self-Efficacy 4	How confident are you in your ability to do each of the following? Choose the healthiest options from foods sold at grocery stores.	8.430	-1.305
Cooking Self-efficacy 3	How confident are you in your ability to do each of the following food preparation and cooking activities? Follow a simple recipe (one that only has a few ingredients and steps).	2.115	-2.556
Cooking Self-efficacy 9	How confident are you in your ability to do each of the following food preparation and cooking activities?	1.775	-0.790

	Prepare meals using plant-based proteins (e.g., beans, lentils, tofu).		
Food Attitudes & Dietary Behaviour 4	How much do you agree or disagree that each of the following statements are true? When ordering takeout food or food in a restaurant, it is important that I choose healthier options from those available, most of the time.	1.023	-0.077
Food Attitudes & Dietary Behaviour 6	How much do you agree or disagree that each of the following statements are true? Eating whole grains (e.g., whole grain pasta and bread, brown rice, oats) is important for my health.	1.264	-1.289
Food Systems 2	How much do you agree or disagree that each of the following statements are true? It is important to use leftovers, when possible	2.079	-1.788
Sociocultural Determinants of Health 1	How much do you agree or disagree that each of the following statements are true? Family, friends, celebrities, and social media can shape/influence what people choose to eat.	1.506	-2.415
Sociocultural Determinants of Health 2	How much do you agree or disagree that each of the following statements are true? It is important that people are able to access foods specific to their culture.	1.711	-2.092