Supporting healthy and sustainable campuses:

Examining food and nutrition interventions in real-world settings

by

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AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see 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.

I understand that my thesis may be made electronically available to the public.

STATEMENT OF CONTRIBUTIONS

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

Chapter 5: Lee KM, Dias GM, Boluk K, Scott S, Chang Y-S, Williams TE, Kirkpatrick SI. Toward a healthy and sustainable campus food environment: A scoping review of post-secondary food interventions. *Advances in Nutrition*. 2021.

Chapter 6: Lee KM, Hammond D, Wallace MP, Price M, Hobin E, Olstad DL, Minaker LM, Kirkpatrick SI. Comparing the impact of numeric versus traffic light calorie labelling at the point-of-purchase on young adults' food and beverage purchases.

Chapter 7: Lee KM, Hammond D, Wallace MP, Dodd KW, Price M, Hobin E, Olstad DL, Minaker LM, Kirkpatrick SI. Examining the impact of numeric versus traffic light calorie labelling at the point-of-purchase on diet quality of food and beverage purchases.

As lead author of these three chapters, I was responsible for conceptualizing the study designs, developing study materials, leading data collection and measure selection, conducting the data analysis, and drafting the manuscripts. My co-authors 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, I also prepared the remaining chapters in this thesis, which were not written for publication.

ABSTRACT

Background: Food and nutrition are major contributors to public health and environmental sustainability challenges. There is currently an unprecedented level of focus on identifying interventions to support eating patterns that are consistent with human and planetary health. Post-secondary campuses represent a microcosm of food environments, providing a real-world setting for evaluating the potential for interventions to improve healthy and environmentally sustainable eating among students. However, the current state of evidence on interventions to support healthy and sustainable eating within post-secondary settings is not well understood. Additionally, there is high policy interest in calorie labelling at the point-of-purchase as a strategy to support healthy eating patterns; however, evidence from real-world settings comparing the impact of numeric versus interpretive calorie labelling on food and beverage purchases is limited.

Objectives: The objectives of this dissertation were to: (1) investigate the extent to which health and environmental sustainability are considered in the implementation and evaluation of food and nutrition interventions on post-secondary campuses (**Chapter 4**); (2) evaluate the impact of numeric and interpretive calorie labelling at the point-of-purchase on consumer noticing, use, and perceptions of the labels, as well as calories purchased and sales (**Chapter 5**); and (3) examine the implications of numeric and interpretive calorie labelling on quality of foods and beverages purchased based on food groups and nutrients of public health concern (**Chapter 6**).

Methods and results: The first study (**Chapter 5**) presents a scoping review of food and nutrition interventions implemented and evaluated on post-secondary campuses to examine the extent to which they integrate considerations related to human health and/or environmental sustainability, as well as to synthesize the nature and effectiveness of interventions and to identify knowledge gaps in the literature. Drawing upon 38 peer-reviewed articles, representing 37 unique interventions, interventions were synthesized according to policy domains within the World Cancer Research Fund's NOURISHING framework. Overall, interventions to support both healthy and environmentally sustainable eating patterns within the context of postsecondary contexts are limited and there is a greater emphasis on human health versus sustainability.

The second study (**Chapter 6**) is comprised of a pre-post quasi-experimental controlled study, where three post-secondary cafeterias were randomized to receive numeric calorie labels, traffic light labelling (red, amber, or green symbol for calories), or no labelling for two weeks. Exit surveys, collecting information on socio-demographics, details of most recent purchase, and consumer noticing, use, and perceptions of labels, were conducted with cafeteria patrons prior to (n=862) and following (n=980) implementation of labels. Generalized estimating equations compared the effects of the labels on noticing, use and perceptions of labels, and calories purchased. Sales data were also collected and examined using ANOVA tests. The increase in noticing of nutrition information from pre-test to post-intervention was significantly greater at the numeric site (+19.5%; OR=3.13, 95% CI=1.79–5.47) and the traffic light labelling site (+33.6%; OR=5.14, 2.95–8.96) than the control (–0.53%). Reported use of nutrition information was significantly greater from pre-test to post-intervention at the numeric (+9.20% vs. –0.30%; OR=2.43, 95% CI=1.14–5.19) and traffic light labelling (+27.5%; OR=5.26, 2.51–11.0) sites relative to the control. Among post-intervention patrons, 32% rated numeric and 48% rated traffic light labels as easy to understand, and 25% rated numeric and 42% rated traffic light labels as easy to use. No differences in three-way interactions with site and time were observed by gender, health literacy, disordered eating, and socioeconomic status for noticing, use, and perceptions of nutrition information. The analyses of the impact of the labels on calories purchased were inconclusive given the assumption of parallel trends across sites could not be satisfied. Numeric and traffic light labels had no effect on total sales, total transactions, and sales per patron.

The third study (**Chapter 7**) utilized data collected from the calorie labelling intervention to examine implications for quality of purchases based on food groups and nutrients of public health concern. The change in purchases of green-, amber-, and red-labelled items and in food groups and nutrients purchased at all sites from pre-test to post-test was assessed. Foods and beverages were coded to food composition databases to calculate amounts of food groups and nutrients, including fruits, vegetables, whole grains, refined grains, plant-based proteins, red meats, added sugars, saturated fats, and sodium, expressed per 1000 kcal. No change in purchasing of red-, amber-, and green-categories at the numeric and traffic light labelling sites versus the control was observed, though the assumption of parallel trends across sites could not

be satisfied. A significant three-way interaction between site, time, and socioeconomic status was observed for purchases of red-labelled items (β=0.11, 95% CI=0.02–0.21; p=0.01). There was a 0.57 oz equivalents/1000 kcal decrease in refined grains purchased at the traffic light labelling site (β=-1.07, 95% CI=-1.82– -0.31; p=0.005) and a 0.05 tsp/1000 kcal decrease in added sugars purchased at the numeric site (β=4.71, 95% CI=0.97–8.45; p=0.01) versus the control. No differences were observed for other nutrients and food groups.

Conclusions: This dissertation examines evidence from real-world settings to improve our understanding of how food and nutrition interventions can support healthy and sustainable eating patterns among post-secondary students. There is a paucity of interventions considering the complexity and interconnectivity of human and planetary health; such approaches are needed to address structural determinants that shape food systems and eating patterns. With respect to a specific nutrition intervention of high policy relevance in Canada, numeric and traffic light calorie labelling at the point-of-purchase has the potential to improve noticing and use of nutrition information, with greater proportions of patrons reporting that TLL were easy to use and understand. Given the lack of parallel trends needed to satisfy the assumptions for quasi-experimental trials, the impact of the labels on purchasing by calories, food groups, and nutrients requires further investigation using group-level sales data. Future research should consider a 'whole-of-systems' approach to identify and evaluate complementary strategies that holistically consider impacts on both human and planetary health.

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LIST OF ABBREVIATIONS

FNDDS	Food and Nutrient Database for Dietary Studies
FPED	Food Patterns Equivalents Database
GEE	Generalized estimating equations
SDG	Sustainable Development Goals
SES	Socioeconomic status
SSS	Subjective social status
TLL	Traffic light label
UK	United Kingdom
US	United States

CHAPTER 1: Introduction

1.1 Overview and scope

Food and nutrition can play a central role in supporting human health and protecting the planet.[1,2] However, current eating patterns and food systems have substantial negative implications for the health of populations and the planet.[2–4] As a result, there is an unprecedented level of attention toward identifying interventions that support healthy and to a lesser extent, sustainable population-level eating patterns.[5,6] Although policy interventions have traditionally focused on supporting healthy eating, co-benefits of interventions that simultaneously consider implications for both human and planetary health are increasingly being recognized.[7] Evidence from real-world settings can provide valuable insight into the effectiveness of such interventions in specific settings, as well as the scalability of policy interventions to other contexts.[8,9] In particular, post-secondary institutions are increasingly committing to health and sustainability within their campus communities and provide settings in which food and nutrition interventions can be investigated.[10–12]

Through a scoping review and a real-world quasi-experimental trial of a high-profile nutrition intervention, this dissertation aimed to investigate the potential of food and nutrition interventions to support healthy and sustainable eating among young Canadian adults in post-secondary settings. The scoping review sheds light on the range and effectiveness of food and nutrition interventions that aim to support human and planetary health within post-secondary contexts. Given nutrition labelling is a priority in *Canada's Healthy Eating Strategy*,[13] the quasi-experimental study examines the potential for numeric versus interpretive calorie labelling at the point-of-purchase in food service settings to support healthy eating patterns. The findings also contribute to broader discussions regarding harmonized nutrition labelling systems in Canada; for example, using similar labelling formats for nutrition information on menus in restaurants and similar settings and for front-of-package labels on pre-packaged products. Overall, this dissertation identifies the need for substantial work to realize interventions that are effective in addressing both the human and planetary implications of eating patterns.

1.2 Dissertation organization

Chapter 2 reviews the literature by defining healthy and sustainable eating patterns, examining the application of systems thinking to policy approaches to support human and planetary health, highlighting the importance of real-world research and the role of post-secondary institutions, and synthesizing the current evidence base on nutrition labelling at the point-of-purchase. **Chapter 3** summarizes the rationale for the dissertation and research objectives for the three studies described in **Chapters 5-7**. **Chapter 4** provides an overview of the methods and analyses.

Chapters 5, 6, and 7 comprise of manuscripts that have been published or prepared for publication, corresponding to three research objectives. **Chapter 5** describes a scoping review and **Chapters 6 and 7** draw upon data collected from a quasi-experimental study of calorie labelling in post-secondary cafeterias. The three manuscript chapters aimed to: (1) explore the current state of knowledge on food and nutrition interventions to address human and planetary health in the context of post-secondary settings; (2) compare the impacts of numeric versus interpretive calorie labelling on noticing, use, and perceptions of nutrition information and food and beverage purchasing among post-secondary students; and (3) examine the effect of numeric versus interpretive calorie labelling on the quality of foods and beverages purchased by post-secondary students, with respect to food groups and nutrients of public health concern.

Chapter 8 summarizes findings across the three chapters and provides interpretation relevant to the overarching aim of the dissertation. Implications for policy and future research are also provided, including recommendations related to: informing the implementation of nutrition labelling at the point-of-purchase; underscoring the need for application of a systems thinking lens to design and implement interventions to support healthy and sustainable eating patterns; and emphasizing the importance of evaluating the impacts of interventions on factors relevant to both human and planetary health, as well as considerations of trade-offs between the two.

CHAPTER 2: Literature Review

2.1 Food systems, human health, and planetary health

Food and nutrition are critical to efforts to support human health and protect the planet. However, current eating patterns and food systems are contributing to substantial public health and environmental sustainability challenges.[2–4] Globally, unhealthy eating patterns are among the leading risk factors for morbidity and mortality. For instance, low intakes of fruit and vegetables, nuts and seeds, and whole grains, and high intakes of sodium are top contributors to diet-related deaths.[14] Over recent decades, eating patterns have shifted toward increased consumption of foods that are highly processed, energy dense, and primarily sourced from animals.[15,16] At the same time, there is a growing body of literature suggesting current eating patterns are associated with high environmental impacts,[2,17] due to their connection to food system activities that heavily rely on fossil fuels and finite natural resources.[18] Evidence suggests wide-ranging impacts including greenhouse gas emissions, climate change, and biodiversity loss.[2,19,20]

To date, the public health nutrition paradigm has focused on supporting eating patterns consistent with human health, primarily by addressing nutrient deficiencies and promoting adequate intake of dietary components.[7] More recently, the paradigm is shifting toward promoting eating patterns that align with *both* human and planetary health.[2,7,21–23] As a result, there is an upswing in global advocacy toward identifying interventions that support healthy and sustainable eating patterns.[2,19] The United Nations' Sustainable Development Goals (SDGs) call for a food system transformation as a means of reducing hunger (SDG2) and supporting health and well-being (SDG3), emphasizing the need to shift activities in the food system to reduce environmental impacts (SDG12).[24,25] Such efforts speak to the need for a 'de-siloing' of the current policy approach,[26] emphasizing the use of systems thinking to jointly consider human and planetary health in the context of the whole food system rather than considering these as isolated issues.[27]

To inform the research undertaken in this dissertation, this chapter defines healthy and sustainable eating patterns, describes policy approaches to support healthy and sustainable eating patterns, highlights the importance of evidence from real-world settings and the role of post-secondary institutions, and synthesizes literature on nutrition labelling at the point-of-purchase.

2.2 Healthy and sustainable eating patterns

Eating patterns are defined as the combination of foods and beverages that represent the totality of an individual's complete dietary intake over time.[28–30] Rather than emphasizing a single food or dietary component, recognizing eating patterns as a whole is important for promoting overall health and well-being.[28] In *Canada's Food Guide*,[29] recommendations for healthy eating patterns include regular consumption of fruits and vegetables, whole grains, protein foods, and limited intake of highly processed foods. The accompanying *Canada's Dietary Guidelines for Health Professionals and Policy Makers*[31] further highlight the importance of appropriate energy balance and reducing consumption of saturated fats, added sugars, and sodium. Internationally, similar guidance for healthy eating patterns have been recommended, including by the World Health Organization[32] and within the *2020-2025 Dietary Guidelines for Americans*.[30]

The concept of sustainability broadly refers to the ability to meet the needs of current and future generations, often relating to actions that protect and maintain environmental resources as a means to support people and the planet.[33] When applied to food and nutrition, a sustainable eating pattern is defined as "diets with low environmental impacts which contribute to food and nutrition security and healthy life for present and future generations".[21] The definition recognizes that sustainable eating patterns includes an array of interconnected dimensions pertaining to health and well-being; biodiversity, environment, and climate; equity and fair trade; eco-friendly, local, and seasonal foods; culture and heritage; and food and nutrient security needs.[4,34]

The need for dietary guidance to address environmental sustainability was recognized as early as 1986.[35] In the past decade, research on how different eating patterns impact the planet has accelerated.[7] Although food-based dietary guidelines have predominantly provided guidance on eating patterns aligning with human health,[36] a few countries have recently moved toward holistic approaches by integrating recommendations for eating patterns consistent with planetary health.[37] For instance, the *Dietary Guidelines for the Brazilian Population*[38] identify social, cultural, and environmental dimensions of food that contribute to overall health and well-being and align with planetary health.[39] The guidelines recommend that eating patterns should primarily consist of freshly prepared foods, mostly from plants, and limited intake of minimally processed foods. The report from the *EAT-Lancet Commission on Healthy Diets from*

Sustainable Food Systems[19] outlines a sustainable eating pattern as one that limits intake of red meats and starchy vegetables, while also emphasizing consumption of fish, fruits, vegetables, whole grains, legumes, and nuts. The report further suggests that healthy eating patterns (i.e., appropriate caloric intake, small amounts of highly processed foods and added sugars) align with sustainable eating patterns (i.e., increased variety of plant-based foods, low amounts of animal sources) due to reduced greenhouse gas emissions and land and water use.[19] Although the *EAT-Lancet Commission*[19] provides guidance for a sustainable eating pattern, the recommendations have been criticized for overlooking contextual factors that influence eating patterns and food systems (e.g., affordability of the eating pattern, job loss in the food system).[40–43]

While planetary health is not explicitly referenced in *Canada's Food Guide*,[29] the guidance emphasizing food groups such as fruits, vegetables, and whole grains is similar to recommendations provided by the *EAT-Lancet Commission*.[19] *Canada's Dietary Guidelines*[31] recognize the impact that eating patterns have on the environment; for example, by linking a focus on plant-based proteins and minimizing food waste to planetary health.[31] The guidelines include additional recommendations that may be theorized as relating to sustainable eating patterns given the dimensions noted above such as culture and heritage,[4,34] including consideration of social environments and behaviours related to cooking and eating meals with others, enjoying cultural aspects of food, and being mindful of eating habits.

Though the specific characteristics of sustainable eating patterns in different contexts are debated, eating patterns aligning with human and planetary health are broadly those that move beyond a reductionist approach that solely focuses on meeting nutrient needs and reducing chronic disease risk. Evidence from modelling studies suggests co-benefits of promoting healthy and sustainable eating patterns, including reduced rates of morbidity and mortality from chronic disease and mitigating environmental impacts related to climate change.[44] For the purpose of this dissertation, healthy and sustainable eating patterns are conceptualized based on recommendations provided in dietary guidance, including: adequate caloric intake; increased consumption of fruits, vegetables, whole grains, and plant-based proteins (i.e., nuts, seeds, legumes, soy); limited consumption of red meats and refined grains; and reduced intake of saturated fats, added sugars, and sodium. Social and cultural aspects of sustainable eating patterns are not explicitly considered.

2.3 Policy approaches and systems thinking

Globally, there is an unprecedented level of attention toward identifying food and nutrition interventions to support eating patterns at the population-level.[5,45–47] The World Cancer Research Fund developed the NOURISHING framework to highlight ten key policy areas to support healthy eating patterns, within the three domains of (1) modifications to the food environment (e.g., nutrition labelling, economic measures); (2) harnessing the food system and supply chain (e.g., supply chain incentives); and (3) behaviour change communication (e.g., media awareness campaigns).[5] Internationally, jurisdictions are increasingly implementing interventions that aim to alter food environments, such as front-of-package labelling and sugar-sweetened beverage taxation, to support healthy eating patterns.[6] In Canada, the *Healthy Eating Strategy*[13] identifies multiple policy interventions to improve food environments, including improved nutrition labelling, restrictions on marketing to children, and improvements to nutritional quality by targeting sodium and trans fats in the food supply.

Despite the increased interest in interventions, policy approaches largely remain ‘siloed’ by focusing on interventions aligning with human health but not planetary health. There are opportunities within existing policy approaches to address sustainable eating patterns. For example, *Canada's Food Guide*[29] emphasizes consumption of fruits and vegetables, whole grains, and plant-based proteins, aligning with recommendations for sustainable eating patterns.[19] However, the *Food Guide*[29] does not explicitly address environmental sustainability and it is not clear that efforts to evaluate whether Canadians follow the guidance or the impacts on human health will consider implications for the environment. Similarly, the *Healthy Eating Strategy*[13] focuses on healthy rather than sustainable eating, although changes in eating patterns potentially stimulated by facets of the *Strategy*,[13] such as restrictions on marketing, may have unintended effects and trade-offs for greenhouse gas emissions, packaging waste, and other factors relevant to sustainability.

Policy approaches and interventions need to be grounded in systems thinking to better embrace the complexity of eating patterns and food systems.[33,48] Systems thinking is increasingly being used as a public health tool to conceptualize complex problems as part of a larger system of interconnected drivers and actors.[49–51] Using systems thinking to examine eating patterns within the context of the broader food system offers an opportunity to identify strategic leverage points for policy and to examine unintended effects or trade-offs elsewhere in the system.[4,33,52] Systems thinking also recognizes the need for policies to move beyond traditional 'siloes' by engaging with actors and stakeholders across multiple levels (e.g., local, national, international, global), sectors (e.g., public and private), and disciplines (e.g., public health, epidemiology, environmental science, political science, economics, agriculture).[4,50,51,53]

The social-ecological model (**Figure 1**)[54–56] is a notable example of a framework grounded in systems thinking, demonstrating that eating patterns and food systems are influenced by a range of factors at individual, sociocultural, community, national, and global levels. Application of the framework suggests interventions should be targeted across multiple levels, and consider interconnections and trade-offs among levels, to support healthy and sustainable eating patterns.[5,6,19,47] Implementation of a suite of integrated and reinforcing interventions is critical to support healthy and sustainable eating patterns;[57] for example, a combination of interventions that alter the food environment (e.g., nutrition labelling, taxation) and improve the food supply (e.g., supply chain incentives to reduce carbon emissions, sodium reduction through industry restrictions) is needed to achieve meaningful changes in population-level eating patterns.

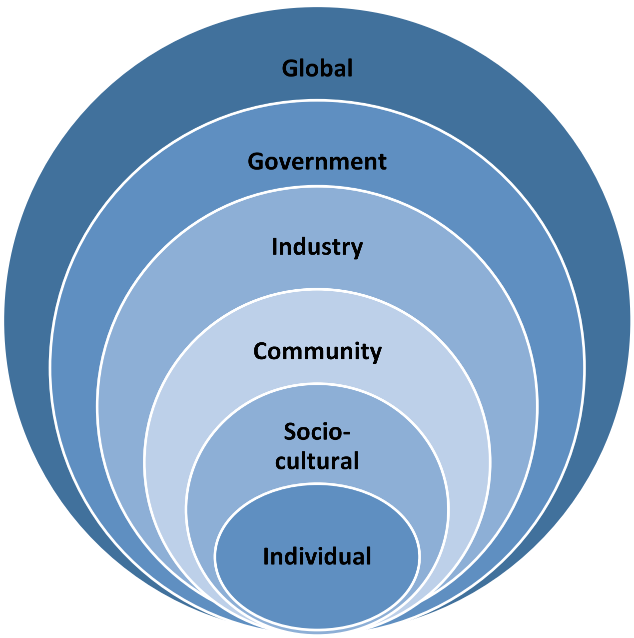


Figure 1. Social-ecological model for supporting eating patterns, adapted from McLeroy et al. (1988),[54] Afshin et al. (2014),[55] and Golden et al. (2015).[56]

2.4 Evaluating interventions in real-world post-secondary settings

Implementation science in public health has increasingly recognized the value of evaluating interventions in real-world settings.[58–60] While evidence from randomized controlled trials is needed, particularly for its high internal validity, generalizability beyond controlled and experimental settings is limited for the purpose of informing public health policy.[60] Evidence from real-world settings can better capture the array of and interactions among factors that may influence the effectiveness of an intervention;[61] for example, socio-demographic factors that may interact with a given policy to influence an individual's selection of foods and beverages in a restaurant. Real-world evaluations can inform public health policy and interventions by providing insight into the context and circumstances in which they may be effective.[8,9]

Post-secondary campuses offer a real-world setting in which food and nutrition interventions can be piloted and evaluated. Campuses have been previously defined as 'living labs', suggesting an enclosed real-world setting where students, faculty, and staff make food and beverage purchasing decisions in the context of settings where they work, live, and play.[10–12] Recognizing that campuses represent a microcosm of food environments, 'whole-of-systems' approaches to interventions have also been recommended to promote health in campus communities and target issues related to sustainability, such as food waste.[62–64]

Post-secondary campuses comprise of consumer food environments with a wide range of eateries and offerings,[65–70] contributing to purchasing power and capacity to shift demand within the food supply chain (e.g., through procurement contracts with multinational corporations and suppliers).[71,72] Several studies have measured elements of the post-secondary food environment[65–70] to provide evidence on facilitators and barriers to supporting healthy eating patterns on campuses. Evidence suggests opportunities to implement interventions related to improving the availability and variety of healthy foods (e.g., improving offerings, placing healthy foods and beverages in more accessible locations),[65–70] increasing availability of nutrition information and signage to support informed food and beverage purchasing decisions,[67–69] and adjusting the cost of healthy items (e.g., through incentives).[68] Further, campuses are increasingly committing to supporting the health of students, while also reducing their impacts on the planet, including through actions related to food and nutrition.[73–78]

Young adulthood is a critical period for establishing life-long health behaviours.[79–81] In 2017/2018, nearly half of all young adults in Canada (approximately 1.4 million) attended a post-secondary institution,[82] further signifying the responsibility of campus stakeholders to support the health and wellbeing of students. A cohort study of young adults in five Canadian cities found that 20% of meals were prepared outside of the home, with most purchased at fast-food and quick-service outlets and coffee shops.[83] Among adults aged 19 years and older, dietary intake data from the *2015 Canadian Community Health Survey* demonstrated the majority consumed excess amounts of sodium.[84] The data also revealed that consumption of "other foods", such as foods high in fat and sugar and sugar-sweetened beverages, represented approximately one-quarter of calories per day.[85,86] Estimates from the *2004 Canadian Community Health Survey* found that the economic burden of not meeting *Canada's Food Guide*[29] was $13.8 billion per year, with low consumption of nuts and seeds and whole grains being top contributors of health care costs.[87] Eating patterns among young adults are influenced by factors throughout the socio-ecological model, including individual-level factors (e.g., taste preferences, time and convenience, stress), socio-cultural factors (e.g., family, friends and peers), barriers in the physical environment (e.g., availability and affordability of foods and beverages), and policies in the macro-environment (e.g., media and advertising).[88–91]

Several reviews have synthesized literature on interventions to support healthy eating patterns in post-secondary settings. Current evidence suggests the potential impact of strategies related to improving the availability of nutrition information (e.g., point-of-purchase nutrition labelling) and increasing the affordability and accessibility of healthy foods.[92,93] A recent review of governance documents from universities in Australia and New Zealand suggests campuses have capacity to leverage a 'whole-of-systems' approach by implementing strategies beyond education to promote sustainability.[94] However, current reviews focused on food sustainability have largely considered pedagogy focused on food waste (e.g., sustainability education) rather than interventions to address structural determinants as a means to shift eating patterns.[95–99] There is a gap in the existing literature related to understanding the extent to which human and planetary health are being jointly considered in the design, implementation, and evaluation of food and nutrition interventions on post-secondary campuses.

2.5 Nutrition labelling at the point-of-purchase

Nutrition labelling is one type of policy intervention that has received significant global attention.[5,6,13] In Canada, nutrition labelling has been a long-standing policy to support informed food selection and purchasing decisions among consumers.[100] Canadian guidelines for voluntary nutrition labelling on pre-packaged foods and beverages were put in place in 1988, with the Nutrition Facts Table becoming mandatory in 2007.[101,102] The Nutrition Facts Table includes quantitative indicators (calories and amounts of 13 nutrients in a serving) to enable comparison of similar products, and the % Daily Value to indicate if a serving of a food or beverage is low or high in specified nutrients.[103,104] Labelling schemes have been shown to stimulate manufacturers to reformulate products,[105–108] potentially resulting in a healthier food supply (e.g., removal of trans fats and lowering of sodium and sugar levels). Canada's *Healthy Eating Strategy*[13] continues to prioritize nutrition labelling as a strategy to support healthy eating patterns by 'making the healthy choice the easy choice' and helping consumers make informed food and beverage purchasing decisions.

Although nutrition labelling has traditionally focused on pre-packaged foods and beverages, evidence suggests a shift toward increased consumption of foods prepared outside of the home in recent decades.[109,110] As a result, increased attention has been placed on nutrition labelling at the point-of-purchase in food service settings,[111–113] such as restaurants and fast-food chains. Nutrition labelling at the point-of-purchase has primarily focused on displaying calorie amounts on menus to inform food selection and purchasing decisions and ultimately, support healthy eating patterns. The underlying rationale for a focus on calories is driven by observations that energy content can vary among similar menu items and that consumers generally lack awareness about the caloric content of products prepared and consumed outside of the home.[114–116]

In Canada and internationally, a number of jurisdictions have mandated calorie labelling on menus. In Ontario, the *Healthy Menu Choices Act*[111] requires establishments with 20 or more locations to present numeric calorie information and a contextual statement on menus. British Columbia's *Informed Dining in Health Care*[117] program requires food service establishments in health care facilities to provide nutrition information on calorie and sodium amounts. In New York City, restaurants and fast-food chains with more than 20 locations are required to post calorie and sodium information for items on menus.[113] The UK government also recently announced that large businesses with more than 250 employees will be required to display calorie amounts for non-prepackaged foods and beverages,[118] further demonstrating ongoing interest in the implementation nutrition labelling at the point-of-purchase.

Building on international approaches to front-of-package labels, there has been speculation about the potential for interpretive formats to support food and beverage selection.[119,120] One example of an interpretive labelling system is traffic light labels (TLL), which use red, amber, and green indicators to convey whether foods or beverages are high, medium, or low in selected dietary components (e.g., calories) based on defined criteria.[121] TLL, first proposed in the United Kingdom, are increasingly used on front-of-package labels,[122–124] with research indicating consumers notice, prefer, and use this format to a greater extent than formats displaying only numeric information.[125–127] Therefore, given their at-a-glance nature, TLL may be a valuable tool for providing a summary of nutrition information to support informed food and beverage purchasing decisions at the point-of-purchase.[128] Within Canada, as part of the *Healthy Eating Strategy*,[13] the government is moving toward providing interpretive nutrition information on the front-of-packages, begging the question of whether nutrition labelling at the point-of-purchase should follow a similar approach rather than the numeric approach currently in place in jurisdictions such as Ontario. While a large body of literature has examined numeric and traffic light calorie labelling in isolation, few studies have explicitly compared the impacts of the two formats in real-world settings. Further, few studies have examined the implications of either labelling format on diet quality with respect to food groups and nutrients recommended for a healthy and sustainable eating pattern (**Section 2.2**), including consideration of trade-offs between human and planetary health.

This chapter subsection synthesizes current evidence related to: (1) impact of numeric calorie labelling; (2) effectiveness of TLL and comparisons to numeric formats; (3) concerns related to differential impacts among subgroup populations; and (4) the potential of calorie labelling to support healthy and sustainable eating patterns.

2.5.1 Evidence on numeric calorie labelling

Evidence suggests that calorie labelling on menus leads to an increase in self-reported noticing of nutrition information.[129–141] Across studies examining consumer awareness of calorie labelling, approximately one-third of those who noticed the labels also reported using the labels.[130–137] A large body of systematic reviews and meta-analyses have examined the impact of numeric calorie labelling on food and beverage purchasing.[142–151]

The first review of calorie labelling was conducted by Harnack et al.[142] in 2008, reporting on six quasi-experimental and simulation studies. The review suggested calorie labelling had limited and inconsistent effects on food and beverage selection and highlighted the need for randomized studies conducted in real-world settings. Swartz et al.[143] updated the review in 2011 and included five studies in real-world settings and two in laboratory settings. The authors concluded calorie labelling had little to no impact on calorie ordering and consumption. Further, the evidence was deemed insufficient for drawing causal inferences to real-world settings due to the observational and simulated nature of the included studies.

Building on the initial two reviews, Kiszko et al.[144] synthesized findings from 31 studies published between 2007 to 2013, including 15 real-world experiments (12 from restaurants, three from cafeterias) and 13 studies from laboratory settings. Evidence from the included studies suggest that while most patrons were aware of calorie labels on menus, calorie labelling had no impact on overall food and beverage purchasing and consumption. The authors highlighted limitations in the evidence, including a low number of studies from a wide variety of real-world settings, inconsistent methodologies, lack of comparison groups in real-world studies, and short study periods. Recent reviews by Fernandes et al.[145] and Bleich et al.[146] suggest calorie labelling may be more effective in certain settings, due to differences in food and beverage selection behaviours among consumer audiences. For example, calorie labelling was found to be more effective in cafeterias compared to restaurants or fast-food chains because cafeteria patrons were often daily visitors.[145,146]

Five meta-analyses provide estimates of the effect of calorie labelling on calories purchased. Sinclair et al.[147] conducted a systematic review of ten experimental studies and seven quasi-experimental studies (seven from real-world settings). The meta-analysis, focused on experimental studies, revealed menu calorie labelling did not lead to a significant reduction in calories purchased (–31 kcal; p=0.35) and consumed (–13 kcal; p=061). The authors reported similar findings from quasi-experimental studies in which calorie labelling has been implemented. Nikolau et al.[148] conducted a meta-analysis of six real-world studies and found that calorie labelling had no effect on calories purchased (−5.8 calories; 95% CI=−19.4, 7.8 kcal) but a reduction of − 124.5 kcal (95% CI=−150.7, 113.8 kcal) was estimated among those who noticed the labels. In a meta-analysis by Long et al.[149] of experimental and quasi-experimental studies (nine from real-world settings), calorie labelling led to a small but significant reduction in calories (–18 kcal per meal; p=0.02). However, when further stratified by site, menu calorie labelling did not lead to a significant reduction in calories purchased (–8 kcal per meal; p=0.26), suggesting findings from laboratory settings may overestimate the effects. Littlewood et al.[150] conducted a meta-analysis of 12 studies (seven real-world) and observed a significant reduction in calories consumed (–100 kcal; p<0.001). Among studies from real-world settings, a significant mean reduction in calories purchased was estimated (–78 kcal; p<0.001). Finally, in a Cochrane review of nutrition labelling by Crockett et al.[151], a meta-analysis of three real-world randomized controlled trials suggests calorie labelling on menus led to an 8% reduction in energy purchased for an average meal of 600 kcal. Significant heterogeneity was noted across findings.

The current evidence base suggests that numeric calorie labelling has limited impact on food and beverage purchasing. Across reviews, there is consensus that conclusions are based on limited data and most existing studies lack adequately-powered designs with a comparison group.[143,145–147,149,151] Findings from laboratory settings are limited in their generalizability, given the complexity of food and beverage selection in the real-world.[142–144] Therefore, studies conducted in a variety of real-world food service settings are needed to understand whether and how findings generalize to different types of consumers.[144–146]

2.5.2 Evidence on traffic light labelling

Few studies have examined the impact of TLL as a point-of-purchase nutrition label.[152–163] The current body of literature evaluates TLL used to provide a summary indicator of the nutrition profile of foods and beverages (e.g., using criteria based on recommendations for healthy eating patterns), and includes comparisons of TLL versus numeric formats.

Real-world studies of using traffic lights as a summary indicator

TLL at the point-of-purchase have been used to summarize nutrition information based on criteria related to presence of fruit and vegetables, whole grains, and lean protein/low-fat dairy as the main ingredient and amounts of saturated fats and calories. In a Boston hospital cafeteria, Sonnenberg et al.[152] implemented a TLL intervention and linked sales data for red-, amber-, and green-items to surveys querying socio-demographics and consumer awareness of labels. The study found respondents who noticed the labels during the intervention were more likely to purchase healthier items than respondents who did not notice the labels ($p<0.001$). Thorndike et al.[153] introduced a TLL (summary indicator of nutritional value) and choice architecture (i.e., changes to positioning of items) intervention at a large hospital cafeteria. The analysis examined sales among all cafeteria patrons and a longitudinal cohort of employees who regularly used the cafeteria. Over a 2-year period, the proportion of sales accounted for by red-labelled items decreased from 24% to 20%, and sales of green-labelled items increased from 41% to 46% ($p<0.001$).[154] A follow-up analysis of the longitudinal cohort observed the intervention led to a 6% decrease in calories per transaction and was sustained over two years ($p<0.001$), with the largest reduction in calories coming from red-labelled foods (–42 calories; $p<0.001$).[154] These findings are consistent with studies showing that consumers utilize a red-avoidance strategy when interpreting TLL,[164–166] suggesting TLL may be more effective in discouraging red-labelled foods rather than encouraging green- or amber-labelled foods.

Seward et al.[156] replicated the same TLL and choice architecture intervention used by Thorndike et al.[153,154] in post-secondary cafeterias; however, they observed no change in purchases of red-labelled (–0.8% change/week; $p=0.2$) and green-labelled (+1.1% change/week; $p=0.4$) foods and beverages in comparison to the control group. A follow-up mixed methods study of perceptions found 60% of students reported TLL were helpful and 57% used them a few times a week.[167]

In a Canadian real-world experiment, Olstad et al.[155] implemented a TLL intervention on menu boards at a recreation facility in Alberta and observed changes in sales from one week prior to and one week after the intervention. The labels were based on standards provided in the *Alberta Nutrition Guidelines for Children and Youth*[168] for foods that should be chosen “more often” (green), “sometimes” (amber), and “less often” (red). With a decrease of 3% in sales of red-labelled items and an increase of 3% in sales of green-labelled items, no loss in revenue was observed, potentially alleviating industry concern about effect on profit.[155]

The inconsistency in findings across different types of food service operations demonstrates the need to examine point-of-purchase labelling in a variety of real-world settings.

Comparing numeric versus traffic light calorie labelling

There is a small body of literature comparing the impacts of numeric versus traffic light calorie labelling on food and beverage purchasing. Systematic reviews comparing pooled estimates from studies examining numeric and TLL in isolation suggest that the influence on food selection and purchasing is mixed,[145–147,169] potentially due in part to heterogeneity in study designs and settings. In a meta-analysis of controlled experimental and real-world studies, Sinclair et al.[147] found consumers purchased (–67 kcal; p=0.008) and consumed (–81 kcal; p=0.007) fewer calories when labels included interpretive information in comparison to numeric information alone. A review of real-world studies by Fernandes et al.[145] demonstrated similar findings, suggesting studies in cafeterias that include only interpretive labels, such as healthy food symbols or TLL, showed has potential to support healthy food choices. However, in another review of real-world studies by Bleich et al.[146], the authors noted evidence on numeric and interpretive calorie labelling remains inconclusive because of the limited number of real-world, randomized controlled trials.

Several experimental studies have specifically compared numeric and TLL, typically examining hypothetical purchases or simulating a consumer experience through an experimental marketplace.[157–161,170] Liu et al.[157] conducted an online survey, randomly assigning participants to menus with numeric and TLL with calorie information. The study found participants in the numeric calorie labelling and the TLL groups ordered fewer calories than the control. Similarly, a between-subjects online experiment by Morley et al.[158] observed a reduction in calories purchased in the numeric calorie labelling (−117 kcal; p<0.05) and the TLL condition for calorie amounts (−120 kcal; p<0.05) in comparison to control groups with no labelling. In contrast, in an experimental marketplace study of numeric and TLL formats for calorie and sodium amounts by Hammond et al.[170], there was no difference in calories ordered depending on the label received, but calorie consumption was lower among those who received menus with numeric calorie labels

(−96 kcal; p=0.048). Three experimental studies have examined implications of numeric and interpretive formats on parents' orders for their children,[159–161] generally finding that the addition of TLL did not further influence food and beverage purchasing in comparison to numbers alone.

Two prior studies have examined the impacts of numeric and TLL formats in real-world settings.[162,163] The first study by Ellison et al.[162] was a field experiment in a full-service restaurant where patrons were randomly assigned to tables with menus that had no calorie labelling, numeric calorie labelling, or TLL for calorie amounts. The study observed the addition of TLL reduced calories ordered for meals when compared to numeric calorie labelling alone and the control (p=0.03). No differences in calories purchased from additional items, such as beverages, were observed. When examining support for labelling, 42% preferred the numeric calorie label whereas 28% preferred the traffic light symbol. The authors noted limitations related to small sample sizes and limited number of labelled items on menus.[162]

In the second real-world study, VanEpps et al.[163] randomized patrons at a worksite restaurant to menus presented with numeric calorie labels, TLL without calorie amounts, or TLL with calorie amounts through an online ordering system. Compared to baseline, participants purchased fewer total calories when exposed to numeric calorie labels (-60 kcal; $p < .05$) and TLL (-78.28; $p < .05$), with no difference observed across formats.[163] The authors noted that the differences between their findings and Ellison et al.[162] may be due to environmental factors, for example, considering differences in behaviour among online versus sit-down patrons.

Overall, few studies have been conducted to compare the impacts of numeric and TLL systems on purchasing patterns in real-world settings. Findings from experimental and the limited number of real-world trials suggest TLL lead to small and inconsistent reductions in calories purchased as do numeric labels,[158,162,170] with a few studies suggesting TLL may outperform formats with numbers alone.[157,163] Experimental marketplace studies provide valuable insight into the potential impacts of numeric versus TLL by maintaining the benefits of randomization. However, the paucity of real-world trials directly comparing numeric and TLL poses a barrier to understanding whether one format could better support food and beverage purchasing in line with recommendations,[145–147] particularly in cafeteria settings where consumer behaviour is influenced by a different set of social and environmental factors than in restaurants.

2.5.3 Differences by subgroup populations

Existing evidence, though limited, suggests that calorie labels may have differential impacts among subgroup populations.[134,171–174] Understanding how calorie labels affect subgroup populations is critical for ensuring the intervention does not exacerbate existing disparities or have potential unintended implications related to health.

Socioeconomic status and health literacy

The relationship between socioeconomic status (SES) and health literacy is well-established, with evidence demonstrating low health literacy is strongly associated with low SES.[175–177] Criticisms that calorie labels will widen socioeconomic disparities is warranted, particularly given the body of literature suggesting that those with higher education, income, literacy, and numeracy are more likely to use nutrition information labels.[151,178] For example, Sinclair et al.[128] found one-third of participants in Southwestern Ontario were unable to comprehend basic information on nutrition labels.[178,179]

Several studies have shown that calorie labelling led to greater noticing and use of nutrition information among those who were white,[134,171,174] more educated,[172–174] and had a higher income.[134,171–174] In contrast, a quasi-experimental study by Goodman et al.[136] of calorie labelling policies in Canada found that nutrition information noticing and use was greater among youth and young adults living in households affected by moderate or severe food insecurity compared to those in food-secure groups, with no difference by levels of health literacy. The underlying reason for this finding is not clear. A review by Sarink et al.[180] found increased awareness of labels among consumers with high compared to low socioeconomic status; however, evidence was limited in quantity and quality.

Less is known about the implications of TLL among different subgroups. In a TLL and choice architecture intervention by Levy et al.[181], the intervention decreased purchases of red-labelled items (–11.2%, 95% CI=–13.6%, –8.9%) and increased purchases of green-labelled items (6.6%, 95% CI=5.2%, 7.9%) across all race and socioeconomic groups. There is a need for evidence examining the implications of numeric versus TLL among these groups, particularly given theoretical underpinnings that suggest TLL may facilitate stronger understanding compared to numeric nutrition information alone.[147,180,182]

Disordered eating risk

Concerns have been raised regarding the potential for calorie labelling to promote or exacerbate disordered eating;[167,183] however, evidence is limited.[184–187] In a web-based survey comparing individuals with self-reported eating disorders to those without, Roberto et al.[184] found high support for labelling, with no differences in relation to eating disorders, dieting, or weight status. In a pre-post intervention study conducted among female undergraduate students, Lillico et al.[185] observed no adverse outcomes in terms of indicators of disordered eating (e.g., body image satisfaction) in response to calorie labels displayed for one week.

Two studies have examined implications of calorie labelling among those with clinically diagnosed eating disorders.[186,187] Haynos et al.[186] conducted an online survey to examine hypothetical purchases from menus with and without calorie information. The study showed women with anorexia nervosa and bulimia nervosa ordered significantly fewer calories, while women with binge eating disorder ordered significantly more calories in the menu labelling conditions versus no labelling. An online survey by Larson et al.[187] suggests using menu labels was associated with binge eating among women and greater weight-related concerns, dieting, and unhealthy weight-control behaviours among both women and men. Relatedly, studies have shown women use labels to select items with fewer calories,[134,171,173] which may be of concern given evidence observing a high prevalence of disordered eating among young adult women.[188]

2.5.4 Potential to support healthy and sustainable eating

Current literature on labelling at the point-of-purchase has primarily focused on calories purchased and consumed. However, as described in **Section 2.2**, healthy and sustainable eating patterns comprise of adequate caloric intake, with increased variety of plant-based foods (e.g., fruits and vegetables, whole grains, plant-based proteins), reduced consumption of red meats, and limited intake of saturated fats, sugars, and sodium.[19,189–192] A focus on calories is inherently biased against some high-fat, nutrient dense foods (e.g., nuts, eggs) that could be part of a healthy and sustainable eating pattern, whereas some lower-calorie foods (e.g., refined grains) may be unintentionally encouraged.[193] Given almost all foods and beverages contain calories, interventions that influence caloric consumption may also change intake of dietary components that are relevant to healthy and sustainable eating patterns. Therefore, it is critical to understand the implications of the labels on eating patterns beyond caloric intake, including unintended effects and trade-offs related to promoting foods that are lower in diet quality and environmental sustainability.

Perhaps due to the relative novelty of healthy and sustainable eating patterns, no evaluations have framed calorie labelling in the context of human and planetary health. However, a limited body of evidence has examined the impacts of calorie labels on intakes of specific nutrients (e.g., carbohydrates, fat, saturated fat, and sodium) and food groups (e.g., nuts and seeds, fruits and vegetables, whole grains) identified in guidance for healthy and sustainable eating patterns.

Following implementation of a city-wide calorie labelling mandate, Gruner et al.[194] conducted a cross-sectional study to examine implications on purchases of healthy options in restaurants. Foods and beverages were categorized based on food groups recommended in the *2015 Dietary Guidelines for Americans*.[30] The study found participants who used calorie labels were more likely to select healthier sides and beverages, with no difference in purchases of meals.[194]

Two studies have observed the impact of numeric calorie labelling on nutrient intakes. Harnack et al.[195] conducted a 2×2 factorial experimental marketplace in which participants were randomized to receive no intervention, calorie labels, a price menu modification, or calorie labels with a price menu modification. The authors reported on hypothetical purchases of calories, carbohydrates, protein, saturated fats and total fats, dietary fiber, vitamin C, and calcium and observed no significant differences for any nutrients when comparing intervention groups to the control.[195] Following implementation of the calorie labelling mandate in New York City, Elbel et al.[131] found no significant impact on calories purchased and similar results were observed for saturated fats, sodium, and sugars. Cantu-Jungles et al.[196] conducted a meta-analysis of 14 experimental studies of menu labelling formats with calories and other dietary components and found no effect on intakes of carbohydrates, saturated and total fats, and sodium.

The existing evidence suggests minimal impact of calorie labels on nutrient purchasing and intakes, similar to what has been observed for calories. Analyses that explicitly examine quality of food and beverage purchases in relation to recommendations for healthy and sustainable eating are needed to provide a stronger understanding of the potential implications of numeric versus TLL on human and planetary health, including possible unintended consequences.

CHAPTER 3: Study Objectives

3.1 Study rationale

A transition to a healthy and sustainable food system, with integration of actors and policy levers at all levels, is urgently needed to support eating patterns that positively impact human and planetary health.[33] Post-secondary institutions are small-scale food systems that have the capacity and power to support healthy and sustainable eating on campus, while also championing broader food system change.[74] Real-world evidence from food and nutrition interventions implemented in post-secondary settings may offer insight into how approaches to support healthy and sustainable eating may be scaled up in other settings.[10–12]

There is high policy interest in calorie labelling in restaurants and similar settings, including within Canada.[111,197] Prior scans of post-secondary food environments have demonstrated that labelling at the point-of-purchase could be a promising strategy to support eating patterns among students, though the evidence is inconsistent.[65,66,68,70] There is a lack of evidence directly comparing the impact of numeric versus TLL formats at the point-of-purchase in real-world settings, including a paucity of research evaluating impact on specific subpopulations. Existing studies have largely focused on calories purchased and less is known about the implications of calorie labelling on the quality of foods and beverages purchased with respect to food groups (e.g., fruits and vegetables, whole grains, plant-based proteins) and nutrients (e.g., saturated fats, sugars, sodium) emphasized for healthy and sustainable eating (**Section 2.2**).[196]

There is a unique opportunity to practice a 'de-siloed' policy approach by synthesizing insights from current interventions implemented on post-secondary campuses and by comparing the potential of numeric and traffic light calorie labelling at the point-of-purchase, to support healthy and sustainable eating patterns. Although calorie labels are not intended to convey information about sustainability, if they change what people eat, they may change the sustainability of our eating patterns. Thus, there is a need to examine the potential effects of interventions on purchases of foods and beverages emphasized with respect to both human and planetary health.

3.2 Research questions

The overall aim of this research was to investigate the potential for food and nutrition interventions to support healthy and sustainable eating among young Canadian adults in post-secondary settings. The research drew upon a scoping review and quasi-experimental trial of numeric versus interpretive calorie labelling in post-secondary cafeterias. This dissertation addressed the following research questions:

1. Are human and planetary health jointly considered in the design, implementation, and evaluation of food and nutrition interventions in post-secondary settings?
    a. Do interventions jointly consider healthy and environmental sustainability?
    b. What types of food and nutrition interventions are effective for supporting healthy and/or sustainable eating patterns in post-secondary contexts?
    c. What are current knowledge and methodological gaps in the literature?
2. What is the impact of numeric versus traffic light calorie labelling on noticing, use, and perceptions of nutrition information and food and beverage purchasing patterns among young adults in post-secondary cafeterias?
    a. What is the effect of numeric versus TLL on noticing, use, and perceptions of nutrition information?
    b. What is the influence of numeric versus TLL on calories purchased? Do the labels impact overall sales?
    c. What are the differential impacts of the labelling formats among subgroups defined by gender identity, health literacy, SES, and disordered eating risk?
3. What is the effect of numeric versus traffic light calorie labelling on the quality of foods and beverages purchased with respect to food groups and nutrients of concerns?
    a. What is the effect of numeric versus TLL on purchasing of red-, amber-, and green- labelled foods and beverages?
    b. What is the effect of numeric versus TLL on the composition of purchases with respect to fruits and vegetables, whole grains and refined grains, and plant-based proteins and red meat?
    c. What is the effect of numeric versus TLL on the composition of purchases with respect to saturated fats, added sugars, and sodium?

CHAPTER 4: General Methods

4.1 Scoping review

To address the first research question (**Chapter 5**), a scoping review was conducted to explore the state of evidence on food and nutrition interventions implemented and evaluated in post-secondary settings. Scoping reviews are an iterative approach for determining the coverage and range of literature on complex and emerging topics.[198–201] Similar to systematic reviews, scoping reviews use systematic searching and screening techniques to ensure transparency and reproducibility. The review drew upon steps outlined in Arksey and O'Malley's framework for scoping reviews[202] and reporting followed the PRISMA Extension for Scoping Reviews guidelines.[203]

For the purpose of this review, environmental sustainability was defined in the context of food and nutrition interventions to improve planetary health. We conceptualized sustainable eating patterns as an array of interconnected determinants pertaining to health and well-being; biodiversity, environment, and climate; equity and fair trade; eco-friendly, local, and seasonal foods; culture and heritage, and food and nutrient security needs.[4,34] Referring to dietary guidance, we defined sustainable eating patterns as those with adequate caloric intake, increased variety of plant-based foods (e.g., nuts/seeds, fruits and vegetables, whole grains), reduced consumption of animal foods, and low intake of highly processed foods and sugars.[19,189] Thus, interventions that considered environmental sustainability (and planetary health broadly) included a focus on: promoting sustainable eating patterns and behaviours (e.g., shopping local); mitigating impacts on greenhouse gas emissions and land and water use; or reducing food waste.

4.1.1 Search strategy

The search strategy was developed in consultation with two research librarians with expertise in searching public health and environmental sciences literature. Research databases relevant to health (MEDLINE via PubMed, CINAHL), environmental sciences (Scopus), and education (ERIC) were searched. Relevant keywords and controlled subject headings (e.g., Medical Subject Headings in MEDLINE) were identified to capture interventions that aimed to address outcomes related to healthy and environmentally sustainable eating patterns within the post-secondary context. The search was limited to January 2015 to December 2019, coinciding with the release of the SDGs[24] in 2015 and the growing emphasis on environmental sustainability within the nutrition literature.[7,19] The search strategy was piloted in MEDLINE to ensure relevant articles were retrieved, and subsequently modified to fit the search parameters of the other databases (e.g., appropriate controlled subject headings were used for each database). The final search strategy (**Appendix A**) for all databases consisted of keywords and subject headings related to core concepts relevant to the research questions, including food and nutrition, environmental sustainability, interventions, and post-secondary campuses.

4.1.2 Screening

Articles were considered eligible for inclusion if they met the following criteria: (1) the article described the implementation and evaluation of an intervention; (2) the intervention was implemented in the real-world within a post-secondary setting;[5] (3) there was a specific focus on supporting healthy and/or environmentally sustainable eating patterns; and (4) the article was published in English in peer-reviewed journals. For the context of this review, interventions were defined as an organized effort to promote healthy and/or environmentally sustainable eating patterns.[204] Studies included evaluated outcomes by measuring dietary intake or antecedent factors that influence eating patterns, such as knowledge, skills, and purchasing.

The NOURISHING framework[5] was used to inform the range of intervention types considered. Given the potential overlap between the Food Environment and Food System policy domains of the framework,[205] Food Environment interventions were characterized as those that altered the physical campus environment (e.g., labelling in dining halls) and Food System interventions were those that altered the food supply chain across multiple campus eateries (e.g., changes to waste management systems, campus gardens supplying multiple eateries).[206] Articles considering interventions focused on other aspects of the food system (e.g., food safety), food-related conditions or behaviours (e.g., disordered eating), or a combination of health behaviours (e.g., healthy eating and physical activity) were excluded.

The records were managed using RefWorks and Covidence, an online Cochrane-recommended tool for supporting reviews,[207] and screened according to the inclusion and exclusion criteria.

Three reviewers independently screened two rounds of 100 articles based on titles and abstracts, with modifications to inclusion and exclusion criteria clarified after each round. The remaining articles were independently screened by two screeners, reaching 95% agreement. Following review of all titles and abstracts, all full texts were independently reviewed by two reviewers against the inclusion and exclusion criteria, with 98% agreement. Discrepancies during screening were resolved by discussing reasons for inclusion or exclusion amongst the reviewers. Reference lists of eligible articles were also searched for relevant articles. Cohen's kappa values were not calculated to express inter-rater reliability because of a skewed distribution due to a higher number of articles excluded than included, as described by Cohen's paradox.[208,209]

4.1.3 Data charting and evidence synthesis

Data from the included studies were extracted using a data charting form (**Appendix B**) to capture location/setting, sample population and size, study objectives, details of the intervention, evaluation design and outcomes, measures, findings on effectiveness, authors' interpretations, and funding sources. Data extraction was conducted by one author and verified by a second.

Interventions were characterized according to the NOURISHING famework,[5] based on the domain that most closely aligned. Interventions were also categorized as focused on human health, environmental sustainability, or both. Since an intervention promoting healthy eating could also be considered as promoting sustainable eating (e.g., an intervention could promote intake of fruits and vegetables), the explicit framing of the intervention within the article was examined to characterize the interventions (e.g., attention to implications of eating patterns on greenhouse gas emissions, water use, or food waste). Other aspects of healthy and sustainable eating patterns, such as social and economic sustainability, were not considered.

As is common in scoping reviews, a risk of bias assessment was not performed.[202] However, limitations and potential biases highlighted by the authors of included studies were synthesized to identify gaps within the literature and inform recommendations for future research. The extracted data were qualitatively synthesized to: (1) characterize and compare food and nutrition interventions implemented on post-secondary campuses by type and their intended focus on healthy and/or sustainable eating; (2) examine the effectiveness of interventions on their intended outcomes; and (3) identify evidence gaps.

4.2 Quasi-experimental trial of calorie labelling

To examine the second and third research questions (**Chapters 6 and 7**), a pre-post quasi-experimental controlled trial was conducted at a large Canadian university from March to April 2019 to compare the impact of numeric calorie labelling versus TLL. Three residence cafeterias were randomly assigned to receive numeric calorie labelling, traffic light calorie labelling, or no labelling (control) (**Figure 2**). Both labelling formats included numeric calorie information; thus, the comparison between label conditions was with respect to the addition of the interpretive format of the TLL via the red, amber, and green indicators.

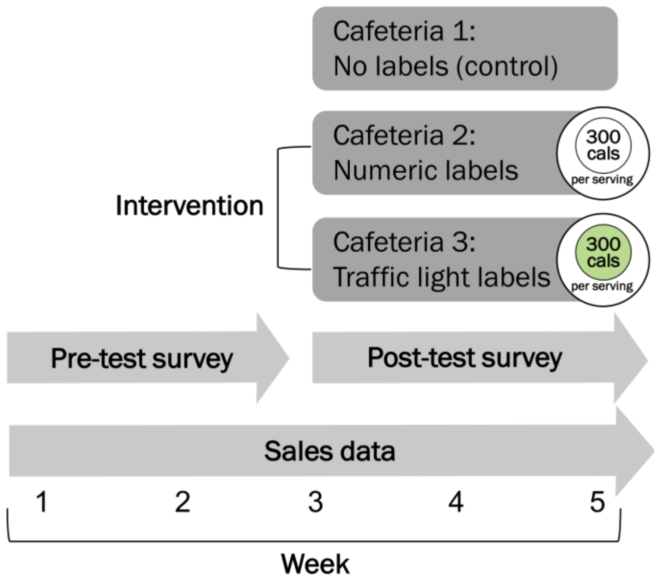


Figure 2. Study design for quasi-experimental controlled trial of calorie labelling

Exit surveys were administered during lunch and dinner periods to patrons at all three cafeterias during the 2 weeks prior to and 2 weeks following a 1-week label implementation period. Labels remained in place throughout the 2-week post-test phase. Sales data were collected for the study period and the same months during the prior year.

This study received ethics clearance from the University of Waterloo Office of Research Ethics (#31830), the University of Calgary Conjoint Health Research Ethics Board, and the Public Health Ontario Ethics Committee. The data collection protocol and analysis plan were registered with the Open Science Framework in November 2019 (available at: https://osf.io/bxfw2).

4.2.1 Sampling frame

Study site

This study was conducted at three residence cafeterias, each catering to ~1000-2000 students, at the University of Waterloo in Ontario, Canada. The three residence cafeterias were as geographically disparate as possible across campus to limit the possibility of students being exposed to the label conditions in other cafeterias. The cafeterias were centrally managed by an on-campus food service operation and provided similar offerings across sites, including hot entrée stations, salad and sandwich bars, customizable stations for meals (e.g., pasta and rice bowls, pizzas), grills (e.g., burgers, French Fries), and grab-and-go stations offering pre-packaged foods, beverages, and snacks. Hot entrées rotated on a weekly basis and were offset across cafeterias (i.e., one cafeteria was on week 1 while another is on week 2). All other stations provided similar offerings, and beverages and snacks remained the same across sites. A detailed description of comparability of offerings at each site is provided in **Appendix C**. The cafeteria randomized to receive TLL included a branded outlet offering smoothies. A preliminary scan conducted in February 2019 indicated that calorie or other nutrition labelling was not in place; however, labels were used to indicate vegetarian, vegan, and halal options.

Study population

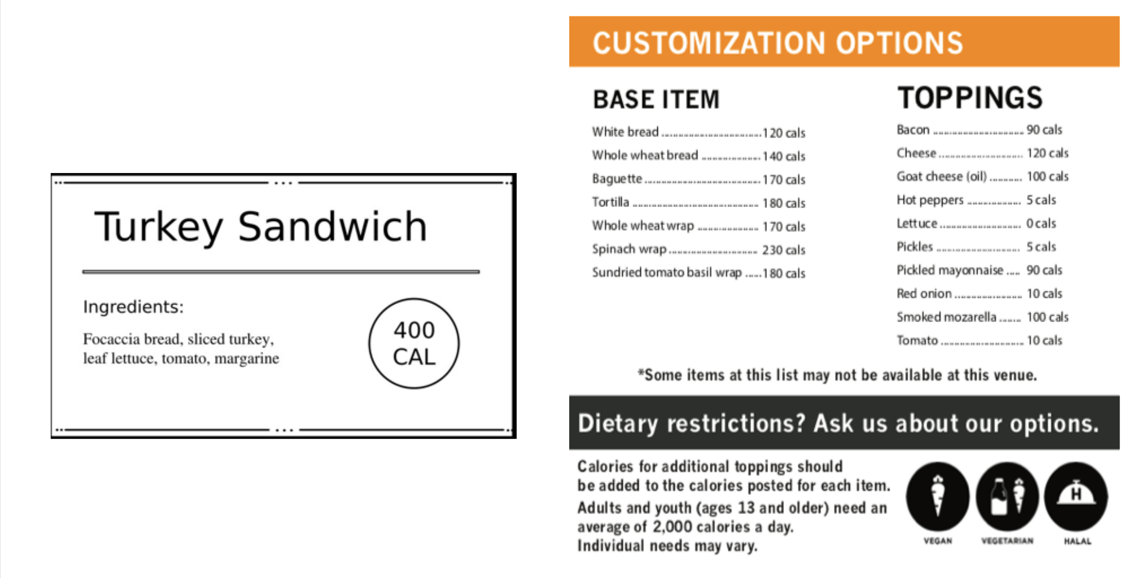
The sampling frame was limited to patrons of cafeterias in residences that primarily house first-year students to maximize similarity among students served. Eligible participants included currently enrolled students who indicated they purchased a food and/or beverage immediately prior to recruitment. Students were not eligible if they participated in cognitive testing of study materials. Staff and faculty were not eligible to maintain comparable samples between cafeterias. Since responses following prior exposure to the survey may pose a risk of response bias (e.g., knowledge of survey questions), patrons who indicated they completed the survey already that week were not eligible.

The target sample size was informed by a naturalistic study conducted by Seward et al.[156] and an experimental study by Hammond et al.[170], using data reported on noticing of labels[156] (binary outcome) and calories consumed[170] (continuous outcome). All calculations assumed a significance level of 0.05. Based on Seward et al.[156], a sample size of approximately 200 at each site was deemed to provide 80% power to detect a difference of 10% in the number of individuals who notice labels across conditions. Based on Hammond et al.[170], a sample size of 485 at each site was estimated to provide 80% power to detect a difference of 63 calories consumed between the TLL and control condition. Comparing the numeric calorie condition to the control condition, a sample size of 236 at each site provided 80% power to detect a difference of 95 calories purchased. Using these calculations as a frame of reference, a sample size of 295 students per site was hypothesized to provide 80% power to detect differences in calories purchased of ~10% and in label noticing of ~6% across labelling conditions. Therefore, the desired sample included 300 students per site during each of the pre-test and post-test phases, totaling 1,800 participants.

4.2.2 Data collection

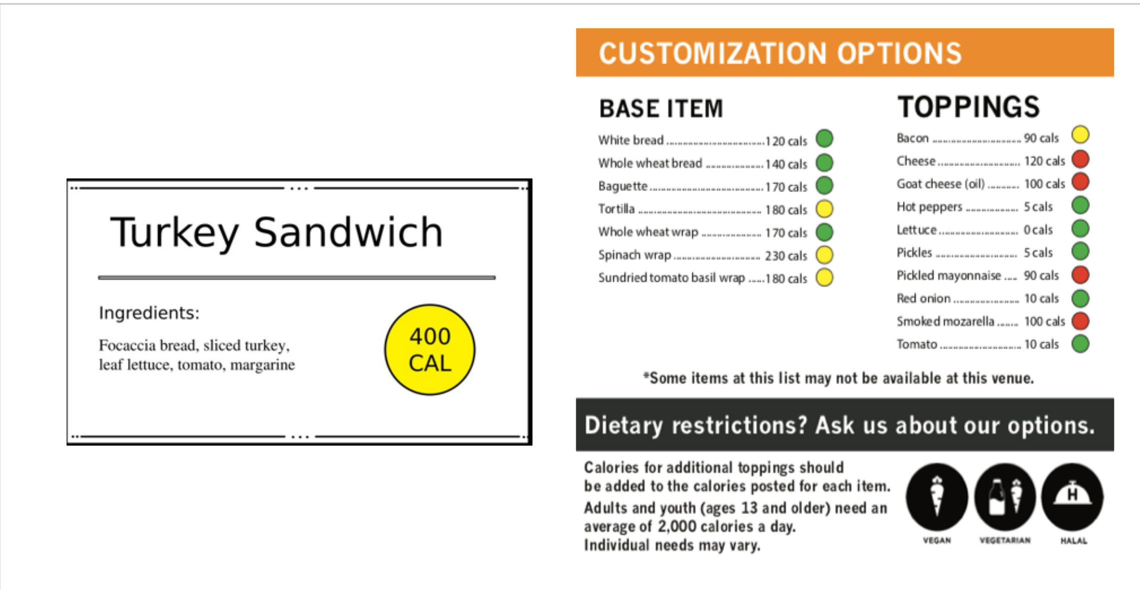
Intervention

The labels were based on designs used in prior studies[155,170,210] and developed in consultation with campus food services and their on-staff dietitian, as well as members of the research team (**Figure 3 and 4**). Both labelling formats included numeric calorie information and the comparison between formats examined any added effect of the red, amber, and green indicators. A plain-language educational poster was developed based on a webpage maintained for *Ontario's Healthy Menu Choices Act*[111] and included contextual information consistent with the mandate (i.e., **"***Adults and youth (ages 13 and older) need an average of 2,000 calories a day. However, individual needs vary.*") (**Appendix D**). The labels and educational posters were tested in cognitive interviews[211,212] with undergraduate students (n=10) and modified to improve readability and understanding (**Appendix E and F**). Participants received $5 cash for their time.



Numeric calorie labels used for entrées, beverages, and snacks (left). List of add-ons for customizable entrée stations (e.g., sandwiches, bowls, pizzas) with numeric calorie labels. Indicators for vegan, vegetarian, and halal options were provided at all sites prior to the study.

Figure 3. Numeric calorie labels for entrées and add-ons, beverages, and snacks



Traffic light calorie labels used for entrées, beverages, and snacks (left). List of add-ons for customizable entrée stations (e.g., sandwiches, bowls, pizzas) with numeric calorie labels. Indicators for vegan, vegetarian, and halal options were provided at all sites prior to the study.

Figure 4. Traffic light calorie labels for entrées and add-ons, beverages, and snacks

An online nutrition information database maintained by campus food services was used to identify the calories provided by a standard serving each item.[213] For items not listed in the database, calorie amounts and serving sizes were identified based on close matches within the Canadian Nutrient File,[214] publicly available via Health Canada. Numeric labels displayed the calories provided by a serving of the item. For the TLL, the numeric amount was accompanied by a red, amber, or green symbol, based on the United Kingdom Food Standards Agency guidelines for TLL on prepackaged foods,[210,215] which provides calorie cut-offs for each colour per serving of foods or beverages, respectively. Criteria for TLL cut-offs were based on a 2,000-calorie diet, consistent with prior TLL studies.[160,170]

Following the pre-test phase in mid-March 2019, labels were positioned and monitored in cafeterias for ~3 weeks. Labels were posted adjacent to foods and beverages or on menu boards, using the same font and size as the item name and price (**Figure 5**). Educational posters and contextual information were placed in multiple locations throughout the intervention cafeterias (e.g., on counters and screens) throughout the post-test phase.

Figure 5. Example of label placement and positioning at the intervention sites

Recruitment

Recruitment took place during lunch and dinner and booths were set up in unobtrusive locations at the cafeteria exits. Informational posters about the study were displayed in the cafeterias throughout the study period (**Appendix G**). Trained research assistants provided patrons who approached the booth with a brief overview of the study (**Appendix H**). Those who expressed interest were provided with an iPad directing them to an eligibility screener on Qualtrics software (Version March 2019, Qualtrics, Provo, UT),[216] with those who were eligible advanced to an information letter and consent form (**Appendix I**). To enable calculation of response rates, research assistants tracked the number of students approached (**Appendix H**) and the numbers who completed eligibility and consent were tracked using Qualtrics. Eligible patrons who provided consent were then linked to the exit survey (~18 minutes to complete, on average). Participants who completed the survey received a $5 honorarium in cash for their time. The same recruitment protocol was followed for both pre-test and post-test phases. Following the full data collection period, participants were emailed a thank you letter to debrief the study (**Appendix J**).

4.2.3 Data sources

Exit survey and measures

An online exit survey, consistent across phases, was programmed for tablets using Qualtrics software (Version March 2019, Qualtrics, Provo, UT).[216] The questions were adapted from prior research[135,136,155,170] and drew upon indicators used in national surveillance,[217] when applicable. The survey was tested using cognitive interviews with a sample of undergraduate students (n=10) to ensure understanding and clarity of questions. Participants received $5 honorarium for their time.

The final exit survey (**Appendix K**) queried noticing, perceptions, and use of nutrition information; information on the most recent purchase at the cafeteria; socio-demographic information (e.g., age, gender, race); information related to consumer behaviour (e.g., average number of visits per week); indicators of health literacy,[218] SES,[219] and disordered eating;[220] and unique identifiers (i.e., day of birth, mother and father’s initials, and city of birth) to enable linking repeat responses from the same participant.[221,222]

Noticing of nutrition information (Chapter 6)

Label noticing was measured through the question, "Did you notice any nutrition information posted in this residence cafeteria when you made your purchase?" (1=yes; 0=no). To minimize social desirability bias (e.g., participants responding positively to the intervention because they were aware of the focus on calorie labels), questions specified *nutrition information* rather than specifically calorie labels. Participants who reporting noticing nutrition information were queried about the location (i.e., menu board, next to an item on a label or food card, other) and type of nutrition information noticed (i.e., calories, fat, carbohydrates, sugar, sodium, overall health indicator, other).[136,137]

Use of nutrition information (Chapter 6)

Participants who reported noticing nutrition information were asked whether they used the information to help make their food and beverage purchases (1=yes; 0=no)[136,155] and the extent to which it influenced their purchase (2='a lot'; 1= 'a little'; 0=no influence).[170] Those who did not notice the labels were also categorized as not using the labels and having no influence on their purchase. Participants who indicated using the labels were also asked about their strategy for using the nutrition information (e.g., selecting items with fewer calories, identifying items perceived as healthy, other). Among those who noticed the labels, behavioural responses to nutrition information were also queried, including whether the nutrition information led them to order something different, consume less of the food ordered, choose to eat somewhere else, or eat at the location less often.

Perceptions of nutrition information (Chapter 6)

Participants who reported noticing nutrition information were asked about ease of understanding and ease of use of nutrition information using a 5-point scale, which was collapsed into binary variables (1=very easy/easy; 0=neutral/difficult/very difficult).[170] Participants were also asked if the nutrition information made them feel more or less in control of making healthy eating decisions (1=more in control; 0=less in control or neutral).

Food and beverage purchasing (Chapters 6 and 7)

Participants were queried for the details of their recent purchase at the recruitment site, supporting analyses for the three remaining outcomes discussed below. The exit survey was pre-populated with items sold in the cafeteria, including entrées, beverages, and snacks, and prompted respondents for specific details (e.g., options for add-ons, such as sauce or cheese). If an item was not captured in a pre-populated list, the participant was provided an opportunity to provide open-ended details about the item. Open-ended responses were matched to an inventory list of offerings at the cafeteria.

Prior to the study, a database of all foods and beverages offered at the cafeterias was developed to inform label and survey development using the online nutrition information database by campus food services and the Canadian Nutrient File.[214] The database included a study food code, a corresponding food code from the Canadian Nutrient File, calorie amounts per serving, the assigned TLL colour, and weight per serving in grams. Serving sizes for all items were based on a pre-determined weight of foods and beverages provided by the on-campus campus food service operation.

Change in calories purchased (Chapter 6)

Drawing upon the food and beverage purchasing data, the study database was used to estimate total calories purchased overall and for entrées, beverages, and snacks for each participant. **Appendix L** demonstrates how the reported foods and beverages were categorized by entrées, beverages, and snacks.

Change in purchasing by TLL categories (Chapter 7)

Reported foods and beverages were coded using the study database, enabling identification of whether each item purchased was labelled as green, amber, or red according to the TLL criteria. For every individual's purchase, scores of green-, amber-, and red-labelled items were calculated. Since the cafeterias offered entrées that had customizable add-ons (e.g., multiple options of bread, vegetables, and cheeses for a sandwich), a proportional weighting and scoring system was used to maintain comparability across similar items. For instance, scoring a purchase of a customizable sandwich with 10 add-ons with 10 TLL indicators (e.g., 5 green, 3 amber, and 2 red) is not comparable to scoring a purchase of a serving of lasagna with one amber indicator. To address this, weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to the total number of add-ons in the full entrée. Thus, the customizable sandwich described above received a score of 0.5 for the green category, 0.3 for the amber category, and 0.2 for the red category. The lasagna coded as amber received a score of 1 for the amber category and zero for the green and red categories. The total scores for each of the red-, amber-, and green-labelled items purchased per individual were calculated by summing scores across items.

Change in purchasing by amounts for food groups and nutrients (Chapter 7)

Changes in purchasing of food groups (fruits, vegetables, whole grains, refined grains, plant-based proteins, and red meat) and nutrients (saturated fats, added sugars, and sodium) per 1000 kcal were examined at all sites from pre-test to post-test. The food groups and nutrients selected were based on dietary guidance. For example, *Canada's Food Guide*[29] encourages consumption of fruits and vegetables, whole grains, and plant-based proteins, while limiting refined grains and red meat. These recommendations are consistent with those related to environmental sustainability, such as the *EAT-Lancet* plate.[19] Within *Canada's Healthy Eating Strategy*,[13] there is also significant attention toward reducing intake of saturated fats, added sugars, and sodium. A prior study examining the food environment of the study site found that whole fruit and whole grain offerings were less prevalent at the eateries,[68] suggesting consumption of these may be low. Nonetheless, fruit and whole grains were included for completeness relative to dietary guidance.

The 2017-2018 Food and Nutrient Database for Dietary Studies[223] (FNDDS) and 2017-2018 Food Patterns Equivalents Database[224] (FPED) were used to estimate the amounts of food groups and nutrients per 100 g of foods and beverages. The FNDDS is a U.S. database consisting of nutrient values for foods and beverages reported in national surveillance. The FPED converts the foods and beverages (per 100 g) reported in the FNDDS to 37 food pattern components identified in the *Dietary Guidelines for Americans*.[28] Although FNDDS and FPED originate in the U.S., previous studies have used the databases to examine population-level eating patterns among Canadians given the similarities in the food supply and dietary guidance.[225–227] Additionally, data collected using the Canadian version of the Automated Self-Administered 24-Hour Dietary Assessment Tool are auto-coded using the FPED since a similar Canadian database that disaggregates all foods and beverages to their component parts is not available.[228]

A linkage file that matches food codes from the Canadian Nutrient File to food codes in FNDDS/FPED was used to merge the study database with the FNDDS and FPED. As a result, all foods and beverages offered at the cafeterias were linked to information on food groups and nutrients of interest per 100 g. We used FPED to provide information on the amounts of fruits, vegetables, whole grains, refined grains, plant-based proteins (i.e., nuts and seeds, soy, legumes), red meats (i.e., beef, veal, pork, lamb, game meat), and added sugars. FNDDS provided information on saturated fats and sodium amounts. Amounts (cup, oz, tsp equivalents, grams) of each dietary component per food or beverage reported were calculated by multiplying the serving size (g) by the FPED or FNDDS amount (per 100 g). The amounts of food groups and nutrients per food or beverage were then summed at the individual level to arrive at totals per person. To enable a focus on the quality of food and beverage purchases rather than quantity, density ratios were calculated by dividing by the total number of calories purchased, drawing upon the calorie information in the study database. Density ratios were multiplied by 1000 kcal to aid interpretability.

Covariates

A standard set of covariates was identified *a priori* and included in all models. These included eating occasion (i.e., lunch or dinner), age, gender,[166] race,[135,174] frequency of visits to cafeteria in the past week,[155] health literacy,[128,136] SES,[128,174] and disordered eating risk.[167,185,186]

Age was included in the models as a continuous variable (years) and calculated by subtracting year of birth from the study year (2019). The exit survey collected information on gender identity, including options for man, woman, trans man, trans woman, non-binary, and other specified identity. Responses for trans man, trans woman, non-binary, and other specified identities were collapsed and provided in tables demonstrating sample characteristics. However, given low cell sizes, gender identity was collapsed into a binary variable (man/woman) for inclusion as a covariate in the model and non-binary responses were not included in the analyses. Drawing upon data collected for ethnicity, race was collapsed into a binary variable (white/person of colour).

Health literacy was assessed using the Newest Vital Sign,[218] which asks the participant six questions about a Nutrition Facts Table provided for a container of ice cream. Health literacy scores were calculated based on the number of correct responses to the questions and included in the models as a categorical variable (4-6=adequate literacy; 2-3=low likelihood of limited literacy; 0-1=high likelihood of limited literacy). Questions from Newest Vital Sign would typically be read by an interviewer to limit the impact of reading literacy on scores; however, it was assumed that participants would be able to comprehend the questions given that the target sample was post-secondary students.

SES was measured using subjective social status[219] (SSS), which queries participants about their perceived position within society. Participants were asked to rank themselves on a ladder from 1 to 10, where those who ranked themselves as 1 were higher up on the ladder (i.e., financially secure, higher levels of education, job security) and those ranked themselves as 10 were lower on the ladder (i.e., financially insecure, lower levels of education, less job security). Rankings for SSS were included as a continuous variable in all models from 1 to 10. Although income, education, and employment status are often used as indicators of SES,[229,230] subjective social status was selected to more accurately reflect financial complexity among students (e.g., student loans, multiple part-time jobs, reliance on family support).[219]

SCOFF,[220] a 5-item questionnaire to observe eating disorder symptomology among non-clinical populations, was used to measure disordered eating risk. Affirmation of 2 or more questions indicated high likelihood of disordered eating (0-1=unlikely demonstrating disordered eating; 2-5=likely demonstrating disordered eating).[220] The measure was not used to identify participants with clinical eating disorders.

Measures of health literacy, SES, and disordered eating risk have been demonstrated to have reasonable reliability and validity among young adults.[218–220,231,232]

Sales data

Sales data for the three cafeterias were provided by campus food services for the data collection period. Data included daily sales, number of transactions, and dollars spent per transaction for the pre-test and post-test phases. Changes in sales were examined to address potential industry concern about the effect of calorie labelling on profit and revenue.[233]

4.2.4 Analyses

Analyses were conducted using SAS® Studio (Version 9.04, SAS Institute, Cary, NC). All tests were interpreted using a significance level of 0.05. Odds ratios with 95% confidence intervals are reported, unless otherwise specified. The following subsection describes the separate analytical approaches for the second and third research questions.

Analytical approach for research question #2 (Chapter 6)

Preliminary ANOVA (continuous variables) and Pearson χ^2 tests (categorical variables) were used to describe differences across sites; correlations were not used to inform inclusion of covariates in models as these were determined *a priori*, as noted above. Descriptive statistics were calculated for the proportions who reported noticing and using nutrition information, perceptions of nutrition information, and calories purchased. The distributions of calories purchased were right skewed and therefore, medians are reported for these outcomes.

Generalized estimating equation (GEE) models were used to generate population-averaged estimates by modelling mean responses of participants at each site across test phases, accounting for repeat responses among those who participated at both pre-test and post-test. Separate GEE models assessed each of noticing of nutrition information and recall of type of nutrition information noticed, nutrition information use and behavioural responses to nutrition information, and calories purchased. Participants who did not report a meal, beverage, and snack were excluded from the analyses of calories purchased. An interaction between site and phase estimated the difference in the change in each outcome from pre-test to post-test across sites.

Descriptive statistics were used to describe differences in perceptions for the labelling formats among post-test participants. Logistic regression models were used to examine differences across sites among the post-test participants who noticed the labels.

Three-way interactions between site, phase, and covariates for gender, health literacy, disordered eating risk, and SSS were individually tested in the models to examine for subgroup differences in noticing, use, perceptions, and calories purchased.

ANOVA tests assessed differences in mean total sales, number of transactions, and sales per patron by site and phase.

Analytical approach for research question #3 (Chapter 7)

Descriptive statistics were calculated for group- and individual-level scores of green-, amber-, and red-labelled foods purchased at all sites from pre-test to post-test. Descriptive statistics were also calculated to describe the foods and beverages purchased in terms of food group and nutrient density ratios. The distributions of scores of TLL categories purchased and density ratios were right skewed and therefore, means and medians are reported for descriptive statistics.

GEE models were used to generate population-averaged estimates by modelling participants at each site across test phases, accounting for repeat data among those who participated at both pre-test and post-test. Separate GEE models were used for each outcome related to the TLL scores and density ratios. An interaction between site and phase estimated the difference in the change in each outcome from pre-test to post-test, comparing intervention sites to the control. Eating occasion, age, gender, race, frequency of visits to the cafeteria in the past week, health literacy, SSS, and disordered eating risk, were included in all models. Three-way interactions between site, phase, and covariates for health literacy, SSS, and disordered eating risk were individually tested in the models to examine subgroup differences.

CHAPTER 5: Toward a healthy and sustainable campus food environment: A scoping review of post-secondary food interventions

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5.1 Overview

Interventions are urgently needed to transform the food system and shift population eating patterns toward those consistent with human health and environmental sustainability. Post-secondary campuses offer a naturalistic setting to trial interventions to improve the health of students and provide insight into interventions that could be scaled up in other settings. However, the current state of the evidence on interventions to support healthy and environmentally sustainable eating within post-secondary settings is not well understood.

A scoping review of food- and nutrition-related interventions implemented and evaluated on post-secondary campuses was conducted to determine the extent to which they integrate considerations related to human health and/or environmental sustainability, as well as to synthesize the nature and effectiveness of interventions and to identify knowledge gaps in the literature. MEDLINE (via PubMed), CINAHL, Scopus, and ERIC were searched to identify articles describing naturalistic campus food interventions published in English from January 2015 to Dec 2019. Data were extracted from 38 peer-reviewed articles, representing 37 unique interventions, and synthesized according to policy domains within the World Cancer Research Fund’s NOURISHING framework.

Most interventions were focused on supporting human health, whereas considerations related to environmental sustainability were minimal. Interventions to support human health primarily sought to increase nutrition knowledge or to make complementary shifts in food environments, such as through nutrition labelling at point-of-purchase. Interventions to support environmental sustainability often focused on reducing food waste and few emphasized consumption patterns with lower environmental impacts. The implementation of integrated approaches considering the complexity and interconnectivity of human and planetary health are needed. Such approaches must go beyond the individual to alter the structural determinants that shape our food system and eating patterns.

Keywords: Healthy eating, environmental sustainability, interventions, nutrition policy, food environments, post-secondary settings, campus settings, young adults, students, scoping review

5.2 Introduction

Dietary risk factors are among the leading contributors to morbidity and mortality worldwide.[1] Low intake of fruits and vegetables, nuts and seeds, and whole grains, and high intake of sodium are the largest contributors to diet-related deaths.[1] At the same time, there is growing recognition of the negative implications of current eating patterns for the environment through their connection to agriculture production, contributing to large impacts on climate change, nitrogen and phosphorous pollution, and biodiversity loss.[2–4] Public health nutrition has traditionally focused on supporting eating patterns consistent with human health, for example, by ameliorating nutrient deficiencies and promoting an appropriate balance of dietary components.[5] More recently, the public health nutrition paradigm has shifted toward environmentally sustainable eating patterns as a means to improve both human health and environmental sustainability.[5] The United Nations Sustainable Development Goals (SDGs) likewise recognize the central role food and nutrition play in supporting human health and protecting the planet by prioritizing reducing hunger (SDG2) and improving health and well-being (SDG3).[6] Further, emphasizing sustainable production and consumption (SDG12)[6] will require transformation of the food system.

The Food and Agriculture Organization broadly defines sustainable eating patterns as those with low environmental impacts that contribute to the health and food and nutrition security of future generations.[7] This definition recognizes an array of interconnected determinants to support sustainable eating patterns pertaining to health and well-being; biodiversity, environment, and climate; equity and fair trade; eco-friendly, local, and seasonal foods; culture and heritage, and food and nutrient security needs.[8,9] This conceptualization was echoed in the report of the *EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems*, which emphasizes policy targets to shift population eating patterns toward those that align with planetary health as a means of achieving health for all.[3] Dietary guidance on healthy and environmentally sustainable eating patterns recommends appropriate caloric intake, increased variety of plant-based foods (e.g., nuts and seeds, fruits and vegetables, whole grains), reduced consumption of animal foods, and intake of small amounts of highly processed foods and sugars.[3,10] Evidence from modelling studies suggests co-benefits of achieving such eating patterns, including reducing rates of morbidity and mortality from chronic disease and stemming climate change and its negative implications for human health.[11]

Currently, there is an unprecedented level of attention globally toward interventions to support eating patterns consistent with human and, perhaps to a lesser extent, planetary health.[3,12,13] Public health nutrition interventions aim to promote and improve population and planetary health by improving food environments and food systems in ways that can support healthy and sustainable eating patterns.[13] Policymakers are interested in understanding the effectiveness of these interventions, evaluated in a variety of settings,[14] to inform the allocation of resources to policies and programs. To encourage policy action, the World Cancer Research Fund developed the NOURISHING framework to highlight policy actions needed to promote healthy eating.[13] NOURISHING consists of 10 key policy areas within the three domains of (1) modifications to the food environment ('NOURIS'), such as economic measures to address food affordability, nutrition labelling standards and regulations; (2) harnessing the food system and supply chain ('H'), such as food waste management interventions and supply-chain incentives for production; and (3) behaviour change communication ('ING'), such as media awareness campaigns and nutrition education in work and school settings.[13] Although environmental sustainability was not explicitly addressed when NOURISHING was developed in 2013, the framework highlights interventions that may simultaneously support human and planetary health. For example, supply chain incentives may support food production systems that contribute to improved dietary quality and lower greenhouse gas emissions.[15] Similarly, food-based dietary guidelines can provide guidance on shifting to healthy eating patterns that reduce greenhouse gas emissions and water and land use.[16,17] NOURISHING also aligns with the SDGs by supporting health and well-being (SDG3), emphasizing education (SDG4), and contributing to sustainable consumption and production patterns (SDG12). Overall, NOURISHING and other approaches call for a suite of integrated policy interventions to transform the food system and support a shift in eating patterns to optimize human and planetary health.[18]

Public and private institutions hold financial power and capacity to support food system transformation.[19,20] In particular, post-secondary institutions offer unique consumer food environments with a variety of campus eateries and offerings, multiple suppliers and other stakeholders, and often, contracts with multinational corporations.[21–23] Such institutions are well-positioned to implement and evaluate a range of interventions to support healthy and environmentally sustainable eating patterns within naturalistic settings[24–26] and to provide insights into interventions that can potentially be scaled up and adapted to other settings. For example, quasi-experimental studies within post-secondary settings allow for real-world evaluations of interventions in which food and beverage selection may be impacted by an array of external factors, with application to a range of other settings. Evidence suggests increasing commitment and action among post-secondary institutions to improve the health of their campus communities and reduce their impacts on the planet through food and nutrition.[27–31] Recognizing that campuses represent a microcosm of food environments, they can provide a testing ground for 'whole-of-systems' approaches to address the complex interconnections among issues related to health and environmental sustainability.[32–34] Simultaneously, such approaches can benefit campus communities, particularly students, recognizing that young adulthood is a critical period for establishing eating patterns that may track into later life.[35–37]

Prior reviews have synthesized literature on interventions intended to promote healthy eating within post-secondary settings.[38,39] Such reviews have evaluated changes to the availability of nutrition information (e.g., point-of-purchase nutrition labelling) and the affordability and accessibility of particular foods (e.g., fiscal measures) as potentially effective strategies to support healthy eating.[38,39] Reviews focused on food sustainability interventions within post-secondary settings have also been conducted, but have largely focused on sustainability education.[40–44] A recent review of governance documents synthesized approaches to supporting sustainable food systems across universities in Australia and New Zealand, demonstrating the capacity of campuses to leverage a 'whole-of-systems' approach by implementing strategies beyond education to promote sustainability.[45] To date, syntheses of the existing evidence have considered approaches to promote health and sustainability in isolation, but have not considered to what extent a range of interventions are designed to jointly support eating patterns consistent with human health and environmental sustainability.

To address this gap, we conducted a scoping review to explore the state of evidence on food- and nutrition- related interventions implemented and evaluated in post-secondary settings. Our objectives were to: (1) determine the extent to which each of health and environmental sustainability were considered, including whether they were addressed in tandem within the same interventions; (2) synthesize the nature and effectiveness of these interventions; and (3) identify gaps in the peer-reviewed evidence on interventions to support healthy and sustainable eating patterns on post-secondary campuses.

5.3 Methods

Scoping reviews are an iterative approach for determining the coverage and range of literature on a topic[46–48] and are an increasingly common approach to characterize evidence on emerging topics.[49] A scoping review was appropriate to synthesize available evidence on campus interventions that aim to support healthy and environmentally sustainable eating patterns, as well as to identify evidence gaps. Based on prior reviews,[38,39] we anticipated the included interventions and corresponding outcomes would vary and therefore, a systematic review or meta-analysis focused on specific research outcomes was not appropriate.[49]

Similar to systematic reviews, scoping reviews use systematic searching and screening techniques for transparency and reproducibility. This review draws upon steps outlined in Arksey and O'Malley's framework for scoping reviews.[50] Reporting followed the PRISMA Extension for Scoping Reviews guidelines,[51] which identifies essential items to be reported.

5.3.1 Evidence acquisition

The search strategy was developed in consultation with two research librarians with expertise in searching public health and environmental sciences literature. Research databases relevant to health (MEDLINE via PubMed, CINAHL), environmental sciences (Scopus), and education (ERIC) were searched. Relevant keywords and controlled subject headings (e.g., Medical Subject Headings in MEDLINE) were identified to capture interventions that aimed to address outcomes related to healthy and environmentally sustainable eating patterns within the post-secondary context. The final search strategy (**Appendix A**) for all databases consisted of keywords and subject headings related to core concepts relevant to the research questions, including: food and nutrition; environmental sustainability; interventions; and post-secondary campuses. The search strategy was piloted in MEDLINE to ensure relevant articles were retrieved, and subsequently modified to fit the search parameters of the other databases (e.g., appropriate controlled subject headings were used for each database). The search was limited to

January 2015 to December 2019. This time frame was defined based on a preliminary search that suggested interventions with a focus on environmental sustainability have become more common since 2015, which coincides with the release of the SDGs[6] and the growing emphasis on environmental sustainability within the nutrition literature.[3,5]

Articles published in English in peer-reviewed journals were considered eligible for inclusion if they met the following criteria: (1) the article included a description of the implementation and evaluation of an intervention, defined as an organized effort to promote healthy and/or environmentally sustainable eating patterns;[52] (2) the intervention was implemented in a naturalistic environment within a post-secondary setting;[13] and (3) there was a specific focus on supporting healthy and/or environmentally sustainable eating patterns. Studies included may have evaluated outcomes by measuring dietary intake or antecedent factors that influence eating patterns, such as such as knowledge, skills, and purchasing. The NOURISHING framework was used to inform the universe of interventions considered as well as the synthesis, though the NOURISHING domains are broad, as described above, allowing consideration of a range of intervention types. Given the potential overlap between the Food Environment and Food System policy domains,[53] Food Environment interventions were characterized as those aiming to alter the physical campus environment (e.g., labelling in dining halls) and Food System interventions were those that aimed to alter the food supply chain across multiple campus eateries (e.g., changes to waste management systems, campus gardens supplying multiple eateries, fair trade initiatives).[54] Articles considering interventions focused on other aspects of the food system (e.g., food safety), food-related conditions or behaviours (e.g., disordered eating), or a combination of health behaviours (e.g., healthy eating and physical activity) were excluded.

The records identified through the searches were managed using RefWorks and Covidence, an online Cochrane-recommended tool for supporting reviews,[55] and screened according to the inclusion and exclusion criteria. After removing duplicates, three study authors (KML, YC, and TEW) screened 100 articles based on titles and abstracts, reaching 81% (KML and YC) and 92% agreement (KML and TEW) on inclusion and exclusion decisions. Discrepancies were resolved and the inclusion and exclusion criteria clarified. Upon screening a second set of 100 articles based on title and abstract, 93% and 92% agreement was reached. The remaining articles were independently screened by YC and TEW and 95% agreement was reached. Discrepancies were resolved through an independent screen by KML or discussion with the study team.

Following review of all titles and abstracts, all full texts were reviewed independently by YC and TEW against the inclusion and exclusion criteria, with 98% agreement. Discrepancies during both stages of screening were resolved by discussing conflicts amongst the reviewers. Reference lists of eligible articles were also searched for relevant articles. Cohen's kappa values were not calculated to express inter-rater reliability because of a skewed distribution from a higher number of articles excluded than included, as described by Cohen's paradox.[56,57]

5.3.2 Evidence synthesis

A data extraction spreadsheet (**Appendix B**) was developed to capture the location and setting, sample population and size, study objectives, details of the intervention(s), evaluation design and outcomes, measures, key findings regarding effectiveness, authors' interpretations, and funding sources. Data extraction was conducted by one study author (KML), with verification by one additional author (YC or TEW). Interventions were characterized according to the NOURISHING Framework, based on the domain that most closely aligned.[13] Interventions were also categorized as focused on human health, environmental sustainability, or both. Although an intervention promoting healthy eating could potentially also be considered to promote environmentally sustainable eating patterns, we examined the explicit framing of the intervention within the article and whether there was attention to the implications of eating patterns for greenhouse gas emissions, water use, food waste, or other aspects related specifically to environmental sustainability. Other aspects of healthy and sustainable eating patterns, such as social and economic sustainability, were not considered. As is common in scoping reviews, a risk of bias assessment was not performed.[50] However, we drew upon limitations and potential biases highlighted by the authors of included studies to identify potential gaps within the literature and recommendations for future research.

Extracted data were qualitatively synthesized to: (1) characterize the nature of literature on interventions; (2) compare and contrast the effectiveness of interventions implemented on post-secondary campuses and their impacts; (3) interpret implications for supporting healthy and environmentally sustainable eating patterns; (4) and identify evidence gaps.

5.4 Results

The results of the search and study selection process are presented in **Figure 6**. The initial search yielded 4,276 articles, 218 of which were identified as potentially relevant after screening titles and abstracts. The most frequent reason for exclusion was because the intervention or outcomes were not relevant to the research question. After full-text screening, 37 records met the inclusion criteria and 1 additional record was identified based on the reference lists of the included records. In total, 38 records were included in the review, representing 37 unique intervention studies: 29 interventions were focused on human health, 8 focused on environmental sustainability, and no interventions mutually considered both.

A consistent number of articles were published by year between 2015 and 2017 (~6-7 articles each year), with an increase in 2018 (n=12) and a decrease in studies by December 2019 (n=6), potentially indicating growing but varied interest in evaluations of food interventions in post-secondary settings. Of the 37 unique interventions, 21 were implemented in the United States, 5 were carried out in Canada, 6 in Europe (3 in England, 1 in Belgium, 1 in Germany, and 1 in Portugal), 3 in South America (Peru, Colombia, and Brazil), and 2 in Australia. In terms of post-secondary context, 22 interventions were implemented in foodservice settings (e.g., cafeterias, dining halls, restaurants), 1 was implemented at an on-campus grocery store, 4 interventions were related to vending machines, 7 were campus-wide (e.g., nutrition education program), and 4 were online. Twelve articles were supported by funds from the respective university or college. One article noted funding from the American Dairy Association-Mideast and aimed to increase milk consumption from vending machines using choice architecture.[58] For 9 articles, there was no funding source whereas for another 7, funding disclosures were not included. The funding source for one article was unclear (i.e., authors indicated they did not receive financial support; however, the methods indicate funding was used to support the intervention).

Table 1 demonstrates the 37 interventions categorized by the NOURISHING Framework policy domains and their focus on human health or environmental sustainability. Although interventions primarily focused on supporting human health, there was an increase in the number of interventions targeting environmental sustainability starting in 2017. Most interventions utilized strategies in the Food Environment (n=15) or Behaviour Change Communication domains (n=9).

Only one intervention explicitly targeted the Food System domain by evaluating the impact of a food waste composting system. Approximately one-third of interventions (n=12) employed strategies from multiple NOURISHING domains. The following sections report on the study designs and observed effectiveness of interventions.

5.4.1 Interventions considering human health

Of the 37 interventions considered, 29 were aimed at supporting human health (**Table 2**). Of these, 14 fit into the Food Environment domain and 7 fit into the Behaviour Change Communication domain, whereas there were no interventions in the Food System domain. The remaining 8 interventions utilized strategies from more than one NOURISHING domain. Most evaluations of the interventions considered outcomes related to changes in consumption patterns or improvements in knowledge and understanding of nutrition. The duration of the study periods was generally relatively limited, ranging from 1 week to 5 months, as summarized in Table 2. Three interventions used sales data representing a period of approximately 2 years. While sales data do not shed light on individual changes in intake, the data are indicative of purchasing behaviours over a long period of time and can help identify potential trade-offs, such as positive health and sustainability outcomes versus changes in revenue.

Food Environment domain

Fourteen interventions aimed to manipulate the food environment by implementing nutrition labelling (n=6 interventions described in 7 articles),[59–65] setting standards for healthy food offerings (n=4),[58,66–68] using economic tools to address food affordability (n=1),[69] or utilizing a combination of food environment strategies (e.g., nutrition labelling and fiscal measures) (n=3).[70–72]

Across nutrition labelling interventions (n=6), outcomes were generally evaluated using surveys to determine label noticing, use, and preferences among consumers and sales data to measure changes in the quality of purchases (e.g., change in mean calories purchased). Overall, nutrition labelling was found to increase consumption of healthy foods (e.g., fruits and vegetables), while also showing decreases in the energy and fat content of foods ordered. Three interventions displayed nutrition information numerically in dining halls.[59–62] Christoph et al.[59] found that a greater proportion of respondents who used the labels selected fruits, vegetables, and beans, and fewer selected potatoes and French fries compared to non-label users. Similarly, Cioffi et al.[61] found that nutrition labels led to significant decreases in energy and fat content of purchases. Hammond et al.[62] observed that numeric calorie labels led to a significant decrease in calories ordered and consumed. Labels that use symbols to present nutrition information at a glance were also evaluated within the literature. Policastro et al.[63] implemented a sandwich order form that indicated healthy ingredients using a star symbol and observed an increase in selection of healthy ingredients and decreased selection of less healthy ingredients. Following a mandatory nation-wide implementation of the Health Star Rating policy on post-secondary campuses in Australia, Shi et al.[64] observed an increase in healthy snacks and beverages offered in vending machines compared to data from 3 years prior to implementation. A labelling campaign that provided point-of-purchase health messages by Sogari et al.[65] found that messages about vitamins and fiber led to a higher proportion of individuals choosing whole grain pasta compared to the condition with no messages.

Interventions that set standards for food offerings used choice architecture strategies, such as relocating healthy options to high-traffic areas (n=3) and changing portion sizes (n=1). Such interventions were evaluated by monitoring changes in sales of foods and beverages (e.g., daily total quantity sold) or using survey data to determine consumer preferences. Evaluations of these interventions yielded mixed evidence on effectiveness.[58,66,68] Walmsley et al.[68] relocated fruits and vegetables to the front of the on-campus grocery store and observed an initial significant increase in the percentage of total sales for fruits and vegetables immediately but the effect was not sustained over a 5-year period. Bevet et al.[66] observed an increase in purchases of vegetable-heavy entrees when they were placed at the start of the self-serve line. Rose et al.[58] observed no changes in milk and calcium intake following implementation of vending machines with milk cartons in high traffic areas of a residence building. Vermote et al.[67] reduced portion sizes for French fries, finding a reduction in consumption, with no differences in reported satiety and caloric intake, despite mixed consumer perceptions about the intervention.

One intervention used economic tools to address food affordability. Deliens et al.[69] increased the price of French fries and reduced the price of fruit and observed a reduction in sales of French fries and an increase in fruit sales during each of the 1-week intervention periods.

Several interventions utilized a combination of strategies within the Food Environment domain. Interventions that used financial incentives[70,71] showed an increase in healthy foods sold. Biden et al.[70] implemented an interpretive label using a checkmark to indicate healthy options and a reward card program to incentivize fruit and milk purchases. The authors found that healthy items were sold more often, were made less expensive by the food operating service on campus and appeared more frequently on menus than less healthy items. Cajrdenas et al.[71] observed a significant increase in fruit sales when phasing in a variety of strategies, including repositioning of fruits to cash registers, implementing posters indicating the health benefits of fruit and vegetable consumption, and lowering the price of fruit by 33%. Seward et al.[72] implemented traffic light labelling to indicate healthy options into a residence cafeteria and repositioned healthy foods and beverages to be more accessible. Interviews and surveys revealed that participants wanted nutrition labels and thought the intervention was helpful; however, there were no significant changes in proportions of red, amber, and green labelled items sold.

Behaviour Change Communication domain

Seven interventions utilized strategies within the Behaviour Change Communication policy domain to support healthy eating patterns. Four were primarily evaluated for impact on dietary intake using dietary assessments, including dietary recalls[73–75] and food frequency questionnaires.[76] In one study, the impact of the intervention was evaluated based on blood samples to assess changes in cholesterol and glucose.[77] Two articles measured changes to behaviour using questionnaires and scoring indices developed for evaluating the intervention.[78,79]

Three interventions were provided online, using strategies such as online educational modules, messaging with personalized feedback, and self-monitoring strategies.[75,76,78] Aboul-Enein et al.[78] implemented an online nutrition course on the Mediterranean dietary pattern and found that participants viewed the dietary pattern more positively and demonstrated an increase in knowledge of it afterward. O'Brien et al.[75] implemented an online nutrition course and messaging intervention, and observed higher vegetable consumption and no difference in fruit consumption among participants when compared to those who received no intervention and those who only received the nutrition course. In an evaluation of a text-messaging and self-monitoring intervention implemented by Rodgers et al.[76], there was an increase in fruit and vegetable consumption observed among those in a higher body mass index category. The intervention did not significantly change vegetable consumption and decreased fruit consumption among those in a lower body mass index category.

The remaining four Behaviour Change Communication interventions were in-person courses with a focus on improving self-efficacy and understanding of nutrition knowledge.[73,74,77,79] All utilized survey measures to evaluate the impact of the interventions on attitudes toward healthy eating behaviours (e.g., self-efficacy to cook with fruits or vegetables) or knowledge (e.g., understanding impact on chronic disease risk). Bernardo et al.[79] implemented a cooking class and observed an increase in cooking confidence and self-reported knowledge of cooking terms following the intervention, as well as an increase in the availability and accessibility of fruits and vegetables. These effects were also demonstrated at a 6-month follow-up. Schroeter et al.[73] implemented an educational session on the *United States Dietary Guidelines* MyPlate, with one intervention group receiving education and a financial incentive, a second intervention group receiving only education, and a control group with no intervention. Dietary quality scores, measured using the U.S. Healthy Eating Index, increased by 15% among those in the intervention groups whereas scores in the control group increased by 8%. An intervention by Valdez et al.[77] that aimed to improve knowledge of a whole foods plant-based diet found participants improved their understanding of the impact of nutrition on chronic health conditions. Similarly, Tallant et al.[74] observed a significant increase in label use following an intervention on food label reading. Participants also indicated choosing healthier food options more frequently following the intervention.

Combination of domains

Eight interventions incorporated both the Food Environment and Behaviour Change Communication domains. Sales data and survey measures were used across interventions to evaluate the impacts on food and beverage selections.

Five interventions used point-of-purchase nutrition labelling, with awareness campaigns to teach consumers how to use the labels.[80–84] Across the 5 interventions, findings on the impact of nutrition labels and education were mixed. Vermote et al.[84] found a significant increase in fruit purchases and the effect was sustained in a campus restaurant. Scourboutakos et al.[83] observed an increase in fruit purchases, as well as a decrease in the proportion of students purchasing sugar sweetened beverages following calorie labelling. Hua et al.[85] randomly assigned a range of strategies to different vending machines across campus, including improving the availability and prices of healthy options and promotional signage to signal the changes. The combination of improving availability of healthy products and implementing promotional signs led to increases in revenue for healthier snacks whereas price reductions alone did not change purchasing. Viana et al.[86] also focused on vending machines and combined nutrition labelling and choice architecture strategies with an information campaign. The authors observed increased profits from healthier items with no compromise in revenue when compared to the previous year. In contrast, Dingman et al.[80] observed no change in purchasing after implementing Nutrition Facts panels, interpretive labels to highlight healthy options, and promotional signage in vending machines in residence dining halls. Mistura et al.[87] increased the availability of vegetable options and displayed promotional signage to indicate the added options, observing no change in the mean number of vegetable servings purchased when compared to the 2-week baseline period.

5.4.2 Interventions considering environmental sustainability

Eight interventions focused on supporting environmentally sustainable eating patterns (**Table 3**). One intervention fit into the Food Environment domain, 1 aligned with the Food System domain, 2 fit into the Behaviour Change Communication domain, and 4 used strategies from a combination of NOURISHING domains. A variety of outcomes were measured across domains, including food waste, consumer perceptions of the intervention, and changes in eating patterns. Intervention periods were typically short-term, ranging from 1 to 6 weeks in duration.

Food Environment domain

In an intervention by Rajbhandari-Thapa et al.[88], trays were removed from a dining hall to encourage consumers to minimize plate waste by reducing portion sizes. The authors observed that students in the intervention dining hall self-selected fewer servings of lunch entrée items and drinks compared to the control. Further, in cafeterias without the trays, food waste appeared to be reduced, based on less leftovers.

Food System domain

Mu et al.[89] implemented a composting system, aligning with the Food System domain by supporting the food supply chain, to collect food and other organic waste across a campus. Using life cycle assessments to measure the environmental impact, the food waste composting system performed well for several environmental indicators (e.g., lower greenhouse gas emissions, smog formation, fossil fuel use, eutrophication) when compared to a landfill waste system.

Behaviour Change Communication domain

An intervention by Pinto et al.[90] incorporated an education awareness campaign aimed at reducing food waste. Compared to the pre-test period, a reduction in plate waste of ~15% was observed. The awareness campaign was initially well-received, but participants' interest declined as the intervention continued. Further, the authors observed initial collaboration to reduce food waste by staff but collaboration declined during busy mealtime hours.

An online intervention by Monroe et al.[91] aimed to educate participants about 'green eating' behaviours, such as eating local, reducing waste, and reducing consumption of red meats. Using a scoring index to evaluate intention to engage in environmentally sustainable eating behaviours (e.g., shopping local), the authors found an improvement in scores (indicative of more sustainable behaviours) from baseline in the intervention group when compared to the control.

Food Environment domain

One intervention by Duram et al.[92] used strategies aligning with the Food Environment and Food System domains by implementing a campus garden as a means to support food service procurement and ingredient use. The authors documented the experience of implementing a student-led campus garden over three years and highlighted the potential for student initiatives to engage in the food system and the local food movement.

Three interventions used strategies from the Food Environment and Behaviour Change Communication domains and showed mixed results. Ahmed et al.[93] implemented changes to food service standards (e.g., reduced portion sizes and providing smaller serving tools) and a messaging campaign led by students to raise awareness about food waste. A 17% reduction in total food waste was observed; however, this reduction was not statistically significant. Students reported the intervention made them think more about food waste and supported campus-wide efforts to address food waste through composting. Lorenz-Walther et al.[94] reduced portion sizes of meat entrees to minimize food waste over several data collection phases, with an educational campaign on food waste implemented during the final 6-week period. The authors observed a small, but significant, decrease in food consumption and waste following the intervention. Further, those who indicated the informational campaign influenced their decisions to eat all the food on their plate had less leftovers than those who indicated the campaign did not influence their decisions. Finally, Godfrey et al.[95] categorized and labelled foods in a dining hall according to small, medium, and large water footprint. Data from interviews demonstrated students connected environmentally sustainable foods with health benefits; however, students often made trade-offs between choosing sustainable foods and convenience. Consumption patterns did not change significantly as a result of the intervention.

5.5 Discussion

Post-secondary campuses are uniquely positioned to demonstrate leadership by committing to actions that support health and environmental sustainability and offering real-world experimental settings in which to evaluate interventions to improve population and planetary health. This review examined 37 food interventions, described in 38 articles. A majority of the interventions focused on supporting human health, whereas fewer were focused on environmental sustainability, and no interventions explicitly addressed both. This is perhaps not surprising given the relatively novel focus on supporting eating patterns that are healthy and environmentally sustainable,[3,5,16] although the implications of the food system and our eating patterns on the planet have long been recognized.[96] More recently, the SDGs have helped to focus attention on the importance of integrated thinking regarding human health and environmental sustainability. The findings of this scoping review indicate there is substantial progress to be made in terms of addressing calls for integrated interventions to protect human and planetary health.[3,97–99]

Among interventions solely focused on supporting human health, the intervention types were concentrated in the Food Environment and Behaviour Change Communication domains of the NOURISHING framework, with none aligning with the Food System domain. Similar to a prior review of post-secondary food interventions focused on healthy eating,[100] a majority of food environment interventions consisted of nutrition labelling at the point-of-purchase, typically using interpretive symbols (e.g., checkmark, star rating system) to indicate healthier options. Consistent with existing reviews on point-of-purchase nutrition labelling, we found mixed evidence on the effectiveness of labels in supporting healthy eating patterns.[101–107] Interventions utilizing choice architecture strategies also demonstrated mixed effectiveness when implemented alone; however, some interventions demonstrated the potential of choice architecture strategies when paired with other strategies such as nutrition labelling.[71,86] Interventions using economic tools, such as price changes or reward programs, demonstrated significant increases in purchases of targeted foods and beverages (e.g., fruit, milk) and decreases in purchases of less healthy food (e.g., French fries).[69–71] A small number of evaluations of such interventions were identified, though a large body of literature supports the salience of pricing to food purchasing decisions.[108–111] Findings from the included Behaviour Change Communication interventions demonstrated effectiveness in improving knowledge; however, changes to behaviour were minimal, aligning with suggestions for multiple intervention strategies that include modifications to the food environment rather than education alone.[112] The fact that some interventions incorporated a combination of strategies is promising given evidence suggesting that using multiple interventions increases the potential to support healthy eating patterns.[112] However, our findings align with prior reviews indicating room for growth in terms of 'whole-of-systems' approaches.[45]

Interventions related to environmental sustainability were often implemented and evaluated with the intention of reducing food waste whereas a focus on altering dietary intake, such as increasing plant-based proteins and reducing red meat, was minimal. This finding echoes a recent review by Grech et al.[45], suggesting that environmental sustainability strategies primarily prioritized sustainable waste management and prevention. Food waste interventions used strategies aligning with the Food Environment and Behaviour Change Communication domains, such as reducing portion sizes of meals and awareness campaigns to minimize plate waste. The emphasis on food waste is unsurprising given the growing body of literature demonstrating that consumers perceive minimizing food waste and packaging as having the greatest impact on reducing the environmental footprint of dietary patterns,[113–115] despite evidence that interventions targeting the production phase show the greatest potential to reduce the overall environmental impact of food service operations.[116] Most interventions focused on food waste used labelling or educational campaigns and although survey responses to the interventions indicated increases in awareness, there was little to no long-term reduction in food waste.[90,93–95] Although the literature on food waste interventions is emerging, interventions that incorporated Food Environment strategies (e.g., reducing portion sizes) demonstrated potential to reduce food waste.[93,94] This finding aligns with literature focused on human health that suggests interventions that modify food environments are needed to change behaviour.[112]

This review did not find any interventions that jointly considered human and planetary health, demonstrating that nutrition and environmental sustainability are being addressed in isolation. Notably, interventions utilizing strategies from the Food Environment (e.g., nudges) and Behaviour Change Communication strategies (e.g., education), which were the predominant intervention types included, are likely insufficient on their own to support a transition toward healthy and sustainable eating patterns.[117] Strategies that utilize a systems lens,[118,119] ideally targeting multiple domains in a joined-up manner, are needed for the joint promotion of health and environmental sustainability. Several authors drew parallels between healthy and environmentally sustainable eating patterns when interpreting their findings.[67,88,89,91–94] For example, in an article describing a food waste reduction intervention, Ahmed et al.[93] highlighted the detrimental consequences of food waste on water and land usage, as well as the potential nutrient loss from wasted food, with implications for human nutrition. Similarly, Vermote et al.[67] focused on reducing portion sizes from a health perspective, but noted the potential for reducing greenhouse gas emissions by minimizing waste. These interpretations suggest growing interest in understanding the potential co-benefits and trade-offs of interventions for health and environmental sustainability. Relatedly, the need for research that measures compensatory food behaviours was identified.[63,67,69,84,88,94] For example, several articles describing interventions that aimed to reduce food waste speculated whether consumers may have responded to the intervention by consuming their entire portion (i.e., increasing caloric intake) rather than reducing their self-served portion sizes.[88,94]

Most interventions were evaluated using a quasi-experimental design and collected pre-test and post-test data with no comparison to a control group. There is a need for trials with control groups to address confounders, allowing for stronger inferences about an intervention's effectiveness.[120,121] Additionally, most interventions were of limited duration and had short follow-up periods, echoing prior reviews demonstrating a paucity of evidence on the long-term impacts of interventions.[38,39] Limitations were also noted in the extent of outcomes studied and the strategies used to measure them. Many evaluations were based on self-reported consumer perceptions of the interventions and aggregate sales data (e.g., change in sales of fruits). Appropriately evaluating interventions to support healthy and environmentally sustainable eating patterns will require expanded data collection tools and analytic methods that can measure implications for both. There is a growing body of evidence that uses a combination of diet quality indices[122,123] and data on the environmental sustainability of foods;[10,124–126] for example, drawing upon life cycle assessment.[10,126] Life cycle assessment incorporates consideration of the full food supply chain by addressing whether an intervention that creates positive health and environmental outcomes at the food consumption stage may have negative health and environmental impacts at other parts of the supply chain. Work to consider how interventions impact the healthfulness and sustainability of the food system and eating patterns, as well as trade-offs between human and planetary health, is made complex by the multidimensionality of healthy and environmentally sustainable eating. Further work is needed to delineate which aspects are most relevant to measure and how best to measure them.[127] Systematic approaches to evaluation could contribute to a more comparable body of literature; for example, using tools from implementation science to evaluate the impact of interventions on similar outcomes in a variety of settings.[128] Further, only one article[92] described a process evaluation of an intervention. Process evaluations provide insight into the implementation of interventions[129,130] and are valuable for understanding whether the intervention was implemented as intended and how it interacted with contextual factors, such as student engagement and other interventions in place. Given the variation in interventions included in this review and the call for multi-strategy approaches, process evaluations can provide campus stakeholders with an understanding of how to design and implement interventions that are best tailored to their context.

Several articles demonstrated the value of students and food service operators being involved in the implementation and evaluation of interventions;[90,92,93] speaking to the need for collaborative partnerships among students, faculty, staff and campus stakeholders. Of note, no studies provided information on the structure of their campus food service operations (e.g., food delivered by food service chains versus self-operated); such information would be valuable for further understanding influences on the types and impacts of interventions conducted and evaluated in post-secondary settings.

This review was limited to peer-reviewed literature and excluded grey literature, likely missing recent efforts on campuses that have not yet been published, as well as those potentially undertaken by campus stakeholders such as food services without the involvement of academic researchers. University food service operations are increasingly committing to initiatives such as the Association for the Advancement of Sustainability in Higher Education and Menus of Change,[131,132] potentially indicative of an increasing level of activity related to actions promoting health and sustainability in campus settings. Associated internal reports may include information not considered in this review about how campuses are attempting to improve human health and environmental sustainability. Given the lack of peer-reviewed literature identified on interventions that jointly addressed health and sustainability, examining the grey literature is an important next step. Additionally, future systematic reviews could focus on the impacts of specific intervention types (e.g., economic tools) by limiting inclusion to study designs that support inferences about causality (e.g., experimental studies with pre-test and post-test periods and control groups). However, systems-informed approaches that consider interactions among interventions are also needed.

The findings of this review may be affected by publication bias, with articles that show null effects not appearing in the published literature. As well, the potential for author bias when interpreting the literature is innate to scoping reviews. However, we aimed to maintain objectivity and transparency in our synthesis and reporting by using a consistent data extraction strategy for each article and conducting independent validation of the extraction by a second reviewer.[50]

5.6 Conclusions

Existing peer-reviewed evidence suggests interventions to support both healthy and environmentally sustainable eating patterns within the context of postsecondary contexts are currently limited and there is a greater emphasis on human health versus environmental sustainability. Interventions that aim to modify cues within the food environment either in isolation or in combination with other strategies demonstrate the greatest potential in effectively supporting human health and environmental sustainability. Specifically, interventions utilizing economic tools, such as price adjustments, show potential in improving dietary intake but are understudied within the literature. Further, interventions focused environmental sustainability primarily focused on food waste, suggesting an opportunity to integrate interventions from other domains within the NOURISHING framework in 'whole-of-system' approaches. Clear operational definitions and robust and standardized measures of healthy and environmentally sustainable eating will be valuable for measuring progress toward global targets for human and planetary health.

Figure 6. PRISMA flow chart illustrating the search and screening process to identify food interventions implemented on post-secondary campuses

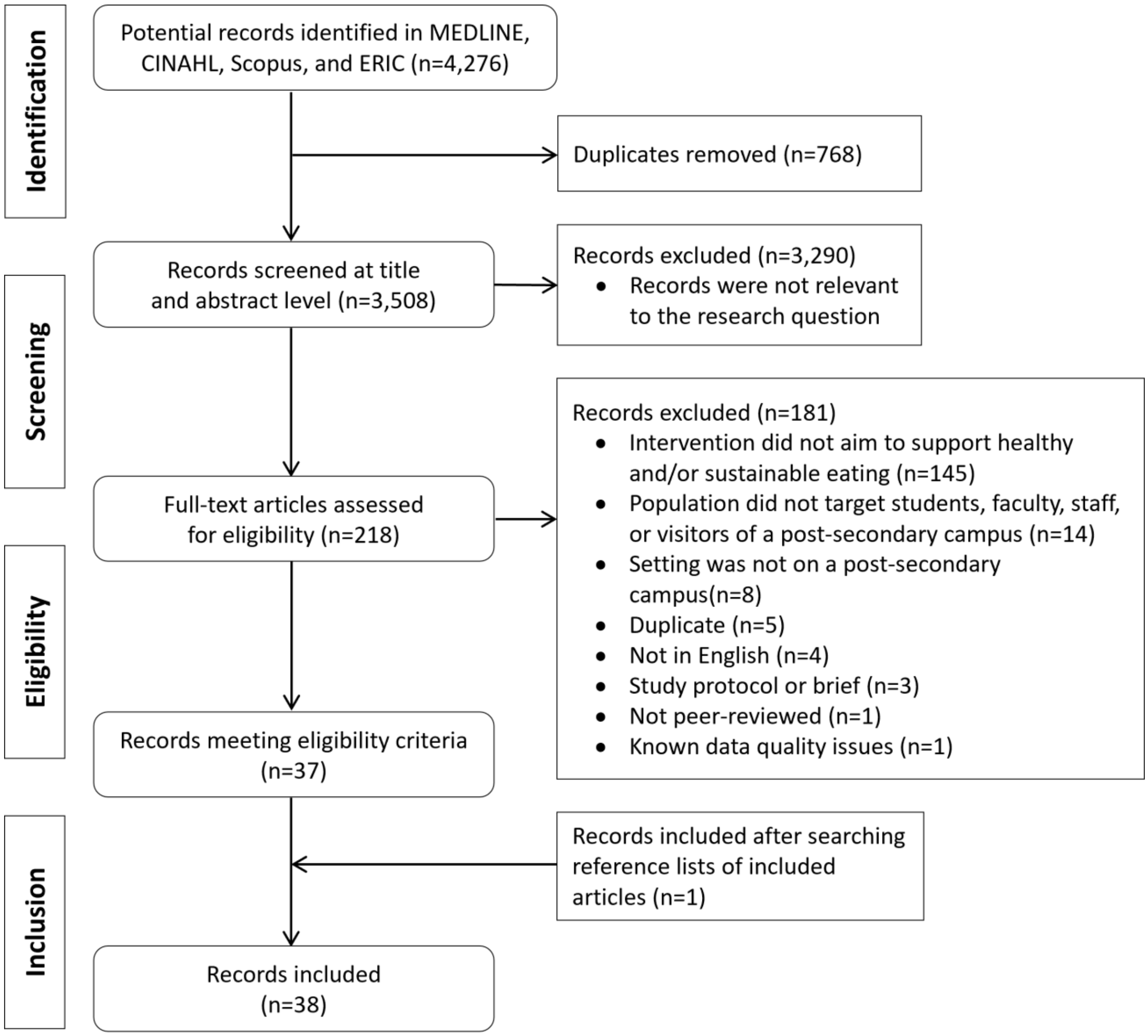

Table 1. Categorizations of included interventions based on the NOURISHING framework (n=37 interventions across 38 records)[1]

	Food environment						**Food system**	**Behaviour change communication**		
Author and year	**N**	**O**	**U**	**R**	**I**	**S**	**H**	**I**	**N**	**G**
	Nutrition label standards and regulations on the use of claims/implied claims on food	Offer healthy food and set standards in public institutions and other specific settings	Use economic tools to address food affordability and purchase incentives	Restrict food advertising and other forms of commercial promotion	Improve nutritional quality of the whole food supply	Set incentives and rules to create a healthy retail and food service environment	Harness food supply chain and actions across sectors to ensure coherence with health	Inform people about food and nutrition through public awareness	Nutrition advice and counselling in health care settings	Giving nutrition education and skills
Interventions considering human health (n=29)										
Aboul-Enein et al., 2015[78]										●
Bernardo et al., 2018[79]										●
Bevet et al., 2018[66]		●								
Biden et al., 2018[70]	●		●							
Cárdenas et al., 2015[71]		●	●							
Christoph et al., 2016[60] and Christoph et al., 2017[59]	●									
Cioffi et al., 2015[61]	●									
Deliens et al., 2016[69]			●							
Dingman et al., 2015[80]	●							●		
Hammond et al., 2015[62]	●									
Hua et al., 2017[85]		●	●					●		
Mistura et al., 2019[87]		●						●		
Mora-García et al., 2019[81]	●							●		
O'Brien et al., 2016[75]										●
Policastro et al., 2017[63]	●									
Rodgers et al., 2016[76]										●

Rose et al., 2018[58]		●								
Roy et al., 2016[82]	●							●		
Schroeter et al., 2019[73]										●
Scourboutakos et al., 2017[83]	●							●		
Seward et al., 2016[72]	●	●								
Shi et al., 2018[64]	●									
Sogari et al., 2019[65]	●									
Tallant et al., 2017 [4]										●
Valdez et al., 2018[77]										●
Vermote et al., 2018[67]		●								
Vermote et al., 2019[84]	●							●		
Viana et al., 2018[86]	●	●	●					●		
Walmsley et al., 2018[68]		●								
Interventions considering environmental sustainability (n=8)										
Ahmed et al., 2018[93]					●			●		●
Duram et al., 2015[92]		●					●			
Godfrey et al., 2017[95]	●							●		
Lorenz-Walther et al., 2019[94]		●						●		
Monroe et al., 2015[91]										●
Mu et al., 2017[89]							●			
Pinto et al., 2018[90]								●		
Rajbhandari-Thapa et al., 2018[88]		●								

[1]Different outcomes from the same intervention were presented in two separate articles.

Table 2. Overview of characteristics and key findings of food interventions considering human health in post-secondary campus settings (n=29 interventions across 30 records)

Author, year, location	Setting	Sample size	Intervention	Duration	Study design / duration	Outcomes and measures	Summary of findings	Funding
Aboul-Enein et al., 2015[78] Houston, Texas, United States	Online	Students enrolled in undergraduate online nutrition course (n=65)	Online nutrition course about the Mediterranean diet (incorporated assigned readings, article reviews, recipe analysis, weekly discussion forums, asynchronous presentations, writing assignments, exams)	1 semester (~4 months)	Pre-test, post-test experiment (no control)	Survey: Perceived quality and value of Mediterranean diet (KIDMED - 16-item questionnaire index; score range 0-12, where <=3 is low, 4-7 is medium, and >=8 is high).	Compared to scores prior to the intervention, participants viewed the Mediterranean dietary pattern more positively and demonstrated an increase in understanding of the pattern.	Not stated
Bernardo et al., 2018[79] Brazil	University campus	Students (n=82; 41 in intervention and 41 in control)	Cooking class intervention (five weekly 3-hour hands-on cooking sessions) and food selection and purchasing workshop. Sessions included cooking demonstrations, discussions about nutrition, hands-on food preparation, and group meals. Session was conducted in groups of 10-12 students, divided into 2-3 students per bench.	6 weeks	Randomized control trial with follow-up at 6 months	Sample characteristics: demographics, cooking characteristics (e.g., self-reported knowledge, cooking experience and location). Outcomes related to cooking skills and healthy eating practices using a questionnaire tested for validity: a) accessibility and availability of fruits and vegetables at	Survey responses demonstrated an increase in cooking confidence and self-reported knowledge of cooking terms following the intervention. Participants increased the availability of fruits and vegetables at home after the intervention. Effects were sustained at the 6-month follow-up.	Federal Agency for Support and Evaluation of Graduate Education in Brazil; Human Resources Development Program; National Council for Scientific and Technological Development

						home; b) cooking attitudes; c) cooking behaviors at home; d) cooking behaviors away from home; e) produce consumption self-efficacy; f) self-efficacy for using basic cooking techniques; g) self-efficacy for using fruits, vegetables, and seasonings (while cooking); and h) knowledge of cooking terms and techniques.		
Bevet et al., 2018[66] Burlington, Vermont, United States	Cafeteria (buffet-style)	Students (n=681 in pre-test; n=128 late-at-night)	Choice architecture 1: Vegetable-heavy entrees added to beginning of self-serve line. Choice architecture 2: Healthy choices snack bar added to salad bar (e.g., hummus, popcorn, trail mix, yogurt, pre-cut fruit)	~3 weeks	Pre-test, post-test quasi-experiment (no control)	Pre-survey (to identify preferences for food options among diners at different eating occasions): preference for foods, sociodemographics At-late-night survey: health score, food choices, satisfaction. Tallied number of students who took food from each intervention station.	Between 54%-69% of students incorporated a vegetable-heavy entrée into their dining session throughout the week. Significant increase in purchases from the healthy choices snack bar.	University of Vermont Dean of Student's Office
Biden et al., 2018[70] London, Ontario, Canada	Residence cafeterias	Sales from cafeterias Students were surveyed to provide	1. Point-of-purchase labels using checkmark indicator based on multi-nutrient "FRESH" criteria. Those not meeting criteria	~2 years for intervention period	Pre-test, post-test ecological study	Sales outcomes: number of items sold, number of fruit and milk items sold, net sales, number of free fruit or milk redeemed, annual cost	Healthy items were sold more often and made less expensive by the food operating service.	Authors had no funding to report

		context to findings (n=1476)	were classified as non-FRESH approved. 2. FRESH Reward Card program provided students with 1 free fruit/milk after 9 purchases of whole fruit/milk.			of free fruit redeemed calculated by taking average cost of the fruits with highest sales quantities.	Healthy items also appeared more frequently on menus than less healthy items.	
Cárdenas et al., 2015[71] Lima, Peru	Cafeteria	Sales from cafeterias (~150 students per day) Students for semi-structured interviews (n=12)	1. Repositioned fruit next to point of purchase with a sign that says, 'Consuming five fruits and vegetables per day prevents many illnesses - World Health Organization' with price per item of fruit. Poster was also placed at entrance of cafeteria. 2. Follow-up intervention where price of fruit was reduced by 33%.	13 weeks; 3 weeks per intervention period	Pre-test, post-test experiment with two intervention phases (no control)	Outcomes (collected by salesperson): number of pieces of fruit sold each day; number of full meals sold; fruit ratio of total fruit purchased and total meals sold in same day. Visible information about each consumer was also collected (e.g., sex, student vs non-student adults). Qualitative interviews: perceptions of marketing strategies of fruit, demographic questions, reasons for purchasing or not purchasing fruit, noticed reduction in price.	Fruit purchasing significantly doubled from phase 1 (repositioning of fruits) to phase 3 (added 33% reduction). There were no differences in fruit sold between the other phases.	National Heart, Lung, and Blood Institute; National Institutes of Health; US Department of Health and Human Services; Fogarty International Center
Christoph et al., 2017[59]	Dining hall	Students (n=1069)	Nutrition label items (with dish title, serving size, number	~16 weeks; data collected at	Cross-sectional	Survey: Gender, age, college classification, height, weight, self-	When compared to non-label users, a greater proportion of	US Department of Agriculture; National

Midwestern United States			of calories, and grams of fat, carbohydrates, and protein).	weeks 8 and 12		perceived eating habits, exercise frequency, enrollment in college-level nutrition courses, and nutrition label use. Dietary intake coding (using pre- and post-meal photographs): Coded selection, type, servings, and consumption according to US Department of Agriculture MyPlate food categories.	label users selected fruits, vegetables, and beans. Fewer label users selected fried foods, foods with added sugars, potatoes, and refined grains when compared with non-users.	Institute of Food and Agriculture
Christoph et al., 2016[60] Midwestern United States	Dining hall	Students (n=2729)	Nutrition label items (with dish title, serving size, number of calories, and grams of fat, carbohydrates, and protein) placed directly in front of food.	~16 weeks; data collected at weeks 8 and 12	Cross-sectional (three waves)	Survey: Nutrition label provision, awareness, and use, behaviour characteristics (sleep, exercise, food habits), specific topics (e.g., what types of information the diner would prefer to see, reasons for label non-use, frequency of dining services mobile application); sociodemographic variables and anthropometric variables (height and weight, weight intention) were collected for correlates.	Nutrition label placement did not influence nutrition label awareness.	US Department of Agriculture National Institute of Food and Agriculture

Cioffi et al., 2015[61] Ithaca, New York, United States	Dining hall	Sales from dining halls	Nutrition labelling on pre-packaged food purchases.	~2 years; 1 year for pre- and post-test periods respectively	Pre-test, post-test experiment (no control)	Mean calories purchased per week, sales patterns, change in high vs low calorie and high vs low fat foods.	Food labels led to a 7% reduction of mean total calories purchased per week. Total fat for purchased foods also demonstrated a 7% reduction among labeled foods.	Division of Nutritional Sciences, Cornell University
Deliens et al., 2016[69] Brussels, Belgium	On-campus restaurant	Students for French Fries experiment (n=2930 total; 2344 during week 1 and 2325 during week 2) Students for fruit experiment (n=3235 total; 3802 during week 1 and 3728 during week 2) Students for interviews (n=230 for French fry experiment; n=227 for fruit experiment)	1. Price increases on French fries by 10% and 20%. 2. Price reductions on fruit purchases by 10% and 20%. 3. Posters and information boards to communicate price adjustments. about the price adjustments.	5 weeks; 1 week per intervention period	Pre-test, post-test quasi-experimental study and qualitative interviews	Data collected at register: student status, chosen menus, whether French fries or fruit was chosen, sex of the student. Interviews: demographics (gender, age, residency, study discipline, height, weight), food choice and price manipulation influenced their choice, asked if price adjustment would change their consumption in the long run, asked if they believed it was a good initiative to support healthy eating.	Increasing the price of French Fries by 10% and 20% led to a 10.9% and 21.8% reduction in purchases, respectively. Decreasing the price of fruit by 10% and 20% led to a 25.1% and 42.2% increase in fruit purchases, respectively.	Authors had no funding to report

Dingman et al., 2015[80] North Carolina, United States	Vending machines in residence halls	Vending machines (sales data for n=18 machines; 9 intervention and 9 control sites) Students (n=670)	1. Poster boards adjacent to each vending machine, listing Nutrition Facts Panel for each product in the vending machine. 2. Five products that met nutrition criteria were highlighted (less than 200 kcal, less 2g of saturated fat, 0g of trans fat, less 7g of sugar, 300mg of sodium) and labelled as "Better Choice" with an interpretive label. 3. Criteria and promotional messages were described on posters and emails.	8 weeks; 4 weeks for pre- and post-test periods respectively	Pre-test, post-test, 2x2 experimental design	Sales data: the average calories sold per snack, and the proportion of snacks that contained fewer calories and less saturated fat, sugar, and sodium than the usual snacks (i.e., Better Choice snacks). Used sex and year of schooling as covariates in models.	Compared to the 4-week pre-test period, there were no significant differences in calories sold.	Not stated
Hammond et al., 2015[62] Ontario, Canada	Residence cafeterias	Students (n=159)	Numeric calorie labels.	2 weeks; 1 week for pre- and post-test periods respectively	Pre-test, post-test naturalistic cohort	Demographic information: sex, race, rate overall health, BMI, weigh perceptions and aspirations. Exit surveys: Noticing information, what types of information, when they saw it, use of information, calories ordered and consumed.	Compared to pre-test, calorie labels led to significant increases in noticing and use of nutrition information to guide food purchases. The calorie content of foods purchased and estimated amount of calories consumed decreased following the intervention.	Canadian Cancer Society Research Institute; Canadian Institutes of Health Research

Hua et al., 2017[85] New Haven, Connecticut, United States	Vending machines	Vending machines (n=56)	1. Improved availability of healthier snacks (using 'FitPick' criteria of <=250 kcal, <=20 g sugar, <=230 mg sodium, <=10 g fat, <=3 g saturated fat, and no trans fat). Water and other beverages (<=25 kcal/237 mL) were classified as healthy. 2. Reduced price for healthy items by 25%. Water reduced price to $1. 3. Promotional signage to indicate price change and labels to indicate healthy items. Signs promoted water consumption.	5 months	2x2x2 balanced factorial experiment	Sales and revenue data: total number of units sold and total revenue, stratified by type of vending machine (i.e., snacks or beverages).	The interaction between improving the availability of healthier options and promotional signage increased revenue of healthier snacks. Price reductions alone did not affect consumer choice. The interaction of all three interventions did not increase purchasing of healthier snacks. Compared to the pre-test period, there was an overall increase in healthier snack purchasing across all intervention machines.	None to report
Mistura et al., 2019[87] Victoria, British Columbia, Canada	Residence cafeterias	Students for surveys (n=340)	1. Improved availability and appearance of vegetables. 2. Poster at eye level to indicate vegetable option and with a character/message.	~11 weeks; 3 weeks per intervention phase	Pre-test, post-test quasi-experiment (no control)	Tallied number of students observed purchasing a vegetable option compared to the total count of students that purchased from hot table, counts were recorded by sex.	Compared to the 2-week pre-test period, there was no change in the mean number of vegetables purchased.	British Columbia Ministry of Health

Mora-García et al., 2019[81] Bogota, Colombia	Cafeteria	Consumers (n=228 for control; n=257 for intervention)	Randomly informed people about existence of FOP Nutri-score labelling system.	4 weeks	Pre-test, post-test randomized controlled trial	Receipts: products bought, price of product. Survey: anthropometric and demographic characteristics, using the system, physical activity measurements.	The intervention led to an increase in total expenditure of $0.18. Spending on healthier items was 21% or $0.26 higher than purchases made during the pre-test period, with no change for less healthy items. Compared to those in the control, customers were 10% more likely to buy healthier items.	Apoyo de Proyectos Interdisciplinarios de Investigación
O'Brien et al., 2016[75] Northeastern United States	Online	Students (n=148; n=48 for control group, n=50 in web-only group; n=49 in web and mobile group)	1. Online nutrition course (on-screen, open-response prompts, writing task, personalized feedback on healthy eating) only. 2. Online nutrition course intervention and daily messages for behaviour planning.	4 weeks	Pre-test, post-test randomized control trial	Dietary habits survey: vegetable and fruit consumption (three 7-day recall items). Healthy food choices: how often students selected university sponsored healthy items (Sargent Choice selection).	Compared to the control group and the group that received the online nutrition course, those who received the online course and daily messaging demonstrated a significant increase in the likelihood of improving vegetable consumption and were three times more likely to meet dietary guideline standards. However, the intervention did not significantly change fruit consumption.	Not stated

Policastro et al., 2017[63] New Jersey, United States	Dining hall (take-out line)	Students (n=9765)	Modified sandwich order form where healthier ingredients were listed first within each category, printed in bold and larger font, and designated with star symbol.	8 days of data collection over 8-week study period	Pre-test, post-test experiment (no control)	Participants' choice of ingredients and measures for calories, fat, sodium, and fiber for each order.	When compared to orders using the unmodified sandwich order form, the modified form led to an increase in selection of healthier ingredients and decreased selection of less healthy ingredients.	None to report
Rodgers et al., 2016[76] Northeastern United States	Online	Students (n=43)	Online intervention which included taking photographs of every meal and text messages to encourage healthy eating (3 times/day at mealtimes).	10 weeks; 3 weeks for intervention period	Pre-test, post-test experiment (no control)	Demographic survey: age, year in school, housing status, weight and height using scale to calculate BMI. Food Frequency Questionnaire: Fruit and vegetable intake. Beverage Intake Questionnaire: Caloric intake from SSB. Drive for Thinness (subscale from Eating Disorder Inventory): 7 items, such as pre-occupation with thinness.	There was a significant increase in fruit and vegetable consumption among those in a higher body mass index category. There were no significant changes in vegetable consumption and a decrease in fruit consumption was observed among those in a lower body mass index category.	None to report
Rose et al., 2018[58] Columbus, Ohio, United States	Vending machines (campus dorms)	Students (n=128)	Vending machines with milk installed in high traffic areas and near other vending machines.	2 months	Pre-test, post-test experiment (no control)	Healthy Habits Survey: vending purchasing habits, motivators and barriers to consuming calcium rich foods. Calcium consumption	No changes in milk and calcium intake.	American Dairy Association-Mideast

						questionnaire: assess calcium and milk intake from foods and beverages.		
Roy et al., 2016[82] Australia	Food outlet	Students (n=713)	1. Calorie labelling placed adjacent to items on menus and contextual statement. 2. Social marketing campaign with comprehensive website/interactive calculators, advertising slides for digital screens, and banners. Dietitians were also available during lunch hours and stood next to banners.	10 weeks; 5 weeks per intervention	Pre-test, post-test experiment (no control)	Sales data: change in itemized food sales data (also compared to same weeks during the same period the year prior). Intercept interviews: customer attitudes, awareness of knowledge and use.	There were no differences in sales between the calorie labelling with social marketing campaign and calorie labelling alone. 30% of participants were aware of the calorie labels on the menus and 75% of participants were accepting of the labelling intervention after they were made aware of the changes. Participants selected meals with lower mean calories following the social marketing intervention, despite most participants claiming that the campaign would not influence their food and beverage purchases.	None to report; corresponding author received Australian Government, Department of Education
Schroeter et al., 2019[73] United States	University campus	Students (n=57; n=18 for control group; n=8 incentive and	1. 4-week educational session on five food groups outlined in USDA's MyPlate, including	6 weeks; 4 weeks for intervention	Pre-test, post-test randomized controlled trial	Survey: demographics, media behaviour (self-rated), nutrition knowledge (self-rated), health	Dietary quality scores increased by 15% among those who received either intervention, whereas	Cornell Center for Behavioural Economics in Child Nutrition;

		education group; n=31 for education group)	1-hour lesson 3-4 quiz questions, interactive style and had tailored personalized suggestions at end of lesson. 2. Education and incentive if HEI score was improved by 5%.			behaviour (dietary recalls using ASA24).	the control group increased by 8%.	California Polytechnic State University-College of Agriculture, Food, and Environmental Sciences
Scourboutakos et al., 2017[83] Toronto, Ontario, Canada	Residence cafeteria (buffet style)	Students (n=368 to 510)	1. Education campaigns for beverages and fruits and vegetables (e.g., healthy eating plate infographic). 2. Physical activity calorie labelling equivalents for sugar-sweetened beverages.	5 months; 2 months for pre-test and 3 months for intervention period	Pre-test, post-test quasi-experiment (no control)	Beverage choices and fruit and vegetable choices.	The proportion of students who purchased fruit significantly increased from 30% to 36%. Proportion of students who purchased a sugar-sweetened beverage significantly decreased from 49% to 41%.	Cancer Care Ontario; Canadian Institutes of Health Research; University of Toronto
Seward et al., 2016[72] Cambridge, Massachusetts, United States	Residence cafeterias	Students (n=1329)	1. Traffic light labelling and healthy-plate stickers. 2. Healthy foods and beverages moved to high-traffic and accessible areas.	13 weeks; 6 weeks for pre-test and 7 weeks for intervention period	Pre-test, post-test quasi-experiment (no control)	Cafeteria servings: Change in proportions of red, yellow, and green items (overall and by subgroups of food categories). Online surveys: How and whether they used the nutrition information to guide choices and asked if they wanted to have nutritional labels.	59% of post-intervention students who noticed the traffic-light labels thought they were helpful and 73% said that they should continue to be used following the study. No significant changes in proportions of red, amber, and green labelled items sold.	Harvard College Museum of Comparative Zoology; National Heart, Lung, and Blood Institute

Shi et al., 2018[64] Australia	University campus	Vending machines (n=60 across 7 campuses; n=27 snack machines, n=33 beverage machines, n=11 with both)	Health Star Rating (voluntary front-of-package labelling system; ranging from half a star to five stars where more stars indicate a healthier choice)	N/A	Cross-sectional	Audits: Name, weight, volume of items; promotions. Nutritional quality: energy, positive nutrients, risk nutrients.	Compared to pre-implementation data ~3 years prior, there was an increase in the proportion of snacks and beverages rated 3.5 stars or higher offered in the vending machines.	None to report
Sogari et al., 2019[65]	Dining hall	Consumers (n=3734)	Messages about the nutritional benefits for whole grain pastas	18 days over 9-week study period	Pre-test, post-test quasi-experiment	Number of diners who selected whole grain pasta versus other types of pasta.	Compared to the non-message condition, messages about vitamin benefits demonstrated a 7.4% increase in the probability of selecting whole grain pastas.	European Union's Horizon 2020 Research and Innovation Programme
Tallant et al., 2017[74]	University campus	Students (n=33)	Nutrition education course focused on self-efficacy, nutrition behaviour skill-building, and nutrients and lifestyle behaviours. Lecture on food labels was also provided.	16 weeks	Pre-test, post-test quasi-experiment	Survey: food label use; healthy food choices; modified survey instrument from Department of Agriculture's Diet and Health Knowledge survey measuring perceptions on diet adequacy, nutrition knowledge, nutrition self-efficacy, and perceptions. Dietary self-assessment. Scores for food label reading.	Compared to the pre-test period, the intervention led to a significant increase in food label-reading behaviour and food choice behaviour. 27% of students practiced food label reading more frequently at the post-test period and 29% indicated choosing healthier options more frequently.	Not stated

Valdez et al., 2018[77]	University campus	Students (n=10)	Experiential learning course: values of whole foods plant-based diet (and nutrition) on chronic condition, provided meals	10 days	Pre-test, post-test quasi-experiment using mixed methods	Qualitative questionnaire: perspectives on whole foods plant-based diets. Blood samples for cholesterol and glucose.	The intervention improved participant understanding of how plant-based diets can affect chronic disease. Compared to the pre-test period, there was an observed mean change in total cholesterol of -26 mg/dL, high-density lipoprotein cholesterol of -6.1 mg/dL, and low-density lipoprotein of -21.6 mg/dL.	Authors stated that they did not receive financial support; however, article stated that grant funding was secured to cover costs of meals.
Vermote et al., 2018[67]	On-campus restaurant	Students (n=2056 at pre-test; n=2175 at post-test) Students and employees for interviews and dietary recall (n=296)	Reduced portion sizes for French fries (~20%).	1 week	Pre-test, post-test quasi-experiment	Consumption and plate waste. Interviews: Satiety and caloric intake, food recall for meal, side, dessert, and beverage, sociodemographics. Noticing of portion sizes and estimates for how much and if portion size was sufficient.	Reduced portion size was effective in reducing consumption and plate waste, with no differences in satiety and caloric intake. Mixed consumer perceptions regarding portion size changes.	Not stated
Vermote et al., 2019[84]	On-campus restaurant	Students (n=556)	1. Food labelling (interpretive) at point-of-purchase. 2. Information campaign (posters).	35 weeks; phased in ranging from 1 to 23 weeks in duration	Pre-test, post-test quasi-experiment using mixed methods	Sales data: Amount sold for desserts. Interviews: demographics, influence and use, feasibility.	Compared to the pre-test period, there was a significant increase in fruit purchasing. The effect was sustained over a 35-week study period.	Not stated

Viana et al., 2018[86]	Vending machines	Vending machines (n=3) Consumers (n=100)	1. Information campaign using Healthy Campus Initiative label (included web address for more nutritional information). 2. Interpretive labelling for healthy products. 3. Healthy products were grouped at eye level.	2 months	Pre-test, post-test quasi-experiment	Sales reports: revenue, profit, number of total products sold, and healthier products sold. Survey: demographics, typical frequency of vending machine purchasing.	Compared to the pre-test period, intervention machines demonstrated an increase in profits of healthier items. Revenue was not compromised following the intervention.	Not stated
Walmsley et al., 2018[68]	On-campus grocery store	N/A	1. Moving fruits and vegetables from back of the store to front and moving beverages.	5 years; 2 years per intervention period	Pre-test, post-test experiment (no control)	Sales data: daily total quantity sold for each product, description, price, profit, barcode, unit size and food category.	The rearrangement of the shop led to an increase in percentage of total fruit and vegetable sales. There was a decline in sales of fruits and vegetables over a 5-year period.	None to report; corresponding authors supported by University of Warwick; National Institute of Health Research

Table 3. Overview of characteristics and key findings of food interventions considering environmental sustainability in post-secondary campus settings (n=8 interventions across 8 records)

Author, year	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Ahmed et al., 2018[93] Bozeman, Montana, United Stated (Montana State University)	Dining hall	Students (n=249 for survey)	1. Reduced portion size of all entrees by at least one quarter. 2. Serving utensils were replaced for smaller tongs, spoons, and ladles (leading to multiple scoops being required to serve same amount of food). 3. Messaging campaign to raise awareness on food waste; posters demonstrated strategies to reduce waste (e.g., mindful portion sizes, coming back for seconds, exploring all food options in dining hall). 4. Teach students to develop, implement, and evaluate a food waste intervention.	3 weeks	Pre-test, post-test experiment (no control)	Food waste measurements: Weighted food and non-food waste for three days pre- and post-intervention. Plate waste measurement: Visual estimates of amount of food waste from scale of 1 to 4 (less than one-quarter to more than three-quarters plate) and frequency of food item wasted. Survey (intercept technique): 5 questions of diner attitudes toward food waste. Participant reflections by research team: Evaluating effectiveness of experiential learning project (focused more on teaching pedagogy; therefore, not included in data charting).	Although not statistically significant, the intervention demonstrated a 17% reduction in total food waste. Participants self-reported that the intervention made them think more about food waste and supported campus-wide efforts to address food waste through composting. Students reported that they would feel more concerned about food waste if the efforts allowed them to save money.	National Institute of General Medical Sciences of the National Institutes of Health; Montana State University's Campus Sustainability Council and Montana Institute on Ecosystems

Duram et al., 2015[92] Carbondale, Illinois, United States	University campus	Students (n=9)	Campus garden (led by students) to promote sustainability education; later helped to supply campus dining halls and campus farmer's markets.	3-year evaluation	Case study using mixed methods (interviews, budget analysis)	Qualitative assessment of growth of garden and future recommendations. Process of implementing the campus garden was documented.	Campus gardens were driven by student leadership and were committed to projects that aimed to improve campus food systems.	Southern Illinois University (Green Fund)
Godfrey et al., 2017[95] Calgary, Alberta, Canada	Dining hall	Students for interviews (n=10) Students for pre- and post-test survey (n=32) Dining hall	1. Communication campaign on water footprints. Foods were categorized into easy-to-understand posters and labels to identify small, medium, and large water footprints. 2. Low water footprint meals were recommended in second week.	3 weeks	Pre-test, post-test experiment (no control) using mixed methods	Production reports and sales report: behaviour change (i.e., increase in proportion of low water footprint meals sold). Survey: Change in attitude scores toward choosing small water footprints (food attributes for environmental sustainability, taste, healthiness, availability, price, lifestyle image; food appearance; measure of belief; emotional response). Interviews: food choices, how they perceived concepts of sustainable food, reactions and interpretations of water footprint signage.	Interviews demonstrated that students perceived environmentally sustainable foods as providing greater health benefits. Students also indicated that they opt for convenience over choosing environmentally sustainable foods. Compared to the pre-intervention period, there were no significant changes in consumption following the intervention.	Canadian Social Sciences and Humanities Research Council; University of Calgary Students Union Sustainability Fund

Lorenz-Walther et al., 2019[94] Germany	Canteen	Consumers (n=503 at pre-test; 377 at post-test)	1. Posters to raise awareness on food waste and provided strategies on how to avoid food waste. 2. Reduce portion size: For meat entrees, portion sizes were reduced from 140g to 120g or used smaller scoops for sauces that contain meat (decrease from 100g to 83g sauce).	30 weeks; 1 6-week period for pre-test and 5 6-week periods for post-test	Pre-test, post-test quasi-experiment	Survey: Cognitive attitude towards finishing food, perceived behavioural control over having plate leftovers, perceived subjective norms in finishing all food, portion size ratings, taste ratings. Plate leftovers (observed by videotaping of returned trays): Leftovers were visually estimated.	Compared to the pre-test period, there was a small decrease in food consumption and food waste. Participants who indicated the informational campaign influenced their decisions to eat all the food on their plate had less leftovers than those who indicated that the campaign did not influence their decisions.	German Federal Ministry of Education and Research
Monroe et al., 2015[91] North Eastern, United States	Online	Students for intervention group (n=241 at pre-test; n-187 at post-test) Students for control group (n=367 at pre-test; n=304 at post-test)	Four modules (1 per week) with topics on green eating behaviours, eating local, reducing waste, choosing environmentally-friendly proteins. Modules included information displayed in text, pictures, video clips, and included interactive questions/quizzes.	5 weeks	Pre-test, post-test randomized controlled trial	Survey: 'Green eating' behaviour scale (six items related to food choices, shopping at farmers markets, fair-trade foods, meals without antibiotics or hormones, and frequency of purchasing meat; decisional balance; self-efficacy at home and school; stage of change; knowledge assessment; readiness to change behaviour; confidence, relevance, attention, and satisfaction with program).	Compared to the pre-test period, scores for 'green eating' behaviour increased among those who received the intervention.	University of Rhode Island

Mu et al., 2017[89] Union, New Jersey, New York	University campus	None	Food waste composting system (in-vessel composting technology).	N/A	Cross-sectional	Plant growth, life cycle assessment (environmental impact), cost-benefit analysis.	The food waste composting system lowered greenhouse gas emissions, smog formation, fossil fuel use, and eutrophication when compared to a landfill waste system.	Kean University
Pinto et al., 2018[90] Lisbon, Portugal	Cafeteria	Cafeteria (~240 students per day)	1. Posters about food waste. 2. Students were trained to provide information on how to reduce plate waste and social impact of food waste.	4 weeks; 10 days for pre- and post-test periods respectively	Pre-test, post-test ecologic study (no control)	Inorganic and organic waste from trays. Plate waste based on average serving size. Monetary loss assessment. Waste consumption index to calculate amount of consumption and per capita waste consumption.	Compared to the pre-test period, there was ~15% reduction in plate waste during the intervention. The information campaign was initially well-received by staff and students, however, interest in food waste declined as the intervention continued.	European Union Horizon 2020 research
Rajbhandari-Thapa et al., 2018[88] Southern United States	Dining halls	Students (n=3153; n=1564 in control group and n=1589 in intervention group)	Removed trays to encourage reduced portions.	1 week	Pre-test, post-test quasi-experiment (with control)	Outcomes: number of lunch entrée servings, number of drink servings, number of salad servings, number of dessert servings, number of lunch entrees, salads, and dessert servings with at least a quarter leftover, and number of lunch entrees servings with at least a quarter left over.	Compared to the control group, students in the dining hall without trays self-selected fewer servings of lunch entrée and drink items. Cafeterias without trays demonstrated fewer servings with leftovers.	None to report

5.7 References

1. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019;393(10184):1958-1972.

2. Gonzalez Fischer C, Garnett T. Plates, pyramids and planets Developments in national healthy and sustainable dietary guidelines: a state of play assessment [Internet]. University of Oxford; 2016 [cited 2020 May 27]. Available from: www.fao.org/

3. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019 Feb;393(10170):447-92.

4. Campbell BM, Beare DJ, Bennett EM, Hall-Spencer JM, Ingram JSI, Jaramillo F, Rodomiro O, Ramankutty N, Sayer JA, Shindell D. Agriculture production as a major driver of the earth system exceeding planetary boundaries. *Ecol Soc*. 2017;22(4).

5. Ridgway E, Baker P, Woods J, Lawrence M. Historical developments and paradigm shifts in public health nutrition science, guidance and policy actions: A narrative review. *Nutrients*. 2019;11(3).

6. United Nations. Sustainable Development Goals [Internet]. [cited 2021 Feb 3]. Available from: https://sustainabledevelopment.un.org

7. Burlingame B, Dernini S, Nutrition and Consumer Protection Division, Food and Agriculture Organization, editors. Sustainable Diets and Biodiversity: Directions and solutions for policy, research, and action [Internet]. Rome; c2010 [cited 2021 Feb 3]. Available from: http://www.fao.org/3/a-i3004e.pdf

8. Johnston JL, Fanzo JC, Cogill B. Understanding Sustainable Diets: A Descriptive Analysis of the Determinants and Processes That Influence Diets and Their Impact on Health, Food Security, and Environmental Sustainability. *Adv Nutr*. 2014;5(4):418-429.

9. Mason P, Lang T. Sustainable diets: How ecological nutrition can transform consumption and the food system. 1st ed. New York, NY: Routledge; 2017 [cited 2020 Sept 11].

10. Heller MC, Willits-Smith A, Meyer R, Keoleian GA RD. Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. *Environ Res Lett*. 2018;13:1-11.

11. Cobiac LJ, Scarborough P. Modelling the health co-benefits of sustainable diets in the UK, France, Finland, Italy and Sweden. *Eur J Clin Nutr*. 2019;73(4):624-633.

12. International Network for Food and Obesity. INFORMAS Modules [Internet]. [cited 2021 Feb 3]. Available from: https://www.informas.org/

13. Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. *Obes Rev*. 2013;14:159-168.

14. Health Canada. Healthy Eating Strategy [Internet]. [cited 2021 Feb 3]. Available from: https://www.canada.ca/

15. Hawkes C. Identifying innovative interventions to promote healthy eating using consumption-oriented food supply chain analysis. *J Hunger Environ Nutr*. 2009;4(3–4):336–56.

16. Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. Adv Nutr. 2016;7(6).

17. Springmann M, Spajic L, Clark MA, Poore J, Herforth A, Webb P, Rayner M, Scarborough P. The healthiness and sustainability of national and global food based dietary guidelines: modelling study. *BMJ*. 2020;370:m2322.

18. Forouhi NG, Unwin N. Global diet and health: old questions, fresh evidence, and new horizons. *Lancet*. 2019;393:1916–8.

19. Fuchs D, Kalfagianni A, Arentsen M. Retail Power, Private Standards, and Sustainability in the Global Food System. In: Clapp J, Fuchs D, editors. *Corporate Power in Global Agrifood Governance*. New York, NY: The MIT Press; 2009. p. 28–59.

20. Clapp J, Fuchs DA. Corporate power in global agrifood governance. MIT Press; 2009.

21. Tseng M, Degreef K, Fishler M, Gipson R, Koyano K, Neill DB. Assessment of a University Campus Food Environment, California, 2015. *Prev Chronic Dis*. 2016 Feb;13(E18).

22. Horacek TM, Erdman MB, Reznar MM, Olfert M, Brown-Esters ON, Kattelmann KK, Kidd T, Koenings M, Phillips B, Quick V, et al. Evaluation of the Food Store Environment on and near the Campus of 15 Postsecondary Institutions. *Nutr Promot Community Des*. 2013;27(4):81-90.

23. Lo BK, Minaker L, Chan AN, Hrgetic J, Mah CL. Adaptation and validation of a nutrition environment measures survey for university grab-and-go establishments. *Can J Diet Pract Res*. 2016 Mar;77(1):17-24.

24. Hansen SS, Savage C. Campus Living Laboratory [Internet]. Macalester College, MN [cited 2021 Feb 3]. Available from: https://serc.carleton.edu/sp/library/campusbased/index.html

25. Evans J, Jones R, Karvonen A, Millard L, Wendler J. Living labs and co-production: University campuses as platforms for sustainability science. *Curr Opin Environ Sustain*. 2015;16:1-6.

26. Hansen SS. The campus as a living laboratory: Macalester College case study [Internet]. 2017 [cited 2021 Feb 3]. Available from: http://www.centerforgreenschools.org/

27. Okanagan Charter: An international charter for health promoting universities and colleges [Internet]. University of British Columbia; 2015 [cited 2020 May 27]. Available from: https://wellbeing.ubc.ca/okanagan-charter

28. Barlett PF. Campus Sustainable Food Projects: Critique and Engagement. *Am Anthropol*. 2011;113(1):101-115.

29. Lozano R, Ceulemans K, Alonso-Almeida M, Huisingh D, Lozano FJ, Waas T, Lambrechts W, Lukman R, Hugé J. A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey. *J Clean*

Prod. 20151;108:1-8.

30. The Association for the Advancement of Sustainability in Higher Education. STARS, Sustainability Tracking Assessment & Rating System [Internet]. 2020 [cited 2021 Feb 3]. Available from: https://stars.aashe.org/

31. The Culinary Institute of America. Menus of Change Initiative [Internet]. 2021 [cited 2021 Feb 3]. Available from: https://www.menusofchange.org/

32. Mcmillin J, Dyball R. Developing a Whole-of-University Approach to Educating for Sustainability. *J Educ Sustain Dev*. 2009;3(1):55-64.

33. Alshuwaikhat HM, Abubakar I. An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *J Clean Prod*. 2008 Nov;16(16):1777-85.

34. Doherty S, Cawood J, Dooris M. Applying the whole-system settings approach to food within universities. *Perspect Public Health*. 2011;131(5):217–24.

35. Winpenny EM, van Sluijs EMF, White M, Klepp K-I, Wold B, Lien N. Changes in diet through adolescence and early adulthood: longitudinal trajectories and association with key life transitions. *Int J Behav Nutr Phys Act*. 2018;15(1):86.

36. Poobalan AS, Aucott LS, Clarke A, Smith WCS. Diet behaviour among young people in transition to adulthood (18–25 year olds): a mixed method study. *Heal Psychol Behav Med*. 2014;2(1):909-928.

37. Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA. Emerging Adulthood and College-aged Youth: An Overlooked Age for Weight-related Behavior Change. *Obesity*. 2008;16(10):2205-2211.

38. Kelly NR, Mazzeo SE, Bean MK. Systematic Review of Dietary Interventions With College Students: Directions for Future Research and Practice. *J Nutr Educ Behav*. 2013;45:304-313.

39. Roy R, Kelly B, Rangan A, Allman-Farinelli M. Food Environment Interventions to Improve the Dietary Behavior of Young Adults in Tertiary Education Settings: A

Systematic Literature Review. *J Acad Nutr Diet*. 2015;115(10):1647-1681.e1.

40. De Young R, Scheuer K, Roush J, Kozeleski K. Student interest in campus community gardens: Sowing the seeds for direct engagement with sustainability. In: *World Sustainability Series*. Springer; 2016:161-175.

41. Laycock Pedersen R, Robinson Z. Reviewing University Community Gardens for Sustainability: taking stock, comparisons with urban community gardens and mapping research opportunities. *Local Environ*. 2018;23(6):652-671.

42. Levkoe CZ, Erlich S, Archibald S. Campus Food Movements and Community Service-Learning: Mobilizing Partnerships through the Good Food Challenge in Canada. *Engag Sch J Community-Engaged Res Teaching, Learn*. 2019;5(1):57-76.

43. Vaughter P, Wright T, McKenzie M, Lidstone L. Greening the Ivory Tower: A Review of Educational Research on Sustainability in Post-Secondary Education. *Sustainability*. 2013;5(5):2252-2271.

44. Findler F, Schönherr N, Lozano R, Reider D, Martinuzzi A. The impacts of higher education institutions on sustainable development: A review and conceptualization. *Int J Sustain High Educ*. 2019;20(1):23-38.

45. Grech A, Howse E, Boylan S. A scoping review of policies promoting and supporting sustainable food systems in the university setting. *Nutr J*. 2020;19(1):97.

46. Levac D, Colquhoun H, O'brien KK. Scoping studies: advancing the methodology. *Implement Sci*. 2010;5(69):1-9.

47. Colquhoun HL, Levac D, O'brien KK, et al. Scoping reviews: time for clarity in definition, methods, and reporting.

48. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015;13(3):141-146.

49. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018;18(1):143.

50. Arksey H, O'Malley L. Scoping Studies: Towards a Methodological Framework. *Int J Soc Res Methodol*. 2005;8(1):1364-5579.

51. Tricco AC, Lillie E, Zarin W, O'Brien KK, Cloquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Ann Intern Med*. 2018;169(7):467-473.

52. Keller LO, Strohschein S, Lia-Hoagberg B, Schaffer MA. Population-based public health interventions: practice-based and evidence-supported. Part I. *Public Health Nurs*. 2004 Sep;21(5):453-68.

53. Global Alliance for Improved Nutrition GAIN and Johns Hopkins University. The Food Systems Dashboard. 2020. Geneva, Switzerland. Available from: https://www.foodsystemsdashboard.org.

54. Parsons K, Hakes C, Wells R. What is the food system? A food policy perspective [Internet]. 2019 [cited 2020 Oct 27]. Available from: www.city.ac.uk

55. Covidence. Covidence systematic review. Version v1532 8c1129e3 [software]. Veritas Health Innovation: Melbourne, Australia. 2020 May 26 [cited 2020 May 27]. Available from: www.covidence.org

56. Belur J, Tompson L, Thornton A, Simon M. Interrater reliability in systematic review methodology: exploring variation in coder decision-making. *Sociol Methods Res*. 2018:0049124118799372.

57. McHugh ML. Interrater reliability: The kappa statistic. *Biochem Medica*. 2012;22(3):276-282.

58. Rose AM, Williams RA, Hanks AS, Kennel JA, Gunther C. Milk Vending Does Not Improve College Students' Milk and Calcium Intakes. *Health Promot Pract*. 2018;19(2):295-302.

59. Christoph MJ, Ellison B. A Cross-Sectional Study of the Relationship between Nutrition Label Use and Food Selection, Servings, and Consumption in a University Dining Setting. *J Acad Nutr Diet*. 2017;117(10):1528-1537.

60. Christoph MJ, Ellison BD, Meador EN. The Influence of Nutrition Label Placement on Awareness and Use among College Students in a Dining Hall Setting. *J Acad Nutr Diet*. 2016;116(9):1395-1405.

61. Cioffi CE, Levitsky DA, Pacanowski CR, Bertz F. A nudge in a healthy direction. The effect of nutrition labels on food purchasing behaviors in university dining facilities ☆. *Appetite*. 2015;92(2015):7-14.

62. Hammond D, Lillico HG, Vanderlee L, White CM, Reid JL. The impact of nutrition labeling on menus: A naturalistic cohort study. *Am J Health Behav*. 2015;39(4):540-548.

63. Policastro P, Smith Z, Chapman G. Put the healthy item first: Order of ingredient listing influences consumer selection. *J Health Psychol*. 2017;22(7):853-863.

64. Shi Y, Grech AL, Allman-Farinelli M. Changes in the nutritional quality of products sold in university vending machines since implementation of the health star rating in 2014; An environmental audit 11 Medical and Health Sciences 1117 Public Health and Health Services. *BMC Public Health*. 2018;18(1):1255.

65. Sogari G, Li J, Lefebvre M, Menozzi D, Pellegrini N, Cirelli M, Gómez MI, Mora C. The influence of health messages in nudging consumption of whole grain pasta. *Nutrients*. 2019;11(12).

66. Bevet S, Niles MT, Pope L. You can't "nudge" nuggets: An investigation of college late-night dining with behavioral economics interventions. *PloS one*. 2018;13(5).

67. Vermote M, Versele V, Stok M, Mullie P, D'Hondt E, Deforche B, Clarys P, Deliens T. The effect of a portion size intervention on French fries consumption, plate waste, satiety and compensatory caloric intake: an on-campus restaurant experiment. *Nutr J*. 2018;17(1):43.

68. Walmsley R, Jenkinson D, Saunders I, Howard T, Oyebode O. Choice architecture modifies fruit and vegetable purchasing in a university campus grocery store: Time series modelling of a natural experiment. *BMC Public Health*. 2018;18(1):1149.

69. Deliens T, Van Crombruggen R, Verbruggen S, De Bourdeaudhuij I, Deforche B, Clarys P.

Dietary interventions among university students: A systematic review. *Appetite*. 2016 Oct;105:14–26.

70. Biden CR, Matthews JI, Laframboise NA, Zok A, Dworatzek PDN, Seabrook JA. Point-of-Purchase Labels and Reward Cards Improve Sales of Healthy Foods in University Dining Halls. *Can J Diet Pract Res*. 2018;79(3):92-98.

71. Cárdenas MK, Benziger CP, Pillay TD, Miranda JJ. The effect of changes in visibility and price on fruit purchasing at a university cafeteria in Lima, Peru. *Public Health Nutr*. 2015;18(15):2742-2749.

72. Seward MW, Block JP, Chatterjee A. A traffic-light label intervention and dietary choices in college cafeterias. *Am J Public Health*. 2016 Oct;106(10):1808-14.

73. Schroeter C, Corder T, Brookes B, Reller V. An incentive-based health program using MyPlate: a pilot study analyzing college students' dietary intake behavior. *J Am Coll Heal*. 2019.

74. Tallant A. First-Year College Students Increase Food Label–Reading Behaviors and Improve Food Choices in a Personal Nutrition Seminar Course. *Am J Heal Educ*. 2017;48(5):331-337.

75. O'Brien LM, Palfai TP. Efficacy of a brief web-based intervention with and without SMS to enhance healthy eating behaviors among university students. *Eat Behav*. 2016;23:104-109.

76. Rodgers RF, Pernal W, Matsumoto A, Shiyko M, Intille S, Franko DL. Capitalizing on mobile technology to support healthy eating in ethnic minority college students. *J Am Coll Heal*. 2016;64(2):125-132.

77. Salerno Valdez E, Pottinger H, Urbon-Bonine A, Duncan B. Feasibility of engaging college students in a 10-day plant-based diet. *Health Educ J*. 2018;77(8):952-963.

78. Aboul-Enein BH, Bernstein J. Feasibility of Internet-based Post-secondary Nutrition Education: Incorporating Features of the Mediterranean Diet. *Heal Promot Perspect*. 2015;5(2):92-97.

79. Bernardo GL, Jomori MM, Fernandes AC, Colussi CF, Condrasky MD, da Costa Proença RP. Positive impact of a cooking skills intervention among Brazilian university students: Six months follow-up of a randomized controlled trial. *Appetite*. 2018 Nov;130:247-55.

80. Dingman DA, Schulz MR, Wyrick DL, Bibeau DL, Gupta SN. Does providing nutrition information at vending machines reduce calories per item sold?. *J Public Health Policy*. 2015;36(1):110-22.

81. Mora-García C, Tobar L, Young J. The Effect of Randomly Providing Nutri-Score Information on Actual Purchases in Colombia. *Nutrients*. 2019;11(3):491.

82. Roy R, Beattie-Bowers J, Min Ang S, Colagiuri S, Allman-Farinelli M. The Effect of Energy Labelling on Menus and a Social Marketing Campaign on Food-Purchasing Behaviours of University Students. 2016.

83. Scourboutakos MJ, Mah CL, Murphy SA, et al. Testing a Beverage and Fruit/Vegetable Education Intervention in a University Dining Hall. *J Nutr Educ Behav*. 2017;49(6):457-465.e1.

84. Vermote M, Nys J, Versele V, D'Hondt E, Deforche B, Clarys P, Deliens T. The effect of nudges aligned with the renewed Flemish Food Triangle on the purchase of fresh fruits: An on-campus restaurant experiment. 2019.

85. Hua SV, Kimmel L, Van Emmenes M, Taherian R, Remer G, Millman A, Ickovics JR. Health Promotion and Healthier Products Increase Vending Purchases: A Randomized Factorial Trial. *J Acad Nutr Diet*. 2017;117(7):1057-1065.

86. Viana J, Leonard SA, Kitay B, Ansel D, Angelis P, Slusser W. Healthier vending machines in a university setting: Effective and financially sustainable. *Appetite*. 2017;121(2018):263-267.

87. Mistura M, Fetterly N, Rhodes RE, Tomlin D, Naylor P-J. Examining the Efficacy of a ‘Feasible’ Nudge Intervention to Increase the Purchase of Vegetables by First Year University Students (17–19 Years of Age) in British Columbia: A Pilot Study. *Nutrients*. 2019;11(8):1786.

88. Rajbhandari-Thapa J, Ingerson K, Lewis KH. Impact of trayless dining intervention on food choices of university students. *Arch Public Health*. 2018 Sep;76:61.

89. Mu D, Horowitz N, Casey M, Jones K. Environmental and economic analysis of an in-vessel food waste composting system at Kean University in the U.S. *Waste Manag*. 2017;59:476-486.

90. Pinto RS, dos Santos Pinto RM, Melo FF, Campos SS, Cordovil CM. A simple awareness campaign to promote food waste reduction in a University canteen. *Waste management*. 2018;76:28-38.

91. Monroe JT, Lofgren IE, Sartini BL, Greene GW. The Green Eating Project: Web-based intervention to promote environmentally conscious eating behaviours in US university students. *Public Health Nutr*. 2015;18(13):2368-2378.

92. Duram LA, Williams LL. Growing a student organic garden within the context of university sustainability initiatives. *Int J Sustain High Educ*. 2015;16(1):3-15.

93. Ahmed S, Byker Shanks C, Lewis M, et al. Meeting the food waste challenge in higher education. *Int J Sustain High Educ*. 2018;19(6):1075-1094.

94. Lorenz-Walther BA, Langen N, Göbel C, Engelmann T, Bienge K, Speck M, Teitscheid P. What makes people leave LESS food? Testing effects of smaller portions and information in a behavioral model. *Appetite*. 2019;139:127-144.

95. Godfrey DM, Feng P. Communicating sustainability: student perceptions of a behavior change campaign. *Int J Sustain High Educ*. 2017;18(1):2-22.

96. Gussow J, Clancy K. Dietary guidelines for sustainability. J Nutr Educ. 1986.

97. International Panel of Experts on Sustainable Food Systems. Unravelling the food-health nexus: Addressing practices, political economy, and power relations to build healthier food systems [Internet]. c2017 [cited 2020 May 28]. Available from: www.ipes-food.org

98. Majowicz SE, Meyer SB, Kirkpatrick SI, Graham JL, Shaikh A, Elliott SJ, Minaker LM, Scott S, Laird B. Food, health, and complexity: towards a conceptual understanding to guide collaborative public health action. *BMC Public Health*. 2016;16(1):487.

99. Bhunnoo R. A food systems approach to policy for health and sustainability [Internet]. 2018 [cited 2020 May 28]. Available from: https://www.foodsecurity.ac.uk

100. Roy R, Hebden L, Kelly B, De Gois T, Ferrone EM, Samrout M, Vermont S, Allman-Farinelli M. Description, measurement and evaluation of tertiary-education food environments. *Br J Nutr*. 2016;115(9):1598-606.

101. Swartz JJ, Braxton D, Viera AJ. Calorie menu labeling on quick-service restaurant menus: an updated systematic review of the literature. *Int J Behav Nutr Phys Act*. 2011;8(1):135.

102. Kiszko KM, Martinez OD, Abrams C, Elbel B. The Influence of Calorie Labeling on Food Orders and Consumption: A Review of the Literature. *J Community Health*. 2014;39(6):1248-1269.

103. Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza Dias BF, Ezeh A, Frumkin H, Gong P, Head P, Horton R. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *Lancet*. 2015;386:1973-2028.

104. Long MW, Tobias DK, Cradock AL, Batchelder H, Gortmaker SL. Systematic review and meta-analysis of the impact of restaurant menu calorie labeling. *Am J Public Health*. 2015;105(5):e11-24.

105. Sinclair SE, Cooper M, Mansfield ED. The Influence of Menu Labeling on Calories Selected or Consumed: A Systematic Review and Meta-Analysis. *J Acad Nutr Diet*. 2014;114(9):1375-1388.e15.

106. Fernandes AC, Oliveira RC, Proença RPC, Curioni CC, Rodrigues VM, Fiates GMR. Influence of menu labeling on food choices in real-life settings: a systematic review. *Nutr Rev*. 2016;74(8):534-548.

107. Bleich SN, Economos CD, Spiker ML, Vercammen KA, VanEpps EM, Block JP, Elbel B, Story M, Roberto CA. A Systematic Review of Calorie Labeling and Modified Calorie Labeling Interventions: Impact on Consumer and Restaurant Behavior. *Obesity*. 2017;25(12):2018-2044.

108. Powell LM, Chriqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: A systematic review of prices, demand and body weight outcomes. *Obes Rev*. 2013;14(2):110-128.

109. An R. Effectiveness of subsidies in promoting healthy food purchases and consumption: A review of field experiments. *Public Health Nutr*. 2013;16(7):1215-1228.

110. Thow AM, Downs S, Jan S. A systematic review of the effectiveness of food taxes and subsidies to improve diets: Understanding the recent evidence. *Nutr Rev*. 2014;72(9):551-565.

111. Gittelsohn J, Trude ACB, Kim H. Pricing Strategies to Encourage Availability, Purchase, and Consumption of Healthy Foods and Beverages: A Systematic Review. *Prev Chronic Dis*. 2017;14(11):170213.

112. Bowen DJ, Barrington WE, Beresford SAA. Identifying the Effects of Environmental and Policy Change Interventions on Healthy Eating. *Annu Rev Public Health*. 2015;36(1):289-306.

113. MacDiarmid JI. Is a healthy diet an environmentally sustainable diet? In: *Proceedings of the Nutrition Society*. Vol 72. Cambridge University Press; 2013:13-20.

114. Lea E, Worsley A. Australian consumers' food-related environmental beliefs and behaviours. *Appetite*. 2008;50(2-3):207-214.

115. Tobler C, Visschers VHM, Siegrist M. Eating green. Consumers' willingness to adopt ecological food consumption behaviors. *Appetite*. 2011;57(3):674-682.

116. Takacs B, Borrion A. The use of life cycle-based approaches in the food service sector to improve sustainability: A systematic review. *Sustain*. 2020;12(9).

117. Lawrence MA, Baker PI, Pulker CE, Pollard CM. Sustainable, resilient food systems for healthy diets: The transformation agenda. *Public Health Nutr*. 2019;22(16):2916-2920.

118. Hammond RA, Dubé L. A systems science perspective and transdisciplinary models for food and nutrition security. *PNAS*. 2012;109(31):12356-12363.

119. Seed B, Rocha C. Can we eat our way to a healthy and ecologically sustainable food system? *Can Food Stud / La Rev Can des études sur l'alimentation*. 2018;5(3):182-207.

120. Handley MA, Lyles CR, Mcculloch C, Cattamanchi A. Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research. *Public Health*. 2018;39:5-25.

121. Stuart, Elizabeth A. and Donald B. Rubin. Best Practices in Quasi–Experimental Designs: Matching Methods for Causal Inference. In: Osborne J, editors. Best Practices in Quantitative Methods. Thousand Oaks, CA: SAGE Publications Inc., 2008. p. 155-76.

122. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: considerations and caveats. *J Acad Nutr Diet*. 2018;118(9):1603-21.

123. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, Wilson MM, Reedy J. Update of the healthy eating index: HEI-2015. *J Acad Nutr Diet*. 2018;118(9):1591-602.

124. Jones AD, Hoey L, Blesh J, Miller L, Green A, Fink Shapiro L. A Systematic Review of the Measurement of Sustainable Diets. *Am Soc Nutr*. 2016;7:641-664.

125. Guinee J, Jeijungs R, Huppes G, et al. Life Cycle Assessment: Past, Present, and Future †. *Env Sci Technol*. 2011;45:90-96.

126. Heller MC, Keoleian GA, Willett WC. Toward a Life Cycle-Based, Diet-level Framework for Food Environmental Impact and Nutritional Quality Assessment: A Critical Review. *Environ Sci Technol*. 2013;47(22):12632-12647.

127. Perignon M, Vieux F, Soler LG, Masset G, Darmon N. Improving diet sustainability through evolution of food choices: Review of epidemiological studies on the environmental impact of diets. *Nutr Rev*. 2017;75(1):2-17.

128. Glasgow RE, Harden SM, Gaglio B, Rabin B, Smith ML, Poter GC, Ory MG, Estabrooks PA. RE-AIM planning and evaluation framework: Adapting to new science and practice

with a 20-year review. *Front Public Heal*. 2019;7(MAR):64.

129. Linnan L, Steckler A, editors. Process evaluation for public health interventions and research: An overview. In: Process Evaluation for Public Health Interventions and Research. San Francisco, CA: Jossey-Bass; 2002. p. 11–21.

130. Volpe SL, Hall WJ, Steckler A, Schneider M, Thompson D, Mobley C, Pham T, El Ghormli L. Process evaluation results from the HEALTHY nutrition intervention to modify the total school food environment. *Health Educ Res*. 2013;28(6):970-978.

131. Maynard M, Lahey D, Abraham A. Campus food report card: The state of food on Ontario university campuses [Internet]. Toronto, ON; c2018 [cited 2020 May 28]. Available from: https://www.mealexchange.com/reportcard/

132. University of Waterloo. Environmental Sustainability Report [Internet]. Waterloo, ON; c2018 [cited 2020 May 28]. Available from: https://uwaterloo.ca/

CHAPTER 6: Evaluating the impact of numeric versus traffic light calorie labelling at the point-of-purchase on young adults' food and beverage purchases

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6.1 Overview

Background: There is high policy interest in calorie labelling on menus, but the impact of numeric versus traffic light formats in real-world settings remains poorly understood.

Methods: Using a pre-post quasi-experimental controlled design, three post-secondary cafeterias received numeric calorie labelling, traffic light calorie labelling (TLL), or no labelling for two weeks. Exit surveys were conducted with patrons prior to and following label implementation (N=1799; n=854 pre-intervention, n=945 post-intervention). Generalized estimating equation modelling was used to determine impacts of label format on noticing, use, and calories purchased. Logistic regression was used to examine differences in perceptions. Differences by gender, health literacy, disordered eating, and socioeconomic status were considered. Sales data were acquired and examined using ANOVA tests.

Results: The increase in noticing of nutrition information from pre-test to post-intervention was significantly greater at the numeric (+19.5%; OR=3.13, 95% CI=1.79–5.47) and TLL sites (+33.6%; OR=5.14, 2.95–8.96) than the control (–0.53%). Reported use of nutrition information was significantly greater from pre-test to post-test at the numeric (+9.20% vs. –0.30%; OR=2.43, 95% CI=1.14–5.19) and TLL (+27.5%; OR=5.26, 2.51–11.0) sites relative to the control. Among post-test patrons, 32% rated numeric and 48% rated TLL as easy to understand, and 25% rated numeric and 42% rated TLL as easy to use. No differences in three-way interactions with site and time were observed by gender, health literacy, disordered eating, and socioeconomic status for noticing, use, and perceptions. The findings on calories purchased were inconclusive given the assumption of parallel trends across sites could not be satisfied. The labels had no effect on daily sales, total transactions, and sales per patron.

Conclusions: Increased noticing and use of nutrition information was observed following implementation of numeric and TLL, with higher proportions of patrons expressing TLL were easy to use and understand. Examining the overall quality of foods and beverages purchased is needed to identify whether calorie labelling impacts choices beyond calorie composition.

Keywords: calorie label, traffic light label, food labelling, nutrition information, nutrition policy, quasi-experiment, post-secondary, universities, cafeterias, young adults

6.2 Introduction

Dietary risk factors are among the leading contributors to morbidity and mortality.[1] There is currently an unprecedented level of focus globally toward identifying interventions to support healthy eating among populations,[2–5] with recognition of the influence of environmental factors on dietary choices.[2,6,7] Nutrition labelling has received particular attention, such as within *Canada's Healthy Eating Strategy*,[8] to support consumers in making informed food selection and purchasing decisions. While nutrition labelling has traditionally focused on pre-packaged foods, there is growing attention toward nutrition labelling at the point-of-purchase because of a shift in recent decades toward increased consumption of foods prepared outside of the home.[9–12]

Nutrition labelling at the point-of-purchase has primarily focused on displaying calorie amounts on menus, driven by observations that energy content can vary among similar menu items and that consumers generally lack awareness about the caloric content of products prepared and consumed outside of the home.[10–12] Internationally, a number of jurisdictions have moved toward mandatory calorie labelling on menus. For example, in New York City, restaurants and fast-food chains with more than 20 locations are required to post calorie and sodium information for items on menus.[13] Similarly, the Healthy Menu Choices Act in Ontario, Canada requires establishments with 20 or more locations to present numeric calorie information and a contextual statement on menus.[14] The United Kingdom recently announced that large businesses with more than 250 employees will be required to display calorie amounts for non-prepackaged foods and beverages.[15] Although interest in calorie labelling is high, evidence on impact is mixed. In studies evaluating awareness of calorie labelling, 28% to 92% of respondents self-reported noticing nutrition information,[16–28] with approximately one-third of those who noticed the nutrition information also reporting label use.[17–24] Systematic reviews and meta-analyses[29–37] of naturalistic and experimental studies suggest that numeric calorie labelling has a modest, if any, impact on calories ordered or consumed.[29–31,33] However, there is consensus across reviews that conclusions are based on limited data and most existing studies lack adequately-powered designs with a comparison group.[29,31–35]

Building on nutrition labelling approaches developed for front-of-package labels, there has been speculation about the potential effectiveness of interpretive formats, such as traffic light labels

(TLL), to encourage healthy food choices based on at-a-glance summary indicators. TLL were first proposed in the United Kingdom[38–40] and were intended to convey whether foods and beverages are high, medium, or low in selected dietary components (e.g., calories, sodium) in relation to defined criteria using red, amber, and green traffic lights. Research focused on TLL formats for front-of-package labels suggests that consumers notice, prefer, and use this format to a greater extent than formats displaying only numeric information.[41–45] A small body of literature[46–55] comparing impacts of numeric versus TLL at the point-of-purchase suggest that the inclusion of the TLL indicator led to reductions in calories purchased relative to numbers alone. Systematic reviews, with pooled estimates examining one of numeric or TLL formats in comparison to control groups or baseline data, suggest consumers purchased fewer calories when labels included interpretive information in comparison to numeric information alone.[32–34] However, the paucity of well-powered naturalistic trials directly comparing the two label formats poses a barrier to understanding whether one format could better support food and beverage purchasing decisions,[34] particularly in the context of complex settings where consumer behaviour is impacted by social and environmental factors.

In addition to uncertainties about overall impacts of labels, there are questions about whether calorie labelling regulations have differential impacts and unintended consequences across sociodemographic subgroups. A study using national surveillance data from the United States found menu labelling was noticed and used more often by individuals who were white, more educated, and in higher income groups.[56] Similarly, a review found a greater effect on awareness and purchasing among consumers with high compared to low socioeconomic status (SES).[57] Lower SES has been associated with poorer understanding of labels, potentially widening diet-related disparities.[58] Concerns have also been raised regarding the potential for calorie labelling to promote or exacerbate disordered eating;[59–64] however, the limited available evidence suggests no adverse effect on indicators of disordered eating.[59,61,62] Nonetheless, studies have shown women use labels to select items with fewer calories,[32] which may be of concern given the high prevalence of disordered eating among young adult women.[65] There is a paucity of research comparing numeric and TLL in relation to gender, health literacy, SES, and eating disorder risk.

The objectives of this study were to examine, in the real-world, the impact of numeric versus traffic light calorie labelling on: (1) consumer noticing, self-reported use, and perceptions of labels; (2) changes in food and beverage purchasing; and (3) differences in label impact among subgroup populations by gender, health literacy, SES, and eating disorder risk. Findings related to changes in the proportions of TLL-categorized foods by site and phase, as well as differences in the quality of foods and beverages purchased, for example, with respect to sodium and added sugars content, are reported elsewhere.

6.3 Methods

A pre-test, post-test quasi-experimental controlled trial was conducted at a large Canadian university from March to April 2019. Post-secondary campuses offer a unique consumer environment to evaluate interventions in a real-world setting.[66–69] Three residence cafeterias, catering to ~1000-2000 students each, were randomly assigned to receive numeric calorie labelling, traffic light calorie labelling, or no labelling (control) (**Chapter 4; Figure 2**). Exit surveys were administered during lunch (~11:30 AM to 2:30 PM) and dinner (~5:30 to 8:30 PM) periods to patrons at all three cafeterias during the 2 weeks prior to and 2 weeks following a 1-week label implementation period. Labels remained in place throughout the 2-week post-test phase. Sales data were collected for the study period and the same months during the prior year.

The study was conducted according to guidelines in the Declaration of Helsinki and all procedures involving human subjects were approved by the University of Waterloo Office of Research Ethics (#31830), the University of Calgary Conjoint Health Research Ethics Board, and the Public Health Ontario Ethics Committee. The data collection protocol and analysis plan were registered with the Open Science Framework in November 2019 (available at: https://osf.io/bxfw2).

6.3.1 Sample and recruitment

The sampling frame was limited to patrons of cafeterias in residences that primarily house first-year students to maximize similarity among students served. The three residence cafeterias were as geographically disparate as possible across campus to limit the possibility of students being exposed to the label conditions in other cafeterias. The cafeterias were centrally managed by an on-campus food service operation and provided similar offerings across sites, including hot entrée stations, salad and sandwich bars, customizable stations for meals (e.g., pasta and rice bowls, pizzas), grills (e.g., burgers, French fries), and grab-and-go stations offering pre-packaged foods, beverages, and snacks. Hot entrées rotated on a weekly basis and were offset across cafeterias (i.e., one cafeteria was on week 1 while another is on week 2). All other stations provided similar offerings, and beverages and snacks remained the same across sites (**Appendix C**). The cafeteria with TLL included a branded outlet offering smoothies, categorized as snacks for analysis purposes.

Eligible participants included currently enrolled students who reported purchasing a food and/or beverage immediately prior to recruitment. Students were not eligible if they participated in cognitive testing of study materials. Staff and faculty were not eligible to maintain comparable samples between cafeterias. The target sample size was informed by a naturalistic study conducted by Seward et al.[43] and an experimental study by Hammond et al.,[48] using data reported on noticing of labels[43] (binary outcome) and calories consumed[48] (continuous outcome). All calculations assume a significance level of 0.05. Based on Seward et al.,[43] a sample size of approximately 200 at each site was deemed to provide 80% power to detect a difference of 10% in the number of individuals who notice labels across conditions. Based on Hammond et al.,[48] a sample size of 485 at each site was estimated to provide 80% power to detect a difference of 63 calories consumed between the TLL and control condition. Comparing the numeric calorie condition to the control condition, a sample size of 236 at each site provided 80% power to detect a difference of 95 calories purchased. Using these calculations as a frame of reference, a sample size of 295 students per site was hypothesized to provide 80% power to detect differences in calories purchased of ~10% and in label noticing of ~6% across labelling conditions. Therefore, the desired sample included 300 students per site during each of the pre-test and post-test phases, totaling 1,800 participants.

Recruitment took place during lunch and dinner and booths were set up in unobtrusive locations at the exits of cafeterias. Informational posters about the study were displayed in the cafeterias throughout the study period (**Appendix G**). Trained research assistants provided patrons who approached the booth with a brief overview of the study (**Appendix H**). Those who expressed interest were provided with an iPad loaded with an eligibility screener, information letter, and consent form (**Appendix I**). Eligible patrons who provided consent were then linked to the exit survey (~18 minutes to complete, on average). Participants who completed the survey received a

$5 honorarium in cash for their time. Since responses after prior exposure to the survey may demonstrate response bias (e.g., knowledge of survey questions), patrons who indicated they had already completed the survey that week were not eligible.

A total of 3355 patrons were approached during the data collection period and 2056 responses were collected (949 during pre-test, 1107 during post-test). The response rate (response rate #4 by the American Association for Public Opinion Research) was 57% and 65% at the pre-test and post-test phases respectively.[70] Unique participant IDs were used to identify repeat responses and only the first response from participants within each phase retained for analyses; this resulted in the exclusion of 87 pre-test responses and 127 post-test responses. After removing responses with data quality concerns (i.e., participants said "Don't know" to all questions related to purchasing and 80% of sociodemographic questions; n=43), the analytic sample included 1799 respondents (n=854 responses during pre-test, n=945 responses during post-test). Of these, 216 participated in both the pre-test and post-test phases.

A total of 101 participants (n=26 during pre-test, n=75 during post-test) did not report a meal, beverage, and snack (see measures, below). Results for noticing, use, and perceptions did not change after conducting a sensitivity analysis excluding these participants. Thus, the participants were retained in the analysis for noticing, use, and perceptions to maintain sample size and power, but excluded from the analysis on calories purchased. The final sample for examination of calories purchased was 1698 respondents (n=828 responses during pre-test; n=870 responses during post-test), with 204 participants providing data in both phases.

6.3.2 Intervention

The labels were based on designs used in prior studies[40,44,48] and developed in consultation with campus food services and their on-staff dietitian, as well as members of the research team (**Chapter 4; Figures 3 and 4**). Both labelling formats included numeric calorie information and the comparison between formats examined any added effect of the red, amber, and green indicators. A plain-language educational poster was based on a webpage maintained for Ontario's Healthy Menu Choices Act [14] and included contextual information consistent with the mandate (i.e., **"*Adults and youth (ages 13 and older) need an average of 2,000 calories a day. However, individual needs vary.*"**) (**Appendix D**). The labels and educational posters were tested in cognitive interviews[71,72] with undergraduate students (n=10) and modified to improve readability and understanding (**Appendix E and F**). Participants received $5 honorarium in cash.

An online nutrition information database maintained by campus food services was used to identify the calories provided by a standard serving each item.[73] For items not listed in the database, calorie amounts and serving sizes were identified based on close matches within the Canadian Nutrient File,[74] publicly available via Health Canada. Numeric labels displayed the calories provided by a serving of the item. For the TLL, the numeric amount was accompanied by a red, amber, or green symbol, based on the United Kingdom Food Standards Agency guidelines for TLL on prepackaged foods,[40,75] which provides calorie cut-offs for each colour per serving of foods or beverages, respectively. Criteria for TLL cut-offs were based on a 2,000-calorie diet, consistent with prior TLL studies.[48,55]

Following the pre-test phase in mid-March 2019, labels were positioned and monitored in cafeterias for ~3 weeks, with post-test data collection beginning after the first week of implementation. Labels were posted adjacent to foods and beverages or on menu boards, using the same font and size as the item name and price (**Chapter 4; Figure 5**). Educational posters and contextual information were placed in multiple locations throughout the intervention cafeterias (e.g., on counters and screens) throughout the post-test phase.

6.3.3 Exit survey and measures

An online exit survey, consistent across phases, was completed on tablets using Qualtrics software Version March 2019 (Qualtrics; Provo, Utah, United States).[76] The questions were adapted from prior research[22,23,44,48] and drew upon indicators used in national surveillance,[77] when applicable. The survey was tested using cognitive interviews with a sample of undergraduate students (n=10) to ensure understanding and clarity of questions; participants received an honorarium of $5 cash. The final exit survey (**Appendix K**) queried noticing, perceptions, and use of nutrition information; information on the most recent purchase at the cafeteria; socio-demographic information (e.g., age, gender, race); information related to consumer behaviour (e.g., average number of visits per week); indicators of health literacy,[78] SES,[79] and disordered eating;[80] and unique identifiers (i.e., day of birth, mother and father's initials, and city of birth) to enable linking repeat responses from the same participant.[81,82]

Noticing, use, and perceptions of nutrition information

Patrons were queried about noticing, use, and perceptions of nutrition information. To minimize social desirability bias (e.g., participants responding positively to the intervention because they were aware of the focus on calorie labels), questions specified *nutrition information* rather than specifically calorie labels. Participants who reporting noticing nutrition information were queried about the location and type of nutrition information noticed.[23,24]

Participants who reported noticing nutrition information were asked whether they used the information to help make their food and beverage purchases[23,44] and the extent to which it influenced their purchase (2='a lot'; 1= 'a little'; 0=no influence).[48] Those who did not notice the labels were categorized within no influence on their purchase. Participants who indicated using the labels were asked about their strategy for using the nutrition information, for example, by selecting items with fewer calories or identifying items perceived as healthy. Among those who noticed the labels, behavioural responses to nutrition information were queried, including whether the nutrition information led them to order something different, eat less of the food ordered, choose to eat somewhere else, or eat at the location less often. Participants who reported noticing nutrition information were also asked about ease of understanding and ease of use of nutrition information using a 5-point scale, which was categorized into a binary response for modelling (1=very easy/easy; 0=neutral/difficult/very difficult).[48] Finally, participants were asked if the nutrition information made them feel more or less in control of making healthy eating decisions (1=more in control; 0=less in control or neutral).

Calories purchased

Participants were queried for the details of their recent purchase at the recruitment site. The exit survey was pre-populated with items sold in the cafeteria, including entrées, beverages, and snacks, and prompted respondents for specific details (e.g., options for add-ons, such as sauce or cheese). Participants could also enter open-text details about their purchase; open-text responses were matched to items sold at the cafeterias. The online nutrition information database, complemented by the Canadian Nutrient File,[74] used to create the labels was used to estimate total calories purchased overall and for entrées, beverages, and snacks. A small number of participants (n=33) had purchases with a total of 0 calories due to selection of items such as water or diet soda; these responses were considered valid and included in the analysis.

Covariates

Potential confounders were identified *a priori* and included age (continuous), gender (man/woman; other specified identities not included due to low sample sizes),[51] race (white/person of colour),[22,56] frequency of visits to cafeteria in the past week (continuous),[44] health literacy,[23,58] socioeconomic status,[56,58] and disordered eating risk.[59,61,83] Eating occasion was included as a covariate to adjust for differences in purchasing behaviour at lunch and dinner.

Age was included in the models as a continuous variable (years) and calculated by subtracting year of birth from the study year (2019). The exit survey collected information on gender identity, including options for man, woman, trans man, trans woman, non-binary, and other specified identity. Responses for trans man, trans woman, non-binary, and other specified identities were collapsed and provided in tables demonstrating sample characteristics. However, given low cell sizes, gender identity was collapsed into a binary variable (man/woman) for inclusion as a covariate in the model and non-binary responses were not included in the analyses. Drawing upon data collected for ethnicity, race was collapsed into a binary variable (white/person of colour).

Health literacy was assessed using the Newest Vital Sign,[78] yielding a score out of 6 based on responses to questions about the nutrition information provided for a pint of ice cream. Health literacy was coded based on categories for adequate literacy (total score of 4 to 6); low likelihood of limited literacy (2 to 3); and high likelihood of limited literacy (0 to 1).[78] SES was measured using a question on subjective social status[79] (SSS), where participants were provided with a 10-point ‘societal ladder’ and identified where they would rank themselves (1=high; 10=low). Rankings for SSS were included as a continuous variable in all models from 1 to 10. SCOFF,[80] a 5-item questionnaire to observe eating disorder symptomology among non-clinical populations, was used to measure disordered eating risk. Affirmation of 2 or more questions indicated high likelihood of disordered eating risk and coded as a categorical variable (0-1=unlikely demonstrating disordered eating; 2-5=likely demonstrating disordered eating). Measures of health literacy, SES, and disordered eating risk have been demonstrated to have reasonable reliability and validity among young adults.[78–80,84,85]

6.3.4 Sales data and measures

Sales data for the three cafeterias were provided by campus food services for the data collection period. Data included daily sales, number of transactions, and dollars spent per transaction for the pre-test and post-test phases. Changes in sales were examined to address potential industry concern about the effect of calorie labelling on profit and revenue.[86]

6.3.5 Analysis

Analyses were conducted using SAS® Studio (Version 9.04, SAS Institute, Cary, NC). All tests were interpreted using a significance level of 0.05. Odds ratios with 95% confidence intervals are reported, unless otherwise specified.

Given the non-randomized nature of the experiment, preliminary ANOVA (continuous variables) and Pearson χ^2 tests (categorical variables) were used to describe any differences across sites; correlations were not used to inform inclusion of covariates in models. Descriptive statistics were also calculated for the proportions noticing and using labels and perceptions of nutrition information. The distributions of calories purchased were right skewed and therefore, medians are reported.

Generalized estimating equation (GEE) models were used to generate population-averaged mean responses of participants at each site across test phases, accounting for repeat responses among those who participated at both pre-test and post-test. Separate GEE models assessed each of noticing of nutrition information and recall of type of nutrition information noticed, nutrition information use, behavioural responses to nutrition information, and calories purchased. Participants who did not report a meal, beverage, and snack were excluded from the analyses of calories purchased. An interaction between site and phase estimated the difference in the change of each outcome from pre-test to post-test across sites (see **Appendix M** for model output for interactions). Age, gender, race, frequency of visits to the cafeteria in the past week, health literacy, disordered eating risk, and SSS were included in all models.

Descriptive statistics were used to describe differences in perceptions of labelling formats among post-test participants. Logistic regression models were used to examine differences in perceptions across sites among the post-test participants who noticed the labels (n=358).

Three-way interactions between site, phase, and covariates for gender, health literacy, disordered eating risk, and SSS were individually tested in the models to examine for subgroup differences in noticing, use, perceptions, and calories purchased.

Finally, ANOVA tests assessed differences in mean total sales, number of transactions, and sales per patron by site and phase.

6.4 Results

6.4.1 Sample characteristics

Table 4 demonstrates characteristics of the sample by site and phase. The mean age was 19.3 years, with no differences by gender across sites and phases. Approximately one-third of the sample demonstrated high likelihood of disordered eating risk and one-third also had a high likelihood of limited literacy. The average score for SSS was ~4.5 (max, 10). Significant differences were observed across sites for frequency of visits per week (F=7.92, *df*=2; p<0.001) and racial identity (χ^2=31.2, *p* <0.001). From pre-test to post-test, significant differences were observed for frequency of visits (F=10.82, *df*=1; *p*=0.001), racial identity (χ^2=13.4, *p* <0.001), and health literacy (χ^2=13.1, *p*=0.001).

6.4.2 Noticing of nutrition information

Figure 7 demonstrates the proportions of participants who noticed nutrition information at each site by phase. There was a significant difference in reported noticing of nutrition information at the numeric site from pre-test to post-test relative to the control (+19.5% vs. –0.53%; OR=3.13, 95% CI=1.79–5.47). Similarly, noticing at the TLL site significantly increased from pre-test to post-test in comparison to the control (+33.6%; OR=5.14, 2.95–8.96). There was no change in noticing nutrition information at the control site from pre-test to post-test (OR=0.85; 0.55–1.20). No significant differences were observed when comparing noticing at the numeric versus TLL site from pre-test to post-test (OR=1.64, 0.99–2.72). The three-way interactions for gender, health literacy, disordered eating, and SSS with site and phase were not significant for noticing of nutrition information (p>0.05 for all); descriptive statistics are provided for noticing by subgroups in **Appendix M**.

From pre-test to post-test, there was a significant increase in respondents recalled noticing calorie information rather than other types of nutrition information) at the numeric (+19.1%; OR=3.04, 1.59–5.79) and TLL sites (+27.0%; OR=3.59, 1.92–6.73) compared to the control site (–0.70%) (**Table 5**). There were no significant differences in the change in noticing calorie information between the numeric and TLL conditions (OR=1.18, 0.69–2.02).

6.4.3 Use and influence of nutrition information on purchasing decisions

Figure 8 shows the proportion of participants who reported using nutrition information to help make their purchasing decisions at each site, by phase. From pre-test to post-test, a significant increase in reported use of nutrition information was observed at the numeric (+9.20% vs. –0.30%; OR=2.43, 95% CI=1.14–5.19) and TLL sites (+27.5%; OR=5.26, 2.51–11.0) relative to the control (OR=0.91, 0.50–1.65). From pre-test to post-test, a difference between the numeric and TLL sites was observed (OR=2.17, 1.15-4.08). No significant three-way interactions between test phase, site, and each of gender, health literacy, disordered eating, and SSS were observed ($p>0.05$ for all).

Among respondents at the numeric labelling site at post-test, 13% reported using the nutrition information 'a little' and 7% reported 'a lot' to help make their purchasing decisions (**Table 5**) (32% and 17%, respectively, among those noticing nutrition information). At the TLL site, 33% reported using the nutrition information 'a little' and 5% reported 'a lot' during the post-test phase (56% and 8% among those who noticed). An increase from pre-test to post-test in respondents reporting they used the nutrition information to identify healthy versus less healthy items was observed at the TLL site compared to the control (+16.1% vs. +5.12%; OR=5.53, 2.37–12.9). Among those who indicated they noticed the labels, an increase in the proportion who reported eating less of their food from pre-test to post-test was observed at the numeric site relative to the control (+6.37% vs. –1.04%; OR=4.47, 1.39–14.4). Similarly, at the TLL site, there was an increase from pre-test to post-test in participants reporting they ordered something different (+15.1% vs. –0.71%; OR=4.09, 1.76–9.49) compared to the control. No significant differences were observed when three-way interactions for gender, health literacy, disordered eating, and SSS were included in models examining label use and behavioural responses ($p>0.05$ for all); descriptive statistics are provided for use by subgroups in **Appendix M**.

6.4.4 Perceptions of nutrition information

Table 5 demonstrates perceptions of the nutrition information following implementation. At post-test, 32% and 48% of participants rated the nutrition information as easy/very easy to understand at the numeric and traffic light labelling sites, respectively (versus 12.1% at the control). Similarly, 26% and 43% of post-test participants rated the nutrition information as easy/very easy to use at the numeric and traffic light labelling sites, respectively (versus 10% at the control). Among those who noticed the labels during the post-test phase (n=358), no differences were observed for ratings of ease of understanding (OR=1.03, 0.45–2.32) and ease of use (OR=0.74, 0.43–1.30) when comparing the numeric and TLL sites. At post-test, 18% of participants at the numeric site and 32% at the TLL site reported that they felt more in control of making healthy eating decisions (versus 9% at the control), respectively, whereas 18% at the numeric site and 22% at the TLL site reported that they felt neutral or less in control of making healthy eating decisions (versus 5% at the control). No differences by label format were observed in perceptions related to control in making healthy eating decisions among those who noticed the labels during the post-test phase (OR=0.65, 0.39–1.09).

6.4.5 Calories purchased

Figures 9-12 shows the median and range of calories purchased overall (Range: 0 to 5174 kcal) and for each of entrées (Range: 0 to 5024 kcal), beverages (Range: 0 to 720 kcal), and snacks (Range: 0 to 980 kcal), by site and phase for the lunch and dinner periods. No significant difference in the change in overall calories purchased was observed from pre-test to post-test at the numeric label site relative to the control (β=60.8, 95% CI=-96.2–217.8; p=0.45) (**Figure 9**). In comparison to the control, a decrease in overall calories purchased was significant at the TLL site from pre-test to post-test (β=186.6, 33.8-339.5; p=0.02). When compared to the control, no difference was observed for the entrées category when comparing the numeric labelling site (β=91.7, -85.8–269.2; p=0.31) from pre-test to post-test. However, a significant difference was observed at the TLL site (β=186.8; 14.2–359.4 p=0.03) from pre-test to post-test (**Figure 10**). There were no differences in the changes in calories purchased for beverages at the numeric labelling (β=22.3, -8.13–52.7; p=0.15) and the TLL sites (β=27.0, -6.58–60.4; p=0.12) relative to the control from pre-test to post-test (**Figure 11**). Similarly, no significant differences in calories purchased from snacks were observed at the numeric labelling (β=-19.1, -86.2–48.0; p=0.58) and TLL sites (β=45.8, -25.8–117.3; p=0.21) relative to the control (**Figure 12**). Three-way interactions for gender, health literacy, disordered eating, and SSS were not significant (p>0.05 for all).

6.4.6 Sales

Table 6 demonstrates mean daily sales, number of transactions, and dollars spent per transaction by site at each phase. No differences were observed at the numeric site for daily sales (p=0.91), number of transactions (p=0.87), and dollars spent per transaction (p=0.42) relative to the control. Similarly, there were no differences when comparing the TLL site to the control for daily sales (p=0.60), number of transactions (p=0.73), and dollars spent per transaction (p=0.44).

6.5 Discussion

We observed that exposure to numeric labels and TLL increased noticing and use of nutrition information among young adults in campus cafeterias, consistent with current literature examining each of numeric and TLL calorie labels in isolation.[16–24] When comparing the numeric and TLL sites, a significant difference in use was observed. Further, a greater proportion of respondents at the TLL site versus the numeric site reported noticing calorie information and indicated the nutrition information was easy to use and understand. Other studies have also demonstrated increased noticing and use of calorie labels and preference for TLL among youth and young adults,[23,43] further signifying that students may be a captive audience for interventions such as calorie labelling.

At all sites, a downward trend in median calories purchased was observed for overall purchases and by categories for entrées, beverages, and snacks at lunch and dinner periods (except for entrées and beverages for lunch and snacks for dinner at the TLL site, during which an increase was observed). The observed pattern in median calories purchased suggests a potential effect of the labels; however, there were large differences in calories purchased at all sites during the pre-test period. There was also a large unexplained difference in calories purchased at the control site between the pre-test and post-test period. Therefore, the data did not satisfy the assumption of parallel trends required for quasi-experimental trials.[87–89] The decrease in calories purchased at the control site may reflect weekly variations in hot meal offerings or minor differences in offerings across the cafeterias, potentially biasing findings toward the null. We conducted an additional investigation of all offerings and observed only minor differences in calories across sites; for example, the difference in calories for hot meal offerings was within 5% (**Appendix C**). At all sites, purchasing patterns may have been affected by the timing of the data collection period, with the post-test period overlapping with the end of the academic term. For example, the frequency of visits at the TLL site decreased from pre-test to post-test and it's possible that purchasing patterns also changed. Therefore, the GEE analyses of calories purchased were inconclusive, warranting further investigation using sales data for the pre-test and post-test periods. Of note, our findings related to increased noticing and use of nutrition information suggest the intervention was implemented as planned and differences may be due to uncontrolled confounding described above.

Current evidence comparing numeric and TLL suggests that both formats could have a small impact on calories purchased, though findings are inconsistent regarding which performs better.[46,48–51,53–55] In a meta-analysis of controlled experimental and real-world studies, Sinclair et al.[32] found consumers purchased (–67 kcal; p=0.008) and consumed (–81 kcal; p=0.007) fewer calories when labels included interpretive information in comparison to numeric information alone. Experimental studies suggest calorie labels, regardless of format, may lead to small reductions in calories purchased; however, these findings are not consistent among experimental studies examining food and beverage choices by parents for their children.[50,54,55] In a field experiment at a restaurant,[46] TLL significantly reduced entrée calories ordered but not ordering of additional items such as beverages and snacks. In a field experiment at a restaurant,[46] both the numeric and TLL significantly reduced entrée calories ordered but not ordering of additional items such as beverages and snacks. A review of real-world studies by Bleich et al.[34] noted that calorie labels may demonstrate a greater decrease in calories purchased in certain types of restaurants and cafeterias, suggesting the context of the setting may influence the performance of numeric and traffic light calorie labels.

Although the findings on calories purchased were inconclusive, numeric and TLL may increase consumer awareness of nutrition information. We observed that those at TLL site reported the nutrition information led them to order something different, whereas those at the numeric site reported they consumed less food. This finding potentially speaks to the variation in calories purchased at the numeric and TLL sites and demonstrates how the formats may be used to compensate purchasing decisions. An experimental marketplace study comparing numeric and TLL[48] found calories purchased did not differ depending on format, but calorie consumption was lower among those who received menus with numeric calorie labels. In the current study, we did not observe consumption, but some patrons did report the labels led them to consume less food. Future research should utilize robust dietary assessment methods to collect information on how labels affect the totality of dietary intake and implications on compensatory behaviour.[34,90]

While we did not observe differences in the three-way interactions for health literacy and SES for all outcomes, we did observe greater noticing and use of nutrition information among those in adequate health literacy and high SSS groups. A prior quasi-experimental study of calorie labelling[23] found that nutrition information noticing and use was greater among youth and young adults living in households affected by moderate or severe food insecurity compared to those in food-secure groups, with no difference by levels of health literacy. Other studies have shown greater noticing and use of nutrition information among high-income individuals.[21,56,91–93] We also did not find differences when comparing groups demonstrating disordered eating risk versus not, consistent with prior research[59,94] suggesting no adverse outcomes on indicators for disordered eating (e.g., body image satisfaction). We used a brief assessment of disordered eating risk; however, further examination of experiences with calorie labelling among individuals with clinically diagnosed eating disorders and the implication on their recovery is needed. In a survey of hypothetical purchases, women with anorexia nervosa and bulimia nervosa ordered fewer calories, while women with binge eating disorder ordered more calories in the menu labelling conditions versus no labelling,[61] warranting further investigation among this population.

Daily sales, numbers of transactions, and dollars per transaction were maintained throughout the data collection period. In an examination of TLL in recreation and sport facility eating environments, Olstad et al.[44] observed a small reduction in sales of red-labelled items and a small increase in sales of green-labelled items, with no change to daily revenues, potentially minimizing perceived industry concerns of implication on revenue loss as a result of labelling. In a review of perceptions of nutrition labelling at the point-of-purchase, Kerins et al.[86] suggest successful implementation of the intervention is influenced by multi-level contextual factors that include the food service sector, speaking to the need for collaborations across stakeholders in post-secondary settings (e.g., food service operators, registered dietitians, students) to support healthy eating patterns.

The global interest on interpretive front-of-package labelling[95–97] begs the question of whether point-of-purchase labelling should follow a similar approach, contributing to a harmonized nutrition information system. The findings from the present study suggest calorie labelling may improve noticing and use of nutrition information; however, the findings related to the impact of the labels on calories purchased were inconclusive. TLL may support increased use of nutrition information by prompting individuals to select different items, whereas numeric labels may reduce calories consumed. Jurisdictions considering calorie labelling should carefully consider the intention behind implementation; for example, if the policy is intended to reduce caloric intake or shift overall diet quality of purchasing and consumption. Although our focus on calories was a study design decision to enable direct comparison of formats, others have developed scoring criteria for TLL based on food groups (e.g., whole grains) and nutrients (e.g., sodium, saturated fat) to more holistically capture nutritional quality.[98] Nutrition labelling has also been shown to stimulate manufacturers to reformulate products,[96] potentially resulting in a healthier food supply (e.g., removing trans fats and lowering sodium and sugar levels). With consistent implementation across settings, it is possible calorie labelling at the point-of-purchase may spur broader reformulation and changes to offerings, playing a role in improving eating patterns within a suite of integrated and reinforcing food and nutrition policies.[2,99]

This study was limited to post-secondary students visiting three residence cafeterias. The findings may be generalizable to situations in which patrons visit the same site regularly (e.g., residence and workplace cafeterias) but are potentially not applicable to other settings, such as fast-food outlets. Many participants may have been exposed to other forms of nutrition information in the cafeteria (e.g., labels indicating vegan and vegetarian options) or numeric calorie labelling in other settings, including branded outlets on campus, potentially dampening their impact. It is possible participants in this study did not prioritize healthy eating and instead emphasized convenience and taste,[100–102] particularly since the study was collected toward the end of the academic term. Collecting detailed data at the individual-level allowed for examination of differential impacts among subgroups, whereas prior studies have primarily used aggregate sales data. However, measures of health literacy, SSS, and eating disorder risk were limited, perhaps biasing analyses on subgroup differences toward the null. We aimed to alleviate inherent biases from self-reporting, for example, by prompting participants for specific details about their purchase (recall bias) and partially disclosing information about the focus on calorie labelling (social desirability bias). While repeat responses were excluded potentially raising concerns about power, a post-hoc power analysis of the study sample and *a priori* estimates from our initial sample size calculation demonstrated that the study was powered to detect a 10% difference in calories purchased. Some comparisons were outside of this magnitude, for example, there was a 1.2% difference in calories purchased at the TLL site compared to the control. Therefore, we suspect that any replication studies using a similar study design may find effects and differences that we were unable to in this study.

In conclusion, the introduction of numeric and TLL led to increased noticing and reported use of nutrition information, with no impact on sales. While the observed pattern in median calories purchased potentially suggests an effect of numeric and TLL, we observed noise across sites which affected interpretation of the results. A future analysis will use sales data over a longer period of time to examine the impact of the labels on calories purchased and to identify potential confounding factors. Long-term research with multiple data collection points, ideally using comprehensive dietary assessment methods to collect information on intake, is needed to provide insight into the impact on consumption patterns and the potential for compensatory effects.

Figure 7. Proportion of participants who reported noticing nutrition labelling at each site by phase (N=1799 respondents; pre=854, post=945)

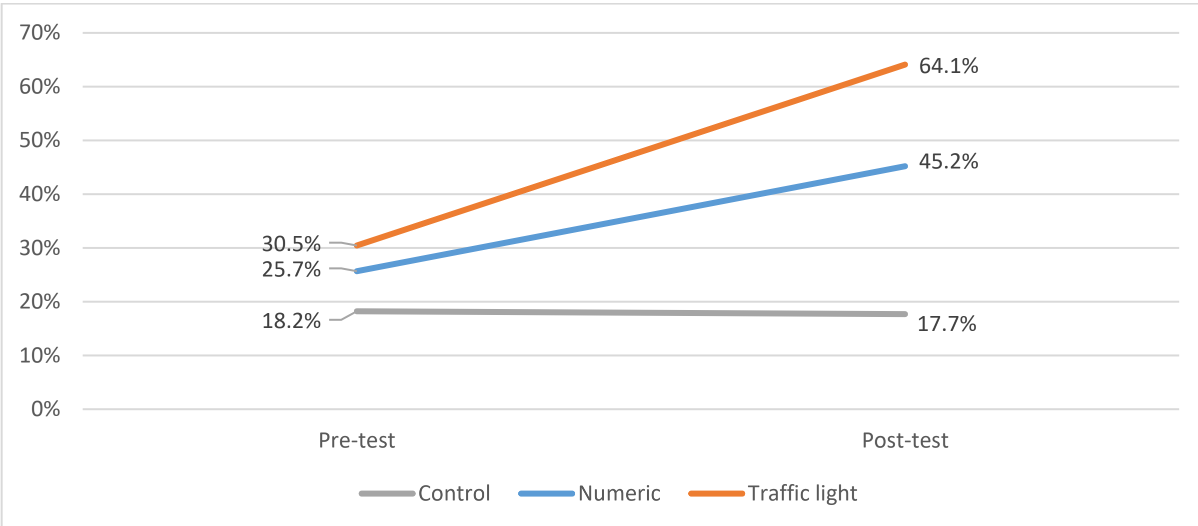


Figure 8. Proportion of participants who reported using nutrition information at each site by phase (N=1799 respondents; pre=854, post=945)

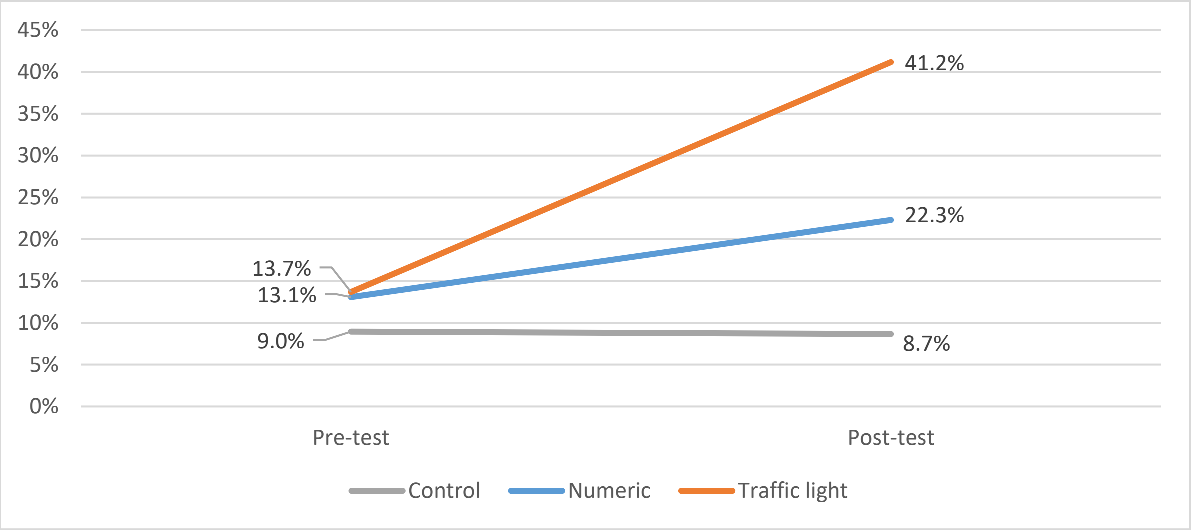
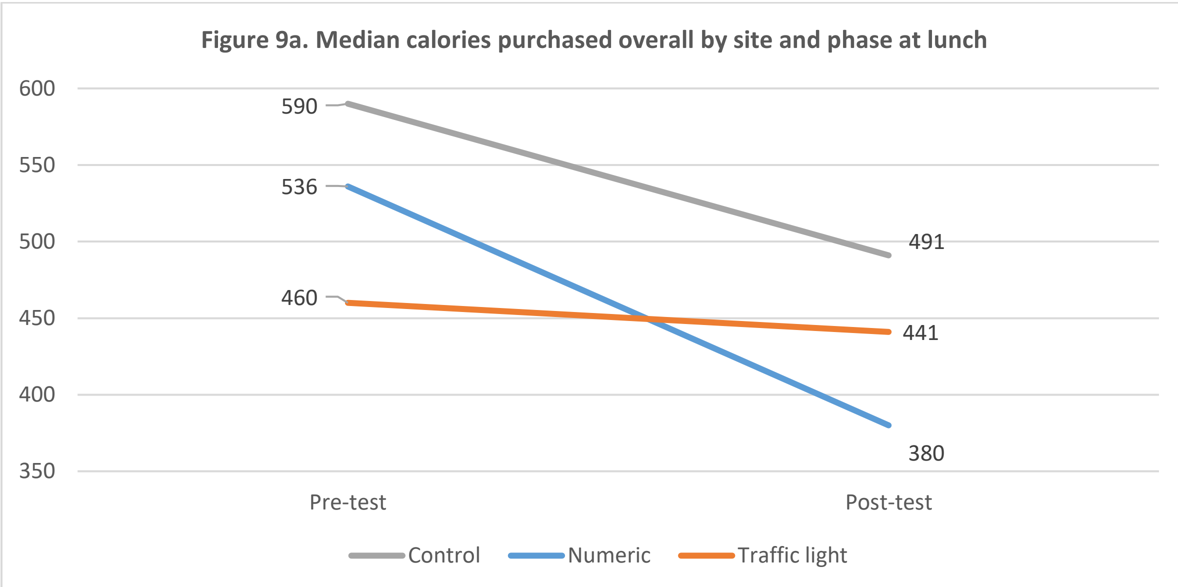


Figure 9. Median calories purchased for overall purchase, separated by lunch and dinner periods (N=1698 respondents; pre=828, post=870)



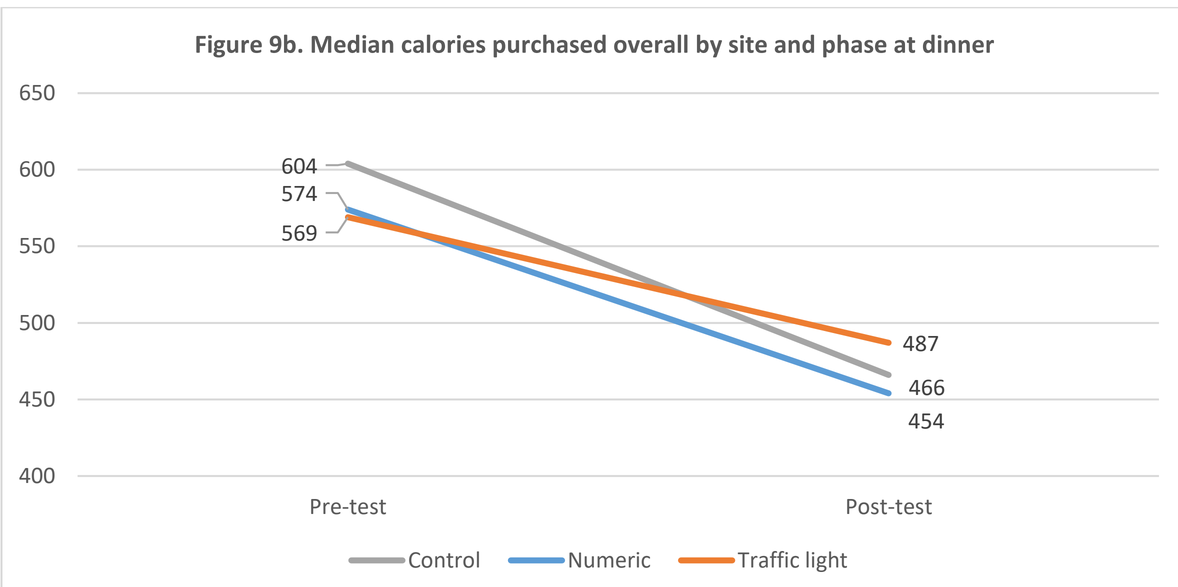
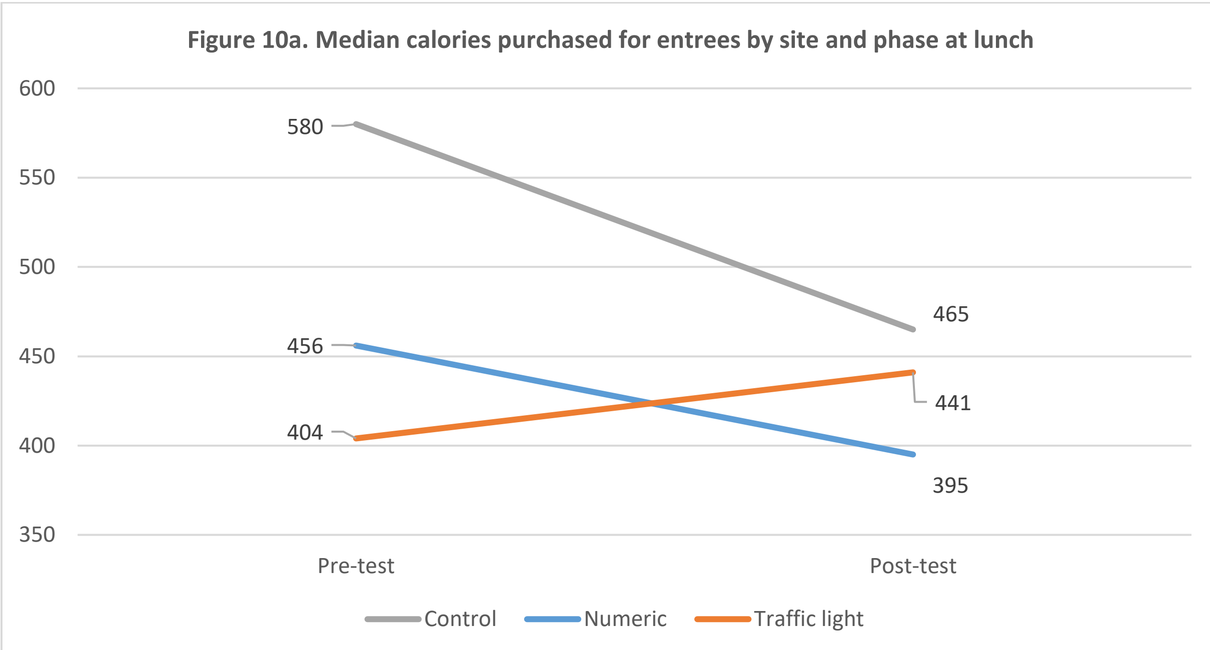


Figure 10. Median calories purchased for entrées, separated by lunch and dinner periods (N=1698 respondents; pre=828, post=870)



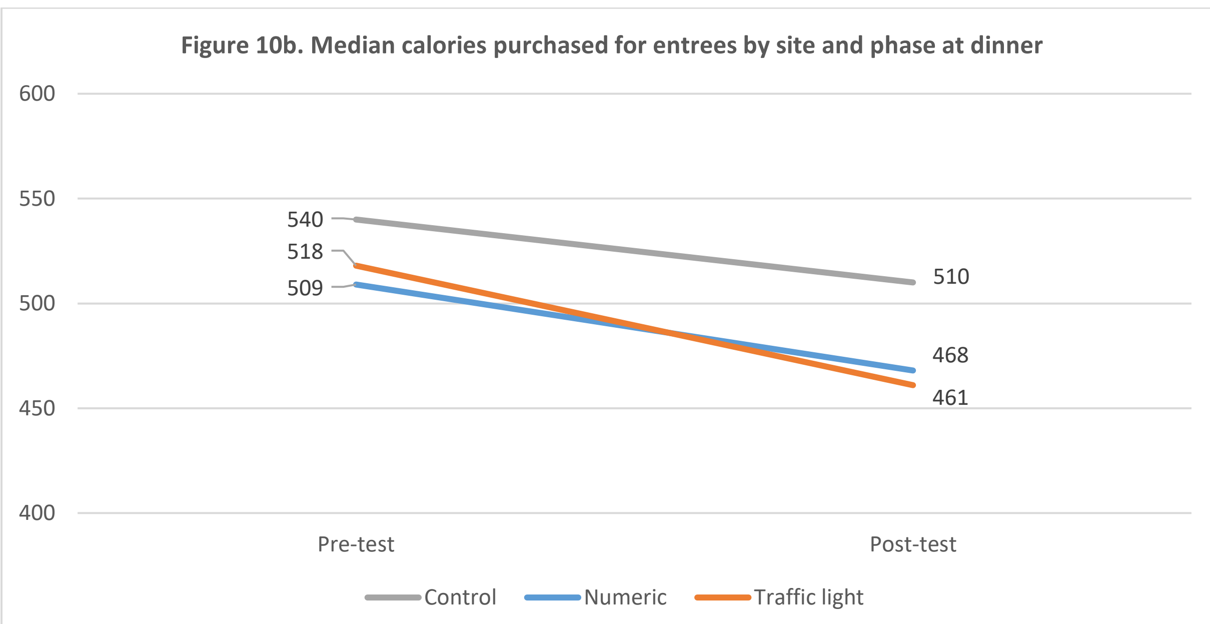
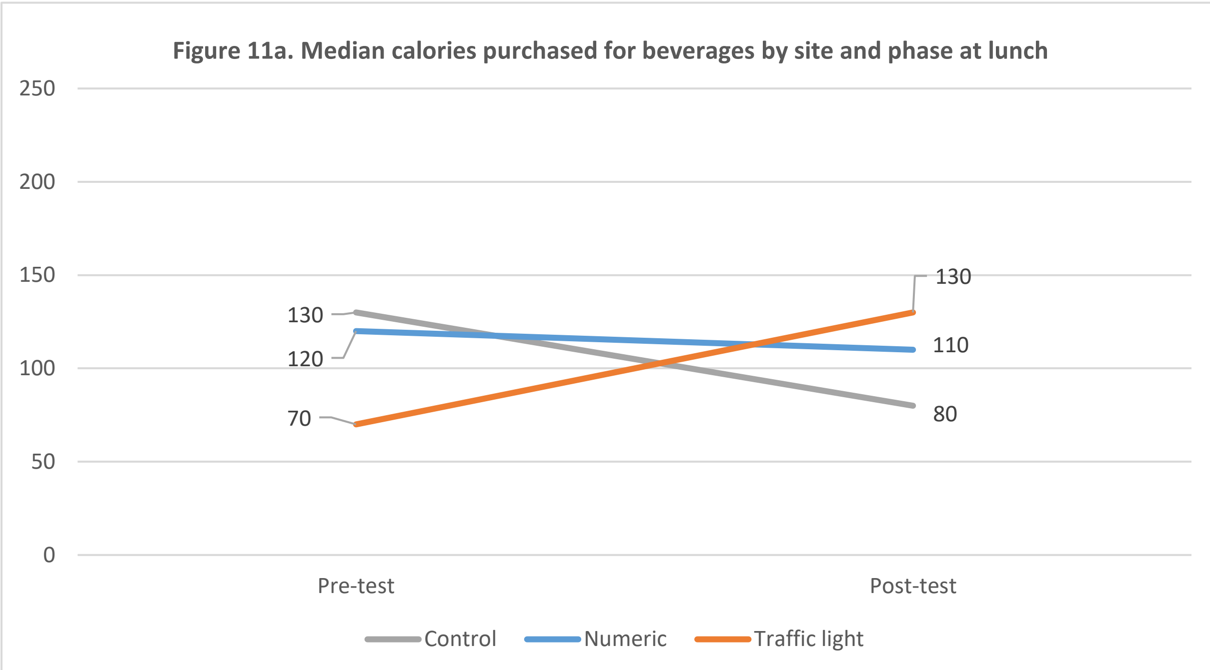


Figure 11. Median calories purchased for beverages, separated by lunch and dinner periods (N=1698 respondents; pre=828, post=870)



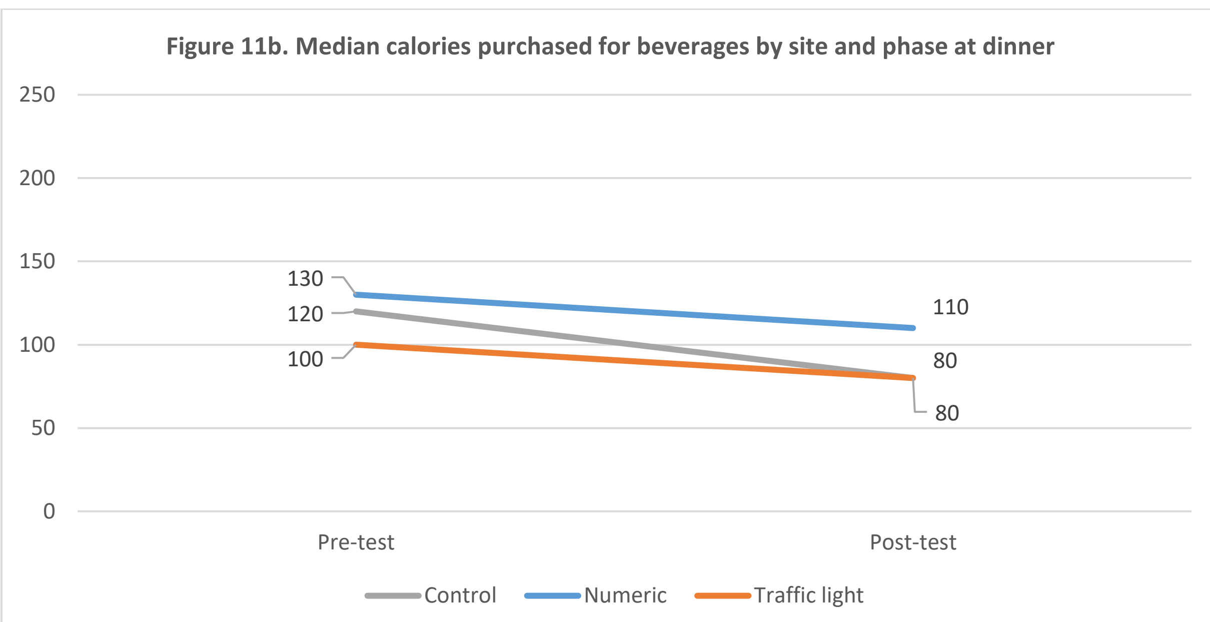
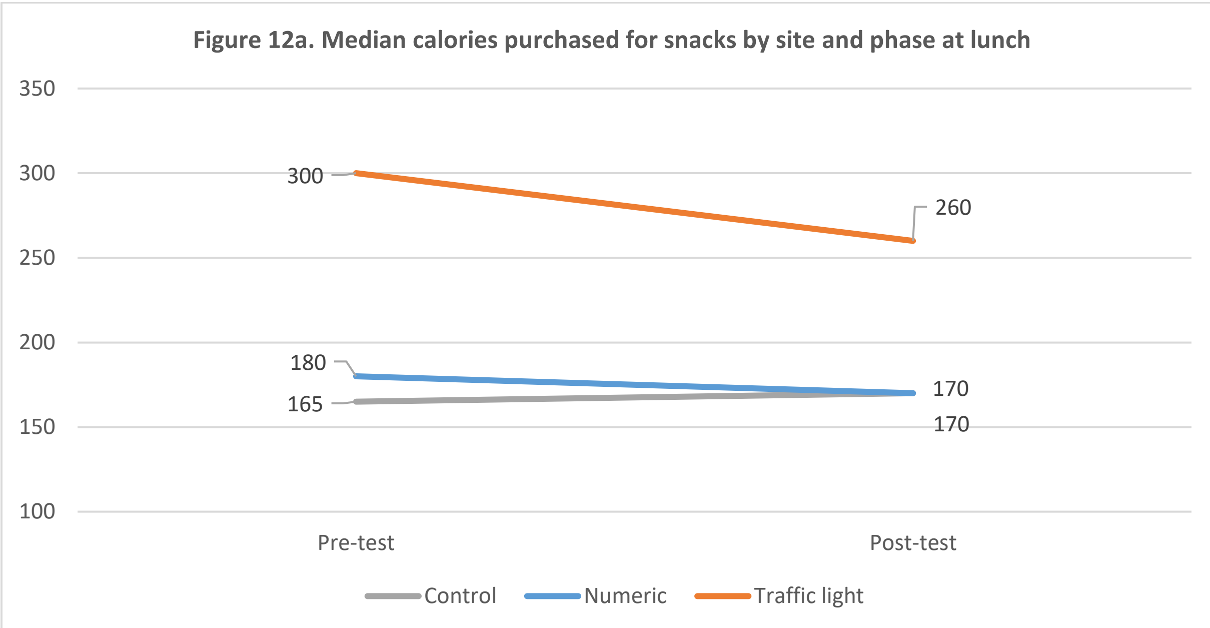


Figure 12. Median calories purchased for snacks, separated by lunch and dinner periods (N=1698 respondents; pre=828, post=870)



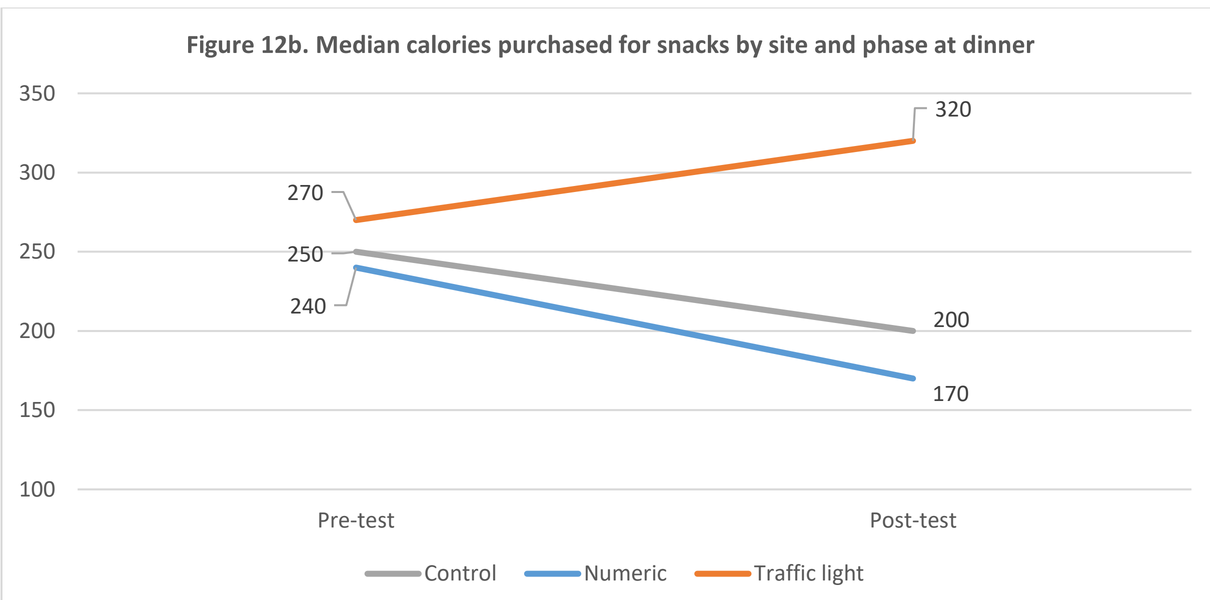


Table 4. Sample characteristics of participants by site and phase (N=1799 respondents; pre=854, post=945)

	Control		Numeric		Traffic light	
	Pre-test (n=274)	**Post-test (n=307)**	**Pre-test (n=287)**	**Post-test (n=337)**	**Pre-test (n=293)**	**Post-test (n=301)**
Eating occasion n(%)						
Lunch	108 (39.4)	103 (33.6)	126 (43.9)	127 (37.7)	132 (45.1)	126 (41.9)
Dinner	166 (60.6)	204 (66.5)	161 (56.1)	210 (62.3)	161 (55.0)	175 (58.1)
Frequency of visits per week M(SD)	13.4 (7.70)	13.2 (8.17)	13.8 (8.94)	12.2 (8.49)	12.6 (8.87)	10.4 (8.35)
Age (year) M(SD)	19.3 (1.84)	19.2 (0.68)	19.4 (0.93)	19.3 (1.28)	19.4 (1.04)	19.3 (0.99)
Gender n(%)						
Woman	125 (45.6)	145 (47.2)	141 (49.1)	154 (45.7)	115 (39.3)	138 (45.9)
Man	147 (53.7)	154 (50.5)	142 (49.5)	176 (52.2)	173 (37.5)	154 (51.2)
Specified identity	0 (0.00)	5 (1.63)	2 (0.70)	5 (2.22)	3 (1.02)	5 (1.66)
Not reported	1 (0.36)	2 (0.65)	2 (0.70)	2 (0.59)	2 (0.68)	4 (1.33)
Race n(%)						
White	90 (32.9)	65 (21.2)	49 (17.1)	53 (15.7)	53 (18.1)	33 (11.0)
Person of colour	184 (67.2)	242 (78.8)	238 (82.9)	284 (84.3)	240 (81.9)	268 (89.0)
Health literacy (NVS)[1] n(%)						
High likelihood of limited literacy (0-1)	67 (24.5)	93 (30.3)	83 (28.9)	116 (34.4)	95 (32.4)	82 (27.2)
Low likelihood of limited literacy (2-3)	100 (36.5)	83 (27.0)	98 (34.2)	86 (25.5)	92 (31.4)	79 (26.3)
Adequate (4-6)	107 (39.1)	131 (42.7)	106 (36.9)	135 (40.1)	106 (36.2)	140 (46.5)
Subjective social status[2] M (SD)	4.48 (1.63)	4.50 (1.61)	4.44 (1.67)	4.51 (1.77)	4.49 (1.64)	4.57 (1.68)
Disordered eating risk (SCOFF)[3] n(%)						
Unlikely disordered eating (0-1)	186 (67.9)	211 (68.7)	187 (65.2)	238 (70.6)	213 (72.7)	211 (70.1)
Likely disordered eating (2-5)	88 (31.1)	96 (31.3)	100 (34.8)	99 (29.4)	80 (27.3)	90 (29.9)

[1]Health literacy was assessed using the Newest Vital Sign, yielding a score out of 6 based on responses to questions about a nutrition label provided for a pint of ice cream (4-6=adequate health literacy; 2-3=low likelihood of limited literacy; 0-1=high likelihood of limited literacy).
[2]Subjective social status was used as an indicator for socioeconomic status. Participants rank their perceived social status on a 10-point scale (1=high; 10=low).
[3]Disordered was assessed using SCOFF, a 5-item questionnaire for eating disorder symptomology among non-clinical populations. Affirmation of 2 or more questions indicated high likelihood of disordered eating risk (0-1=unlikely disordered eating; 2+=likely disordered eating).

Table 5. Reported responses for noticing, use, and perceptions of nutrition information by site and phase (N=1799 respondents; pre=854, post=945) n(%)

	Control		Numeric		Traffic light	
	Pre-test (n=274)	Post-test (n=307)	Pre-test (n=287)	Post-test (n=337)	Pre-test (n=293)	Post-test (n=301)
Type of nutrition information noticed[1]						
Calories	33 (12.1)	35 (11.4)	45 (15.6)	117 (34.7)	68 (23.2)	151 (50.2)
Fat	16 (5.84)	11 (3.58)	24 (8.36)	16 (4.75)	15 (5.12)	21 (6.98)
Carbohydrates	14 (5.11)	15 (4.89)	22 (7.67)	15 (4.45)	14 (4.78)	17 (5.65)
Sugar	16 (5.84)	14 (4.56)	26 (9.06)	15 (4.45)	15 (5.12)	17 (5.65)
Sodium	12 (4.38)	11 (3.58)	22 (7.67)	12 (3.56)	15 (5.12)	11 (3.65)
Overall health indicator	12 (4.38)	8 (2.61)	15 (5.23)	15 (4.45)	15 (5.12)	44 (14.6)
Other	5 (1.82)	1 (0.33)	6 (2.09)	0 (0.00)	2 (0.68)	3 (1.00)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	20 (7.30)	30 (9.77)	30 (10.5)	44 (13.1)	31 (10.6)	35 (11.6)
Format[1]						
Symbols	15 (5.47)	6 (1.95)	36 (12.5)	38 (11.3)	31 (10.6)	123 (39.3)
Numbers	33 (12.0)	38 (12.4)	42 (14.6)	137 (40.7)	65 (22.2)	105 (33.5)
Other	6 (2.19)	2 (0.53)	0 (0.00)	0 (0.00)	2 (0.68)	2 (0.64)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	5 (1.82)	10 (3.26)	8 (2.79)	2 (0.59)	3 (1.02)	4 (1.28)
Location[1]						
Menu boards	28 (10.2)	28 (9.12)	41 (14.3)	86 (25.5)	61 (20.8)	114 (37.9)
Card next to item	30 (10.9)	26 (8.47)	43 (15.0)	90 (26.7)	39 (13.3)	119 (39.5)
Other	1 (0.36)	1 (0.33)	2 (0.69)	1 (0.29)	1 (0.34)	1 (0.33)
Did not notice	211 (77.0)	172 (51.0)	234 (76.2)	188 (64.2)	198 (69.0)	104 (34.6)
Not reported[2]	16 (5.84)	35 (11.4)	30 (10.5)	43 (12.8)	33 (11.2)	33 (10.9)
Influence of nutrition information						
Used a little	18 (6.57)	16 (5.21)	21 (7.32)	43 (12.8)	29 (9.90)	98 (32.6)
Used a lot	5 (1.82)	8 (2.61)	13 (4.53)	23 (6.82)	7 (2.39)	14 (4.65)
Did not use/did not notice	234 (85.4)	253 (82.4)	226 (78.8)	230 (68.3)	227 (77.5)	160 (53.2)
Not reported[2]	17 (6.20)	30 (9.77)	27 (9.41)	41 (12.2)	30 (10.2)	29 (9.63)

Strategies for nutrition information use[1]						
Selected items with fewer calories	6 (2.19)	9 (2.93)	14 (4.88)	43 (12.8)	18 (6.14)	58 (19.3)
Selected items that were healthy versus less healthy	21 (7.66)	17 (5.54)	28 (9.76)	36 (10.7)	23 (7.85)	72 (23.9)
Other	0 (0.00)	0 (0.00)	2 (0.70)	2 (0.59)	2 (0.68)	2 (0.66)
Did not use/did not notice	234 (85.4)	253 (82.4)	226 (78.8)	230 (68.3)	227 (77.5)	160 (53.2)
Not reported[2]	40 (14.6)	50 (16.3)	56 (19.5)	101 (30.0)	70 (23.9)	89 (29.6)
Behavioural response to nutrition information[1]						
Ordered something different	18 (6.57)	18 (5.86)	22 (7.67)	42 (12.5)	25 (8.53)	71 (23.6)
Ate less of the food ordered	10 (3.65)	8 (2.61)	15 (5.23)	39 (11.6)	13 (4.44)	47 (15.6)
Chose to eat somewhere else	0 (0.00)	4 (1.30)	7 (2.44)	9 (2.67)	6 (2.05)	12 (3.99)
Ate at the location less often	0 (0.00)	2 (0.65)	1 (0.35)	5 (1.48)	7 (2.39)	10 (3.32)
Other	0 (0.00)	0 (0.00)	1 (0.35)	1 (0.30)	1 (0.34)	1 (0.33)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	19 (6.93)	30 (9.77)	29 (10.1)	38 (11.3)	30 (10.2)	33 (11.0)
Perceived ease of understanding						
Easy/very easy	39 (14.2)	37 (12.1)	53 (18.5)	113 (32.1)	65 (22.2)	149 (47.6)
Neutral/difficult/very difficult	6 (2.19)	6 (1.95)	7 (2.44)	14 (3.98)	12 (4.10)	16 (5.11)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	18 (6.57)	38 (12.1)	29 (10.1)	53 (15.1)	29 (9.56)	44 (14.1)
Perceived ease of use						
Easy/very easy	30 (11.0)	31 (10.1)	44 (15.3)	88 (26.1)	55 (18.8)	130 (43.2)
Neutral/difficult/very difficult	15 (30.0)	12 (3.91)	15 (5.23)	37 (11.0)	20 (6.83)	37 (12.3)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	18 (6.57)	30 (9.77)	30 (10.45)	40 (11.9)	30 (10.2)	30 (9.97)
Perceived ease of control in making healthy eating decisions						
More in control	22 (8.03)	27 (8.79)	29 (10.1)	62 (18.4)	44 (15.0)	97 (32.2)
Neutral/less in control	22 (8.03)	16 (5.21)	34 (11.9)	62 (18.4)	33 (11.3)	65 (21.6)
Did not notice	211 (77.0)	234 (76.2)	198 (69.0)	172 (51.0)	188 (64.2)	104 (34.6)
Not reported[2]	19 (6.93)	30 (9.77)	26 (9.06)	56 (12.2)	28 (9.56)	35 (11.6)

[1]Participants could select multiple responses and therefore, total responses do not sum to 100%.
[2]Responses include participants who selected “Don’t know”, “Prefer not to answer”, or missing responses.

Table 6. Daily sales, number of transactions, and dollars spent per transaction by site and phase

	Control		**Numeric**		**Traffic light**	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Daily sales ($)[1]	14,727	13,188	29,476	28,061	17,250	16,318
	(1,411)	(1,566)	(1,609)	(2,265)	(1,187)	(1,599)
Number of transactions	1525.3	1381.7	3023.3	2861.1	1782.1	1678.7
	(147.1)	(186.6)	(173.4)	(203.1)	(114.5)	(160.4)
Dollars spent per transaction ($)	9.66	9.57	9.75	9.80	9.67	9.72
	(0.24)	(0.31)	(0.10)	(0.22)	(0.18)	(0.32)

[1]Rounded to nearest dollar.

6.6 References

1. Institute for Health Metrics and Evaluation. Global Burden of Disease Country Profiles [Internet]. Seattle, WA: Institute for Health Metrics and Evaluation [cited 2021 May 21]. Available from: http://www.healthdata.org/canada

2. Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. *Obes Rev*. 2013;14:159-168.

3. Vandevijvere S, Swinburn B. Towards global benchmarking of food environments and policies to reduce obesity and diet-related non-communicable diseases: design and methods for nation-wide surveys: Table 1. *BMJ Open*. 2014;4(5):e005339.

4. Gorski MT, Roberto CA. Public health policies to encourage healthy eating habits: Recent perspectives. *J Healthc Leadersh*. 2015;7:81-90.

5. Afshin A, Penalvo J, Del Gobbo L, Kashaf M, Micha R, Morrish K, Pearson-Stuttard J, Rehm C, Shangguan S, Smith JD, et al. CVD prevention through policy: a review of mass media, food/menu labeling, taxation/subsidies, built environment, school procurement, worksite wellness, and marketing standards to improve diet. *Curr Cardiol Rep*. 2015;17(11):1-2.

6. Vandevijvere S, Swinburn B, International Network for Food and Obesity/non-communicable diseases (NCDs) Research, Monitoring and Action Support (INFORMAS. Towards global benchmarking of food environments and policies to reduce obesity and diet-related non-communicable diseases: design and methods for nation-wide surveys. *BMJ open*. 2014;4(5).

7. Story M, Kaphingst KM, Robinson-O’Brien R, Glanz K. Creating Healthy Food and Eating Environments: Policy and Environmental Approaches. *Annu Rev Public Health*. 2008;29(1):253-272.

8. Health Canada. Healthy Eating Strategy [Internet]. [cited 2021 Jul 21]. Available from: https://www.canada.ca/

9. Black JL, Billette J-M. Fast food intake in Canada: Differences among Canadians with diverse demographic, socio-economic and lifestyle characteristics. *Can J Public Heal*. 2015;106(2):52-58.

10. Powell LM, Chaloupka FJ, Bao Y. The Availability of Fast-Food and Full-Service Restaurants in the United States. *Am J Prev Med*. 2007;33(4):S240-S245.

11. Scourboutakos MJ, L'Abbé MR. Restaurant Menus. *Am J Prev Med*. 2012;43(3):249-255.

12. Burton S, Creyer EH, Kees J, Huggins K. Attacking the obesity epidemic: the potential health benefits of providing nutrition information in restaurants. *Am J Public Health*. 2006;96(9):1669-1675.

13. Bernell B. The history and impact of the New York City menu labeling law. *Food Drug Law J*. 2010;65:839.

14. Ministry of Ontario. Healthy Menu Choices Act, 2015, S.O. 2015, c. 7, Sched. 1 [Internet]. Ontario, Canada: Ministry of Health and Long-Term Care; 2017 [cited 2021 May 21]. Available from: https://www.ontario.ca/laws/statute/15h07

15. Government of the United Kingdom. Mandating calorie labelling in the out-of-home sector: Government response to public consultation. United Kingdom: Department of Health and Social Care; 2020 [cited 2021 May 21]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/903714/Calorie_Labelling_-_Consultation_Response.pdf

16. Dumanovsky T, Huang CY, Bassett MT, Silver LD. Consumer awareness of fast-food calorie information in new york city after implementation of a menu labeling regulation. *Am J Public Health*. 2010;100(12):2520-2525.

17. Elbel B, Mijanovich T, Dixon LB, Abrams C, Weitzman B, Kersh R, Auchincloss AH, Ogedegbe G. Calorie labeling, fast food purchasing and restaurant visits. *Obesity*. 2013;21(11):2172-9.

18. Elbel B, Kersh R, Brescoll VL, Dixon LB. Calorie labeling and food choices: A first look at the effects on low-income people in New York City: Calorie information on menus

appears to increase awareness of calorie content, but not necessarily the number of calories people purchase. *Health Aff*. 2009;28(6):w1110-w1121.

19. Krieger JW, Chan NL, Saelens BE, Ta ML, Solet D, Fleming DW. Menu labeling regulations and calories purchased at chain restaurants. *Am J Prev Med*. 2013;44(6):595-

20. Pulos E, Leng K. Evaluation of a voluntary menu-labeling program in full-service restaurants. *Am J Public Health*. 2010;100(6):1035-1039.

21. Breck A, Cantor J, Martinez O, Elbel B. Who reports noticing and using calorie information posted on fast food restaurant menus? *Appetite*. 2014;81:30-36.

22. Hammond D, Lillico HG, Vanderlee L, White CM, Reid JL. The impact of nutrition labeling on menus: A naturalistic cohort study. *Am J Health Behav*. 2015;39(4):540-548.

23. Goodman S, Vanderlee L, White CM, Hammond D. A quasi-experimental study of a mandatory calorie-labelling policy in restaurants: Impact on use of nutrition information among youth and young adults in Canada. *Prev Med*. 2018 Nov 1;116:166-72.

24. Vanderlee L, Hammond D. Does nutrition information on menus impact food choice? Comparisons across two hospital cafeterias. *Public Health Nutr*. 2014;17(6):1393-402.

25. Bassett MT, Dumanovsky T, Huang C, Silver LD, Young C, Nonas C, Matte TD, Chideya S, Frieden TR. Purchasing behavior and calorie information at fast-food chains in New York City, 2007. *Am J Public Health*. 2008;98(8):1457-9.

26. Tandon PS, Zhou C, Chan NL, et al. The impact of menu labeling on fast-food purchases for children and parents. *Am J Prev Med*. 2011;41(4):434-438.

27. Vadiveloo MK, Dixon LB, Elbel B. Consumer purchasing patterns in response to calorie labeling legislation in New York City. *Int J Behav Nutr Phys Act*. 2011;8.

28. Webb KL, Solomon LS, Sanders J, Akiyama C, Crawford PB. Menu labeling responsive to consumer concerns and shows promise for changing patron purchases. *J Hung Env Nutr*. 2011;6(2):166-78.

29. Swartz JJ, Braxton D, Viera AJ. Calorie menu labeling on quick-service restaurant menus: an updated systematic review of the literature. *Int J Behav Nutr Phys Act*. 2011;8(1):135.

30. Kiszko KM, Martinez OD, Abrams C, Elbel B. The Influence of Calorie Labeling on Food Orders and Consumption: A Review of the Literature. *J Community Health*. 2014;39(6):1248-1269.

31. Long MW, Tobias DK, Cradock AL, Batchelder H, Gortmaker SL. Systematic review and meta-analysis of the impact of restaurant menu calorie labeling. *Am J Public Health*. 2015;105(5):e11-24.

32. Sinclair SE, Cooper M, Mansfield ED. The Influence of Menu Labeling on Calories Selected or Consumed: A Systematic Review and Meta-Analysis. *J Acad Nutr Diet*. 2014;114(9):1375-1388.e15.

33. Fernandes AC, Oliveira RC, Proença RPC, Curioni CC, Rodrigues VM, Fiates GMR. Influence of menu labeling on food choices in real-life settings: a systematic review. *Nutr Rev*. 2016;74(8):534-548.

34. Bleich SN, Economos CD, Spiker ML, Vercammen KA, VanEpps EM, Block JP, Elbel B, Story M, Roberto CA. A Systematic Review of Calorie Labeling and Modified Calorie Labeling Interventions: Impact on Consumer and Restaurant Behavior. *Obesity*. 2017;25(12):2018-2044.

35. Crockett RA, King SE, Marteau TM, et al. Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption. *Cochrane Database Syst Rev*. 2018;2.

36. Littlewood JA, Lourenço S, Iversen CL, Hansen GL. Menu labelling is effective in reducing energy ordered and consumed: A systematic review and meta-analysis of recent studies. *Public Health Nutr*. 2016;19(12):2106-2121.

37. Rincón-Gallardo PS, Zhou M, Da Silva GF, Lemaire R, Hedrick V, Serrano E. Effects of menu labeling policies on transnational restaurant chains to promote a healthy diet: A scoping review to inform policy and research. *Nutrients*. 2020;12(6).

38. National Health Services. Food labels: Eat well [Internet]. United Kingdom: Department of Health; 2018 [cited 2021 May 21]. Available from: https://www.nhs.uk/Livewell/Goodfood/Pages/food-labelling.aspx

39. World Cancer Research Fund International. Building on momentum: lessons on implementing a robust front-of-pack food label [Internet]. London, United Kingdom; 2019 [cited 2021 May 21]. Available from: https://www.wcrf.org/policy/our-publications/building-momentum-series/lessons-implementing-robust-front-of-pack-food-label

40. Food Standards Agency. Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets [Internet]. United Kingdom; 2016 [cited 2021 May 21]. Available from: https://www.food.gov.uk/sites/default/files/multimedia/pdfs/pdf-ni/fop-guidance.pdf

41. Thorndike AN, Riis J, Sonnenberg LM, Levy DE. Traffic-light labels and choice architecture: Promoting healthy food choices. *Am J Prev Med*. 2014;46(2):143-149.

42. Thorndike AN, Gelsomin ED, McCurley JL, Levy DE. Calories Purchased by Hospital Employees after Implementation of a Cafeteria Traffic Light-Labeling and Choice Architecture Program. *JAMA Netw Open*. 2019;2(7).

43. Seward MW, Block JP, Chatterjee A. A Traffic-Light Label Intervention and Dietary Choices in College Cafeterias. *Am J Public Health*. 2016;106(10):1808-1814.

44. Olstad DL, Vermeer J, McCargar LJ, Prowse RJL, Raine KD. Using traffic light labels to improve food selection in recreation and sport facility eating environments. *Appetite*. 2015;91:329-335.

45. Labonté ME, Emrich TE, Scarboroguh P, Rayner M, L'Abbé MR. Traffic light labelling could prevent mortality from noncommunicable diseases in Canada: A scenario modelling Study. *PloS One.* 2019;14(12):e02269875.

46. Ellison B, Lusk JL, Davis D. Looking at the label and beyond: The effects of calorie labels, health consciousness, and demographics on caloric intake in restaurants. *Int J Behav Nutr Phys Act*. 2013;10(1):1-9.

47. Ellison B, Lusk JL, Davis D. The impact of restaurant calorie labels on food choice: Results from a field experiment. *Econ Inq*. 2014;52(2):666-681.

48. Hammond D, Goodman S, Hanning R, Daniel S. A randomized trial of calorie labeling on menus. *Prev Med.* 2013;57(6):860-6.

49. Liu PJ, Roberto CA, Liu LJ, Brownell KD. A test of different menu labeling presentations. *Appetite.* 2012;59(3):770-7.

50. Prowse RJL, Lee KM, Chen E, Zuo F, Hammond D, Hobin E. Testing the efficacy of and parents' preferences for nutrition labels on children's menus from a full-service chain restaurant: Results of an online experiment. *Public Health Nutr*. 2020;23(10):1820-1831.

51. VanEpps EM, Downs JS, Loewenstein G. Calorie label formats: using numeric and traffic light calorie labels to reduce lunch calories. *J Public Policy Mark*. 2016;35(1):26-36.

52. Emrich TE, Qi Y, Lou WY, L'Abbe MR. Traffic-light labels could reduce population intakes of calories, total fat, saturated fat, and sodium. *PLoS One*. 2017;12(2).

53. Morley B, Scully M, Martin J, Niven P, Dixon H, Wakefield M. What types of nutrition menu labelling lead consumers to select less energy-dense fast food? An experimental study. *Appetite*. 2013;67:8-15.

54. Dodds P, Wolfenden L, Chapman K, Wellard L, Hughes C, Wiggers J. The effect of energy and traffic light labelling on parent and child fast food selection: A randomised controlled trial. *Appetite*. 2014;73:23-30.

55. Hobin E, Lillico H, Zuo F, Sacco J, Rosella L, Hammond D. Estimating the impact of various menu labeling formats on parents' demand for fast-food kids' meals for their children: An experimental auction. *Appetite*. 2016;105:582-590.

56. Feng W, Fox A. Menu labels, for better, and worse? Exploring socio-economic and race-ethnic differences in menu label use in a national sample. *Appetite*. 2018;128:223-232.

57. Sarink D, Peeters A, Freak-Poli R, Beauchamp A, Woods J, Ball K, Backholer K. The impact of menu energy labelling across socioeconomic groups: A systematic review. *Appetite*. 2016;99:59-75.

58. Sinclair S, Hammond D, Goodman S. Sociodemographic Differences in the Comprehension of Nutritional Labels on Food Products. *J Nutr Educ Behav*. 2013;45(6):767-772.

59. Lillico HG, Hanning R, Findlay S, Hammond D, Hammond (D. The effects of calorie labels on those at high-risk of eating pathologies: a pre-post intervention study in a University cafeteria. *Public Health*. 2015;129:732-739.

60. Larson N, Haynos AF, Roberto CA, Loth KA, Neumark-Sztainer D. Calorie Labels on the Restaurant Menu: Is the Use of Weight-Control Behaviors Related to Ordering Decisions? *J Acad Nutr Diet*. 2018;118(3):399-408.

61. Haynos AF, Roberto CA. The effects of restaurant menu calorie labeling on hypothetical meal choices of females with disordered eating. *Int J Eat Disord*. 2017;50(3):275-283.

62. Roberto CA, Haynos AF, Schwartz MB, Brownell KD, White MA. Calorie estimation accuracy and menu labeling perceptions among individuals with and without binge eating and/or purging disorders. *Eat Weight Disord - Stud Anorexia, Bulim Obes*. 2013;18(3):255-261.

63. McGeown L. The calorie counter-intuitive effect of restaurant menu calorie labelling. *Can J Public Heal*. 2019;110(6):816-820.

64. Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias: a mixed methods study. *Obes Sci Pract*. 2018;4(2):159-177.

65. Nagata JM, Garber AK, Tabler JL, Murray SB, Bibbins-Domingo K. Prevalence and Correlates of Disordered Eating Behaviors Among Young Adults with Overweight or Obesity. *J Gen Intern Med*. 2018;33(8):1337-1343.

66. Tseng M, DeGreef K, Fishler M, Gipson R, Koyano K, Neill DB. Assessment of a University Campus Food Environment, California, 2015. *Prev Chronic Dis*. 2016;13(E18).

67. Horacek TM, Erdman MB, Reznar MM, Olfert M, Brown-Esters ON, Kattelmann KK, Kidd T, Koenings M, Phillips B, Quick V, et al. Evaluation of the Food Store Environment on and near the Campus of 15 Postsecondary Institutions. *Nutr Promot Community Des*. 2013;27(4):81-90.

68. Lo BK, Minaker L, Chan AN, Hrgetic J, Mah CL. Adaptation and validation of a nutrition environment measures survey for university grab-and-go establishments. *Can J Diet Pract Res*. 2016 Mar;77(1):17-24.

69. Lee KM, Marcinow ML, Minaker LM, Kirkpatrick SI. The healthfulness of eateries at the University of Waterloo: a comparison across 2 time points. *Can J Diet Pract Res*. 2019 Nov 18;81(2):72-9.

70. The American Association for Public Opinion Research. Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys, 9th edition. 2016 [cited 2021 May 21]. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf

71. Beatty PC, Willis GB. Research synthesis: The practice of cognitive interviewing. *Public Opin Q*. 2007;71(2):287-311

72. Lenzner T, Neuert C, Otto W. Cognitive pretesting. *GESIS Survey Guidelines*. 2016:3.

73. University of Waterloo. Food Services: Product Information Database [Internet]. Ontario, Canada; 2019 [cited 2021 May 21]. Available from: https://uwaterloo.ca/food-services/menu/search.

74. Health Canada. Canadian Nutrient File [Internet]. Ontario, Canada; 2018 [cited 2021 May 21]. Available from: https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp.

75. Malam S, Clegg S, Kirwan S, McGinigal S, Raats M, Shepherd R, Barnett J, Senior V, Hodgkins C, Dean M. Comprehension and use of UK nutrition signpost labelling schemes [Internet]. London: Food Standards Agency; 2009 [cited 2021 May 21]. Available from:

https://www.foodwatch.org/fileadmin/_migrated/content_uploads/FSA-Studie_2009_original_englisch.pdf

76. Qualtrics. Qualtrics Software, version March 2019. Utah, USA; 2020 [cited 2021 May 21]. Available from: https://qualtrics.com

77. Heath Canada. Canadian Community Health Survey [Internet]. Ottawa, Canada; 2018 [cited 2021 May 21]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs.html

78. Powers BJ, Trinh J V., Bosworth HB. Can this patient read and understand written health information? *J Am Med Assoc*. 2010;304(1):76-84.

79. Bradshaw M, Kent BV, Henderson WM, Setar AC. Subjective social status, life course SES, and BMI in young adulthood. *Heal Psychol*. 2017;36(7):682-694.

80. Hill LS, Reid F, Morgan JF, Lacey JH. SCOFF, the development of an eating disorder screening questionnaire. *Int J Eat Disord*. 2009;43(4):344-351.

81. Ewing W, Weir S, Sanusi A. Unique Identifier Codes: Guidelines for use with key populations [Internet]. *Unique Identifier Codes: Guidelines for Use with Key Populations*. 2016. Available from: https://www.fhi360.org/sites/default/files/media/documents/resource-linkages-uic-guidance.pdf

82. Lorden AL, Radcliff TA, Jiang L, Horel SA, Smith ML, Lorig K, Howell BL, Whitelaw N, Ory M. Leveraging administrative data for program evaluations: A method for linking data sets without unique identifiers. *Eval Health Prof*. 2016 Jun;39(2):245-59.

83. Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias: a mixed methods study. *Obes Sci Pract*. 2018;4(2):159-77.

84. Mansfield ED, Wahba R, Gillis DE, Weiss BD, L'Abbé M. Canadian adaptation of the newest vital sign©, a health literacy assessment tool. *Cambridge Archaeol J*. 2018;21(11):2038-2045.

85. Erola J, Jalonen S, Lehti H. Parental education, class and income over early life course and children's achievement. *Res Soc Stratif Mobil*. 2016;44:33-43.

86. Kerins C, McHugh S, McSharry J, Reardon CM, Hayes C, Perry IJ, Geaney F, Seery S, Kelly C. Barriers and facilitators to implementation of menu labelling interventions from a food service industry perspective: A mixed methods systematic review. *Int J Behav Nutr Phys Act*. 2020;17(1):1-15.

87. Kim Y, Steiner P. Quasi-Experimental Designs for Causal Inference. *Educ Psych*. 2016;51(3-4):395-405.

88. Stuart EA, Rubin DB. Best practices in quasi-experimental methods: Matching methods for causal inference. In: Best Practices in Quantitative Social Science. Thousand Oaks, CA: Sage Publications; 2007 [cited 2021 Oct 22]. p. 155–76.

89. Handley MA, Lyles CR, Mcculloch C, Cattamanchi A. Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research. *Public Health*. 2018;39:5-25.

90. Roberto CA, Larsen PD, Agnew H, Baik J, Brownell KD. Evaluating the impact of menu labeling on food choices and intake. *Am J Pub Health*. 2010;100(2):312-318.

91. Chen R, Smyser M, Chan N, Ta M, Saelens BE, Krieger J. Changes in awareness and use of calorie information after mandatory menu labeling in restaurants in King County, Washington. *Am J Public Health*. 2015;105(3):546-553.

92. Green JE, Brown AG, Ohri-Vachaspati P. Sociodemographic Disparities among Fast-Food Restaurant Customers Who Notice and Use Calorie Menu Labels. *J Acad Nutr Diet*. 2015;115(7):1093.

93. Lee-Kwan SH, Pan L, Maynard LM, McGuire LC, Park S. Factors Associated with Self-Reported Menu-Labeling Usage among US Adults. *J Acad Nutr Diet*. 2016;116(7):1127-1135.

94. Raffoul A. The ignored consequences of obesity and nutrition policies: How a focus on weight influences psychosocial wellbeing. 2020. *UWSpace.*

95. Hawley KL, Roberto CA, Bragg MA, Liu PJ, Schwartz MB, Brownell KD. The science on front-of-package food labels. *Public Health Nutr*. 2013;16(3):430-439.

96. Mhurchu CN, Eyles H, Choi Y-H. Effects of a Voluntary Front-of-Pack Nutrition Labelling System on Packaged Food Reformulation: The Health Star Rating System in New Zealand. *Nutrients*. 2017;9(8).

97. Roberto CA, Bragg MA, Schwartz MB, Seamans MJ, Musicus A, Novak N, Brownell KD. Facts up front versus traffic light food labels: A randomized controlled trial. *Am J Prev Med*. 2012;43(2):134-141.

98. Lucan SC, DiNicolantonio JJ. How calorie-focused thinking about obesity and related diseases may mislead and harm public health. An alternative. *Public Health Nutr*. 2015;18(4):571-581.

99. Forouhi NG, Unwin N. Global diet and health: old questions, fresh evidence, and new horizons. *Lancet*. 2019;393:1916-1918.

100. Deliens T, Clarys P, de Bourdeaudhuij I, Deforche B. Determinants of eating behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health.* 2014;14(1):1-12.

101. Sogari G, Velez-Argumedo C, Gómez MI, Mora C. College Students and Eating Habits: A Study Using An Ecological Model for Healthy Behavior. *Nutrients*. 2018;10(12).

102. Mascioli BA, Davis R. Health-protective eating style among students at a Canadian university. *Can J Behav Sci.* 2019;51(4):269.

CHAPTER 7: Examining the impact of numeric versus traffic light calorie labelling at the point-of-purchase on diet quality of food and beverage purchases

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7.1 Overview

Background: There is substantial interest in point-of-purchase calorie labelling. Evaluations of numeric versus interpretive labels have primarily focused on calories purchased and consumed.

Objective: To examine the impact of numeric versus traffic light calorie labelling on quality of purchases based on food groups and nutrients of public health concern.

Design: Pre-post quasi-experimental controlled trial.

Participants/setting: Student patrons (n=1698) within a large Canadian university.

Intervention: Three residence cafeterias were randomly assigned to receive numeric calorie labelling, traffic light calorie labelling, or no labelling (control) for ~3 weeks.

Main outcome measures: Change in purchases of green-, amber-, and red-labelled items and in food groups and nutrients purchased at all sites from pre-test to post-test. Food groups and nutrients included fruits, vegetables, whole grains, refined grains, plant-based proteins, red meats, added sugars, saturated fats, and sodium, expressed per 1000 kcal. Subgroup differences by health literacy, socioeconomic status, and disordered eating risk were considered.

Statistical analyses performed: Generalized estimating equation models were conducted for all outcomes, adjusting for age, gender, race, eating occasion, frequency of visits, health literacy, socioeconomic status, and disordered eating risk.

Results: No change in purchasing of red-, amber-, and green-categories at the numeric and traffic light labelling sites versus the control was observed. A significant three-way interaction for site, time, and socioeconomic status was observed (β=0.11, 95% CI=0.02–0.21; p=0.01). There was a 0.57 oz equivalents/1000 kcal decrease in refined grains purchased at the traffic light labelling site (β=-1.07, 95% CI=-1.82– -0.31; p=0.005) and a 0.05 tsp/1000 kcal decrease in added sugars purchased at the numeric site (β=4.71, 95% CI=0.97-8.45; p=0.01) versus the control. No differences were observed for other nutrients and food groups. Parallel trends across sites were not observed, potentially indicating the influence of confounding.

Conclusions: Neither label impacted purchasing of foods categorized as green, amber, and red and minor impacts on the quality of foods and beverages purchased were observed; however, the assumption of parallel trends across sites was not satisfied. Future research will use sales data to investigate potential confounders that may have affected the purchasing data.

Keywords: calorie label, traffic light label, diet quality, quasi-experiment, young adults

7.2 Introduction

Dietary risk factors, such as low intake of fruit and vegetables, nuts and seeds, and whole grains, and high intake of sodium are among the leading contributors to morbidity and mortality globally.[1] At the same time, eating patterns have shifted toward increased consumption of foods prepared outside of the home,[2–5] where food offerings are typically large in portion size and high in calories and fats, and low in fibre, fruits, and vegetables.[6] In response, there has been an unprecedented level of attention toward identifying interventions to improve diet quality of eating patterns,[7,8] with particular attention toward those that can support food and beverage decisions at the point-of-purchase in cafeterias, restaurants, and fast-food chains.

Nutrition labelling on menus is one strategy that has received significant policy interest and often focuses on displaying calorie amounts.[9] Calorie labelling has been implemented in a number of jurisdictions, such as New York City[10] and Ontario,[11] driven by observations that energy can vary among similar offerings.[3–5] Building on nutrition labelling approaches for front-of-package labels, interpretive formats have been considered to provide an at-a-glance summary indicator of nutrition information.[12–14] One example of an interpretive format is traffic light labelling (TLL), which indicates foods and beverages as high, medium or low in selected dietary components (e.g., calories) in relation to defined criteria for red, amber, and green lights.[15–17] Current evidence comparing numeric and TLL is limited.[18–27] Systematic reviews suggest calorie labels have modest, yet inconsistent, impacts on calories ordered and consumed.[28–30] Several real-world studies have directly compared the impacts of numeric versus TLL and found that both formats led to small reductions in calories, with some suggesting TLL outperformed numbers alone.[18,23]

Within food-based dietary guidelines, recommendations for healthy eating patterns emphasize appropriate caloric intake, increased variety of plant-based foods (e.g., nuts and seeds, fruits and vegetables, whole grains), reduced consumption of animal foods, and intake of small amounts of highly processed foods and sugars.[31–35] Similarly, these food groups and nutrients have been emphasized in recommendations for eating patterns aligning with planetary health, such as within the *EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems*.[31] While prior studies of calorie labelling have focused on calories purchased and consumed,[18–27] few have examined implications of numeric and TLL formats on purchasing and consumption of key food groups and nutrients.[24,36–38] In a 2×2 factorial experimental marketplace of numeric calorie labels and price modifications, calorie labels had no significant effect on hypothetical purchasing of calories, saturated fats, and total fats in comparison to the control.[37] A cross-sectional study, which categorized foods based on food groups recommended in the *2015-2020 Dietary Guidelines for Americans*,[39] found that calorie label users were more likely to select healthier sides and beverages.[38] A modelling study examining TLL on population-level dietary intake among Canadian adults showed reductions in consumption of energy, total fats, saturated fats, and sodium, with no impact on sugars.[24] To inform policy, there is a need for real-world evidence on whether the label formats support healthy eating patterns with respect to food groups and nutrients of public health concern.

There are concerns about the potential for calorie labels to widen socioeconomic disparities.[40,41] A review found a greater effect on awareness among consumers with high compared to low socioeconomic status (SES); however, evidence was limited in quantity and quality.[40] Only one study has examined the implications of numeric calorie labelling among residents in low SES neighbourhoods, suggesting no impact on purchasing of saturated fats, sodium, and sugars relative to baseline.37 Within the calorie labelling literature, some have suggested interpretive formats may benefit those with lower health literacy and SES due to the focus on providing a summary of nutrition information rather than numeric values.[28,29] Concerns have also been raised regarding the potential for calorie labelling to promote or exacerbate disordered eating.[42–47] However, there is a paucity of research directly comparing the impacts of numeric versus TLL on diet quality of purchases among subgroup levels for health literacy, SES, and disordered eating risk.

The objectives of this research were to examine the impact of numeric versus traffic light calorie labelling on changes in purchasing of: (1) foods and beverages labelled as red, amber, and green (based on calorie amounts); (2) food groups (fruits and vegetables, whole grains and refined grains, plant-based protein foods and red meats) per 1000 kcal; and (3) nutrients (total fats, added sugars, and sodium) per 1000 kcal. The analyses presented here expand on a prior analysis (**Chapter 6**) examining impacts of numeric and TLL formats on calories purchased.

7.3 Methods

A pre-test, post-test quasi-experimental controlled trial was conducted at a large Canadian university from March to April 2019. In mid-March 2019, three residence cafeterias were randomly assigned to receive numeric calorie labelling, traffic light calorie labelling, or no labelling (control) (**Chapter 4; Figure 2**). Both labelling formats included numeric calorie information to explicitly examine the effect of including the red, amber, and green indicators. Exit surveys were administered at all three cafeterias for 2 weeks prior to and 2 weeks following the 1-week implementation period.

The study received ethical clearance from the University of Waterloo Office of Research Ethics (#31830), the University of Calgary Conjoint Health Research Ethics Board, and the Public Health Ontario Ethics Committee. The data collection protocol was registered with the Open Science Framework in November 2019 (available at: https://osf.io/bxfw2).

7.3.1 Sample and recruitment

The sampling frame was limited to patrons of cafeterias in residences primarily housing first-year students to maximize similarity among students served. The three residence cafeterias, catering to ~1000-2000 students each, were as geographically disparate as possible across campus to limit the possibility of students being exposed to the label conditions in other cafeterias. The cafeterias were centrally managed by an on-campus food service operation and provided similar offerings across sites, including hot entrée stations, salad and sandwich bars, customizable stations for meals (e.g., pasta bowls, pizzas), grills (e.g., burgers, French fries), and grab-and-go stations with pre-packaged foods, beverages, and snacks. Hot entrées rotated on a daily basis and were offset across cafeterias (i.e., one cafeteria was on week 1 while another is on week 2). All other stations provided similar offerings, and beverages and snacks remained the same across sites (**Appendix C**). The cafeteria with TLL had a branded outlet for smoothies.

Eligible participants were currently enrolled students who purchased one or more food(s) and/or beverage(s) immediately prior to recruitment. Students were not eligible if they participated in cognitive testing of study materials. Staff and faculty were not eligible to maintain comparable samples between cafeterias. The target sample size was informed by a naturalistic study conducted by Seward et al.[48] and an experimental study by Hammond et al.,[20] using data reported on noticing of labels[48] (binary outcome) and calories consumed[20] (continuous outcome). All calculations assume a significance level of 0.05. Based on Seward et al.,[48] a sample size of approximately 200 at each site was deemed to provide 80% power to detect a difference of 10% in the number of individuals who notice labels across conditions. Based on Hammond et al.,[20] a sample size of 485 at each site was estimated to provide 80% power to detect a difference of 63 calories consumed between the TLL and control condition. Comparing the numeric calorie condition to the control condition, a sample size of 236 at each site provided 80% power to detect a difference of 95 calories purchased. Using these calculations as a frame of reference, a sample size of 295 students per site was hypothesized to provide 80% power to detect differences in calories purchased of ~10% and in label noticing of ~6% across labelling conditions. Therefore, the desired sample included 300 students per site during each of the pre-test and post-test phases, totaling 1,800 participants.

Recruitment took place during (~11:30 AM to 2:30 PM) and dinner (~5:30 to 8:30 PM). Booths were set up in unobtrusive locations at the exits of cafeterias and informational posters about the study were displayed in the cafeterias throughout the study period (**Appendix G**). Trained research assistants provided patrons who approached the booth with a brief overview of the study (**Appendix H**). Those who expressed interest were provided with an iPad loaded with an eligibility screener, information letter, and consent form (**Appendix I**). Eligible and consenting patrons were then linked to the exit survey (~18 minutes to complete, on average). Participants who completed the survey received a $5 honorarium in cash for their time. Since responses following prior exposure to the survey may demonstrate response bias (e.g., knowledge of survey questions), patrons who indicated they had completed the survey that week were not eligible.

A total of 3355 patrons were approached during the data collection period and 2056 responses were collected (949 during pre-test, 1107 during post-test). The response rate (response rate #4 by the American Association for Public Opinion Research) was 57% and 65% at the pre-test and post-test phases respectively.[49] Unique participant IDs were used to identify repeat responses and only the first response from participants within each phase retained for analyses; this resulted in the exclusion of 87 pre-test responses and 127 post-test responses. Responses with data quality concerns (i.e., participants said “Don’t know” to all questions related to purchasing and 80% of sociodemographic questions; n=43) and responses from participants who did not report a meal, beverage, and snack (i.e., participants likely skipping questions related to purchasing; n=101) were removed from the dataset. The final analytic dataset included 1698 respondents (n=828 respondents during pre-test; n=870 respondents during post-test), with 204 repeat responses from participants who completed the survey in both phases.

7.3.2 Intervention

The labels were based on designs used in prior studies[17,20,50] and developed in consultation with campus food services and their on-staff dietitian, as well as members of the research team (**Chapter 4; Figures 3 and 4**). A plain-language educational poster was based on a webpage maintained for *Ontario's Healthy Menu Choices Act*[11] and included contextual information consistent with the mandate (i.e., **"*Adults and youth (ages 13 and older) need an average of 2,000 calories a day. However, individual needs vary.*"**). The labels and educational posters were tested in cognitive interviews[51,52] with undergraduate students (n=10) and modified to improve readability and understanding. Participants received $5 cash.

An online nutrition information database maintained by campus food services was used to identify the calories provided by a standard serving each item.[53] For items not listed in the database, calorie amounts and serving sizes were identified based on close matches within the Canadian Nutrient File,[54] publicly available via Health Canada. Numeric labels displayed the calories provided by a serving of the item. For the TLL, the numeric amount was accompanied by a red, amber, or green symbol, based on the United Kingdom Food Standards Agency guidelines for TLL on prepackaged foods,[17,55] which provides calorie cut-offs for each colour per serving of foods or beverages, respectively. Criteria for TLL cut-offs were based on a 2,000-calorie diet, consistent with prior TLL studies.[20,27]

Labels were positioned and monitored in cafeterias for ~3 weeks following the pre-test phase. Labels were posted adjacent to foods and beverages or on menu boards, using the same font and size as the item name and price (**Chapter 4; Figure 5**). Educational posters and contextual information were placed in multiple locations throughout the intervention cafeterias (e.g., on counters and screens) throughout the post-test phase.

7.3.3 Exit survey and measures

An online exit survey, consistent across phases, was completed on tablets using Qualtrics software (Version March 2019, Qualtrics, Provo, UT).[56] The questions were adapted from prior research[20,50,57,58] and drew upon indicators used in national surveillance,[59] when applicable. The survey was tested using cognitive interviews with a sample of undergraduate students (n=10) to ensure understanding and clarity of questions; participants received $5 cash. The final exit survey (**Appendix K**) queried information on noticing, use, and perceptions of the labels (reported elsewhere); the most recent purchase at the cafeteria; socio-demographic information (e.g., age, gender, race); information related to consumer behaviour (e.g., average number of visits per week); indicators of health literacy,[60] SES,[61] and disordered eating;[62] and unique identifiers (i.e., day of birth, mother and father's initials, and city of birth) to enable linking repeat responses from the same participant.[63,64]

To collect detailed data on most recent purchase at the cafeteria, the exit survey was pre-populated with items sold in the cafeteria, including entrées, beverages, and snacks, and prompted respondents for specific details (e.g., options for add-ons, such as sauce or cheese). Participants could also enter open-text details about their purchase; open-text responses were matched to items sold at the cafeterias. Prior to the study, a database of all foods and beverages offered at the cafeterias was developed to inform label and survey development. The database included a study food code, a corresponding food code from the Canadian Nutrient File,[54] calorie amounts per serving, the assigned TLL colour, and weight per serving in grams. Serving sizes for all items were based on a pre-determined weight of foods and beverages provided by the on-campus campus food service operation.

Food and beverage purchasing by TLL categories

Reported foods and beverages were coded using the study database, enabling identification of whether each item purchased was labelled as green, amber, or red according to the TLL criteria. For every individual's purchase, median scores of green-, amber-, and red-labelled items were calculated. Since the cafeterias offered entrées that had customizable add-ons (e.g., multiple options of bread, vegetables, and cheeses for a sandwich), a proportional weighting and scoring system was used to maintain comparability across similar items. For instance, a purchase of a customizable sandwich with 10 add-ons, subsequently assigned 10 TLL categories (e.g., 5 add-ons green, 3 amber, and 2 red), is not comparable to a purchase of a serving of lasagna assigned one amber indicator. To address this, weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to the total number of add-ons in the full entrée. Thus, the customizable sandwich described above received a score of 0.5 for the green category, 0.3 for the amber category, and 0.2 for the red category. The lasagna coded as amber received a score of 1 for the amber category and zero for the green and red categories. The total scores for each of the red-, amber-, and green-labelled items purchased per individual were calculated by summing scores across items.

Food group and nutrient density ratios

Changes in purchasing of food groups (fruits, vegetables, whole grains, refined grains, plant-based proteins, and red meat) and nutrients (saturated fats, added sugars, and sodium) per 1000 kcal were examined at all sites from pre-test to post-test. The food groups and nutrients selected were based on dietary guidance. For example, *Canada's Food Guide*[65] encourages consumption of fruits and vegetables, whole grains, and plant-based proteins, while also limiting refined grains and red meat. These recommendations are consistent with those related to environmental sustainability, such as the *EAT-Lancet* plate.[31] Within *Canada's Healthy Eating Strategy*,[9] there is also significant attention toward reducing intake of saturated fats, added sugars, and sodium. A prior study examining the food environment of the study site found that whole fruit and whole grain offerings were less prevalent at the eateries,[66] suggesting consumption of these may be low. Nonetheless, fruit and whole grains were included for completeness relative to dietary guidance.

The 2017-2018 Food and Nutrient Database for Dietary Studies[67] (FNDDS) and 2017-2018 Food Patterns Equivalents Database[68] (FPED) were used to estimate the amounts of food groups and nutrients per 100 g of foods and beverages. The FNDDS is a U.S. database consisting of nutrient values for foods and beverages reported in national surveillance. The FPED converts the foods and beverages (per 100 g) reported in the FNDDS to 37 food pattern components identified in the *Dietary Guidelines for Americans*.[39] Although FNDDS and FPED originate in the U.S., previous studies have used the databases to examine population-level eating patterns among Canadians given the similarities in the food supply and dietary guidance.[69–71] Additionally, data collected using the Canadian version of the Automated Self-Administered 24-Hour Dietary

Assessment Tool are auto-coded using the FPED since a similar Canadian database that disaggregates all foods and beverages to their component parts is not available.[72]

A linkage file that matches food codes from the Canadian Nutrient File to food codes in FNDDS/FPED was used to merge the study database with the FNDDS and FPED. As a result, all foods and beverages offered at the cafeterias were linked to nutrient information related to the food groups and nutrients of interest per 100 g of the item. We used FPED to provide information on the amounts of fruits, vegetables, whole grains, refined grains, plant-based proteins (i.e., nuts and seeds, soy, legumes), red meats (i.e., beef, veal, pork, lamb, game meat), and added sugars. FNDDS provided information on saturated fats and sodium amounts. Amounts (cup, oz, tsp equivalents, grams) of each dietary component per food or beverage reported were calculated by multiplying the serving size (g) by the FPED or FNDDS amount (per 100 g). The amounts of food groups and nutrients per food or beverage were then summed at the individual level to arrive at totals per person. To enable a focus on the quality of food and beverage purchases rather than quantity, density ratios were calculated by dividing by the total number of calories, drawing upon the calorie information in the study database. Density ratios were multiplied by 1000 kcal to aid interpretability.

Covariates

Potential confounders were identified *a priori* and included age (continuous), gender (man/woman; other specified identities were not included due to low cell sizes),[23] race (white/person of colour),[57,73] frequency of visits to cafeteria in the past week (continuous),[50] health literacy,[41,58] socioeconomic status,[41,73] and disordered eating risk.[42,44,74] Eating occasion was included as a covariate to adjust for differences in purchasing behaviour at lunch and dinner.

Age was included in the models as a continuous variable (years) and calculated by subtracting year of birth from the study year (2019). The exit survey collected information on gender identity, including options for man, woman, trans man, trans woman, non-binary, and other specified identity. Responses for trans man, trans woman, non-binary, and other specified identities were collapsed and provided in tables demonstrating sample characteristics. However, given low cell sizes, gender identity was collapsed into a binary variable (man/woman) for inclusion as a covariate in the model and non-binary responses were not included in the analyses.

Drawing upon data collected for ethnicity, race was collapsed into a binary variable (white/person of colour).

Health literacy was assessed using the Newest Vital Sign,[60] yielding a score out of 6 based on responses to questions about the nutrition information provided for a pint of ice cream. Health literacy was coded based on categories for adequate literacy (total score of 4 to 6); low likelihood of limited literacy (2 to 3); and high likelihood of limited literacy (0 to 1).[60] SES was measured using a question on subjective social status[61] (SSS), where participants were provided with a 10-point 'societal ladder' and identified where they would rank themselves (1=high; 10=low). Rankings for SSS were included as a continuous variable in all models from 1 to 10. SCOFF,[62] a 5-item questionnaire to observe eating disorder symptomology among non-clinical populations, was used to measure disordered eating risk. Affirmation of 2 or more questions indicated high likelihood of disordered eating risk and coded as a categorical variable (0-1=unlikely demonstrating disordered eating; 2-5=likely demonstrating disordered eating). Measures of health literacy, SES, and disordered eating risk have been demonstrated to have reasonable reliability and validity among young adults.[60–62,75,76]

7.3.4 Analysis

Analyses were conducted using SAS® Studio (Version 9.04, SAS Institute, Cary, NC). All tests were interpreted using a significance level of 0.05. Odds ratios with 95% confidence intervals are reported, unless otherwise specified.

Preliminary ANOVA (continuous variables) and Pearson χ^2 tests (categorical variables) were used to describe differences across sites, though the tests were not used to inform inclusion of covariates in the model. Descriptive statistics were calculated for group- and individual-level scores of green-, amber-, and red-labelled foods purchased at all sites from pre-test to post-test. The distributions for scores of TLL categories purchased and density ratios were right skewed and therefore, means and medians are reported for all outcomes. Descriptive statistics were also calculated to describe the foods and beverages purchased in terms of food group and nutrient density ratios.

Generalized estimating equation (GEE) models were used to generate population-averaged estimates by modelling mean responses of participants at each site across test phases, accounting for repeat data among those who participated at both pre-test and post-test. Separate GEE models were run for each outcome related to the scores of TLL categories and density ratios. An interaction between site and phase estimated the difference in the change of each outcome from pre-test to post-test, comparing intervention sites to the control (see **Appendix N** for model output for the interactions). Eating occasion, age, gender, race, frequency of visits to the cafeteria in the past week, health literacy, SSS, and disordered eating risk were included in all models. Three-way interactions between site, phase, and covariates for health literacy, SSS, and disordered eating risk were individually tested in the models to examine subgroup differences.

7.4 Results

7.4.1 Sample characteristics

Sample characteristics are described in **Table 7,** by site and phase. The mean age was 19.3 years, with ~one-third of the sample demonstrating a high likelihood of limited literacy and an average SSS score of ~4.5 (max, 10). Significant differences were observed by site for frequency of visits per week (F=6.94, *df*=2; p<0.001) and race (χ^2=30.4, *p* <0.001). By test phase, significant differences were observed for frequency of visits (F=8.81, *df*=1; *p*=0.0013), race (χ^2=12.9, *p* <0.001), and health literacy (χ^2=13.7, *p*=0.001).

7.4.2 Food and beverage purchasing by TLL categories

Table 8 demonstrates the scores of green-, amber-, and red-labelled items purchased at all sites from pre-test to post-test. The median number of green-, amber-, and red-labelled items purchased per individual at each site are also reported by site and phase. For the average individual, the number of green-labelled items purchased decreased at all sites by approximately 0.5-0.7 items from pre-test to post-test. Adjusting for covariates, no significant differences were observed in the change in purchases of green-labelled items from pre-test to post-test at the numeric (β=-0.18, 95% CI=-0.53–0.18; p=0.34) and TLL sites (β=-0.04, 95% CI=-0.41–0.33; p=0.83) relative to the control.

From pre-test to post-test, significant differences were observed in the change in purchases of amber-labelled items at the numeric (β=0.21, 95% CI=-0.03–0.39; p=0.02) and TLL (β=0.26, 95% CI=0.09–0.43; p=0.003) sites relative to the control. These differences were due to a median decrease of 0.8 for amber-labelled items purchased at the control site (β=-0.20, 95% CI=-0.33– -0.07; p=0.003).

Changes in purchasing of red-labelled items from pre-test to post-test were minimal, ranging from no change to a 0.1 decrease in red-labelled items purchased. The models revealed no differences in red-labelled items purchased at the numeric (β=0.09, 95% CI=-0.06–0.23; p=0.25) and TLL (β=0.11, 95% CI=-0.33–0.26; p=0.14) sites relative to the control from pre-test to post-test.

The three-way interaction for SSS with the TLL site and post-test phase was significant for red-labelled items purchased (β=0.11, 95% CI=0.02–0.21; p=0.01). Interaction plots (**Figure 13**) revealed lower purchasing of red-labelled items among those with higher SSS scores (i.e., representing individuals in low SES groups) at the TLL site during the pre-test phase. At the post-test phase, greater purchasing of red-labelled items among those with higher SSS scores was observed at the TLL site. No other differences in purchasing were observed when testing the three-way interactions for each of SSS, health literacy, and disordered eating risk with site and phase (p>0.05 for all).

7.4.3 Density ratios for food groups

Table 9 demonstrates food group density ratios per 1000 kcal at each eating occasion (i.e., lunch and dinner combined and separately) by site and phase. In comparison to the control, no differences in the change in cups of fruit purchased were observed from pre-test to post-test at the numeric (β=-0.09, 95% CI=-0.66–0.48; p=0.76) and TLL sites (β=-0.11, 95% CI=-0.63–0.41; p=0.69). The medians for cups of vegetables purchased increased by 0.04 cup equivalents at the numeric site and 0.05 cup equivalents/1000 kcal at the TLL site; these differences in change from pre-test to post-test were not statistically significant when compared to the control, accounting for covariates (Numeric: β=-0.01, 95% CI=-0.58–0.48; p=0.96 | TLL: β=-0.042, 95% CI=-0.96–0.12; p=0.13).

For whole grains, no differences were observed when comparing the change in ounce equivalents purchased at the numeric (β=-0.07, 95% CI=-0.39–0.24; p=0.65) and TLL sites β=0.12, 95% CI=-0.20–0.44; p=0.47) in comparison to the control from pre-test to post-test. From pre-test to post-test, there was a 0.57 decrease in median oz equivalents for refined grains purchased at the TLL site and this difference was significant relative to the control (β=-1.07, 95% CI=-1.82–-0.31; p=0.005). No difference was observed when comparing ounce equivalents of refined grains purchased at the numeric site versus the control from pre-test to post-test (β=-0.74, 95% CI=-1.51–0.02; p=0.06). There was a 0.57 oz equivalents increase in refined grains purchased at the control site from pre-test to post-test, though this difference was not significant (β=0.55, 95% CI=-0.01–1.11; p=0.06).

In comparison to the control, there were no differences in the change in purchases of plant-based proteins in ounce equivalents at the numeric (β=-0.11, 95% CI=-1.38–0.16; p=0.41) and the TLL sites (β=0.03, 95% CI=-0.32–0.37; p=0.88) from pre-test to post-test. Similarly, no differences were observed in purchases of red meat in ounce equivalents when comparing the numeric (β=0.03, 95% CI=-0.37–0.43; p=0.88) and TLL sites (β=0.42, 95% CI=-0.06–0.09; p=0.09) to the control from pre-test to post-test. The three-way interactions for health literacy, SSS, and disordered eating risk with site and phase for all food groups were not significant (p>0.05 for all).

7.4.4 Density ratios for nutrients

Nutrient density ratios per 1000 kcal for foods and beverages purchased at each eating occasion (i.e., lunch and dinner combined and separately) by site and phase are also presented in **Table 9**. For saturated fats, there were no significant differences when examining purchases from pre-test to post-test at the numeric (β=0.45, 95% CI=-3.16–3.25; p=0.98) and TLL sites (β=-2.10, 95% CI=-4.61.61–041; p=0.10) relative to the control. Similarly, no differences were observed in sodium purchased at the numeric (β=-45.2, 95% CI=-355.7–3265.4; p=0.78) and TLL sites β=-295.4, 95% CI=-614.1–23.3; p=0.07) relative to the control from pre-test to post-test.

From pre-test to post-test, there was a 0.05 tsp decrease in median added sugars purchased at the numeric site and the difference in change was significant when compared to the control (β=4.71, 95% CI=0.97-8.45; p=0.01). There was a 0.08 g increase in added sugars purchased at the TLL site, but the difference was not significant relative to the control from pre-test to post-test (β=2.70, 95% CI=-0.76–6.16; p=0.13). There was a 0.97 g decrease in median added sugars purchased at the control site from pre-test to post-test (β=-2.27, 95% CI=-4.56–0.02; p=0.05). Three-way interactions for health literacy, SSS, and disordered eating risk were not significant for all nutrients examined (p>0.05 for all).

7.5 Discussion

The present study observed that numeric and traffic light calorie labelling had little impact on purchasing of foods and beverages labeled as green, amber, and red relative to the control, consistent with prior research.[24,36–38] However, the assumption of parallel trends required for quasi-experimental trials was not satisfied as revealed through a prior analysis focused on calories purchased (**Chapter 6**). Decreases in purchasing of refined grains at the TLL site and added sugars at the numeric site were observed. Numeric and TLL did not affect purchasing of other food groups and nutrients examined, including fruits, vegetables, whole grains, plant-based proteins, red meat, saturated fats, and sodium.

At the individual-level, there was a downward trend in the scores of green-labelled items purchased from pre-test to post-intervention, whereas purchases of red-labelled items stayed the same. A significant difference in amber-labelled items was observed at the numeric and TLL sites relative to control; however, this was driven by a reduction in scores of amber-labelled items purchased at the control site. Similar trends were observed when examining purchases at the group-level by site and phase, with purchasing of green-labelled items decreasing at all sites and variation in amber- and red-labelled foods purchased at the control site. It is notable that the scores for purchasing of items labeled as green within the TLL scenario were higher than those for amber and red across phases and sites, potentially indicating a food environment that supports purchases of green-labelled items. However, examining the nutrients and food groups per 1000 calories suggests substantial room for improvement in terms of low intake of components such as fruit and whole grains and high sodium and added sugars purchased at a single eating occasion. In terms of the impact of the calorie labels, a small decrease in purchasing of refined grains at the numeric site was observed; neither labelling format impacted purchasing of fruits, vegetables, whole grains, or red meat. A prior scan of eateries on the campus at which this study was conducted found low availability of whole fruit and whole grain offerings at the eateries relative to total offerings,[66] likely biasing the present findings toward the null for these dietary components. Fruit options consisted of pre-packaged fruit cups, whole fruit (e.g., bananas, apples), and fruit within the salad bars, with smoothies available at the control site. Whole grain offerings were typically not the default option for meals and refined grains were prominent. Plant-based proteins were limited to one or two daily hot meal offerings and few add-ons for customizable meals, such as tofu for rice bowls and nuts and seeds at the salad bar. Purchasing of red meat per 1000 kcal also did not differ from pre-test to post, perhaps due to the array of animal-based protein options available at the cafeterias.

A prior analysis focused on calories purchased using this data (**Chapter 6**) revealed an unexplained decrease in calories purchased at the control site from pre-test to post-test, indicating the assumption of parallel trends required for quasi-experimental trials was not satisfied.[77–80] Thus, the observed trends on foods and beverages purchased by TLL categories, food groups, and nutrients may reflect weekly variations in hot meal offerings or minor differences in offerings across the cafeterias, potentially biasing findings toward the null. We conducted an additional investigation of all offerings and observed only minor differences in calories of menu offerings across sites; for example, the difference in proportion of green-, amber-, and red-labelled items for meals, beverages, and snacks were within 1% (**Appendix C**). At all sites, purchasing patterns may have been affected by the timing of the data collection period, with the post-test period overlapping with the end of the academic term. For example, the frequency of visits at the TLL site decreased from pre-test to post-test and it's possible that purchasing patterns also changed. Similar to our analyses of calories purchased, the GEE analyses of purchasing of foods and beverages by TLL categories and food groups and nutrients were inconclusive and warrant further investigation using group-level sales data of specific foods or itemized categories. Of note, our findings related to increased noticing and use of nutrition information (**Chapter 6**) suggest the intervention was implemented as planned and differences may be due to uncontrolled confounding described above.

Current evidence examining numeric and TLL studies on changes in green-, amber-, and red-labelled items is limited. The findings of the present study are consistent with an evaluation of a 7-week TLL and choice architecture intervention in post-secondary cafeterias, which found no changes in red-labelled or green-labelled items purchased at the intervention sites relative to the controls.[81] In contrast, prior studies examining the impact of TLL in worksite hospital cafeterias[82–84] and a recreation facility[50] observed decreases in sales of red-labelled items and increases in sales of green-labelled items, potentially suggesting TLL may be effective in shifting purchasing patterns in particular settings. Some studies have suggested consumers utilize a red-avoidance strategy when interpreting TLL;[23,24,85] however, findings of prior studies were based on data, which do not account for the influence of individual-level sociodemographic characteristics on purchasing and interactions between those characteristics and labelling.

Only one other labelling-focused study has examined purchasing relative to dietary guidance.[38] Following a jurisdictional calorie mandate for restaurants and fast-food chains, the cross-sectional study observed participants who used calorie labels had a higher probability of purchasing healthier sides and beverages, with respect to guidance in the *2015 Dietary Guidelines for Americans*,[39] than those who did not use the labels.[38] While this finding could have been due to the low number of healthy entrée options available, the authors speculated that compensating less healthy meals with a healthier side dish or beverage may be an 'easier' choice for patrons to make.[38] The analyses presented here were based on a single meal per patron and do not capture the totality of an individual's eating pattern. We also did not examine changes to food and beverage purchasing by entrée, beverage, and snack categories due to low prevalence of offerings for specific food groups (e.g., the cafeterias offered a low number of whole grain options). Future research could further examine the potential for calorie labels to influence compensatory purchasing behaviour and the implications on diet quality.

Given the data on food and beverage purchasing were based on a single eating occasion, purchasing of saturated fat, sodium, and added sugars were high overall. A difference in purchasing of added sugars was observed at the TLL site from pre-test to post-test, with no differences in purchasing of saturated fats and sodium at either the numeric or TLL sites. Prior real-world studies, though limited, observed no impact of TLL on purchasing of saturated fats, sodium, and added sugars.[36,37] On the other hand, a modelling study examining population-level intake found that TLLs could lead to decreases in purchases of energy, total fats and saturated fats, and sodium, with no implications for added sugars.[24] Of note, although the difference in purchasing of added sugars was significant from pre-test to post at the numeric labelling site, the median decrease was limited to 0.05 tsp. Further, the difference in added sugars purchased at the TLL site could be explained by the decrease observed at the control (p=0.05).

There was a significant three-way interaction between SSS and TLL site at post-test, suggesting that purchases of red-labelled items increased among those with lower SSS, with no changes to purchasing of green- or amber-labelled items. In contrast, a TLL and choice architecture intervention decreased all purchases of red-labelled items and increased green-labelled items across all race and socioeconomic groups.[84] Though their review focused on numeric calorie labelling, Sarink et al.[40] observed calorie labels led to a significant decline in fast food calories purchased among consumers in high SES neighbourhoods relative to those in low SES neighbourhoods. Contrary to discourse that TLL may minimize socioeconomic differences by ameliorating differences in health literacy,[28,29] the findings of this study suggest TLL could exacerbate diet-related disparities by increasing purchasing of red-labelled foods. No differences by health literacy, SSS, and disordered eating risk were observed for food groups and nutrients.

This study was one of the first real-world experiments to compare the impacts of numeric and TLL formats on the quality of purchases with respect to dietary guidance. The findings are subject to several limitations. The study was limited to post-secondary students visiting three residence cafeterias and the findings may not be generalizable to other settings, such as fast-food outlets. On the other hand, participants may have been exposed to other forms of nutrition information in the cafeteria (e.g., labels indicating vegan and vegetarian options) or numeric calorie labelling in other settings, including branded outlets on campus, potentially dampening their impact. The post-test period overlapped with the end of the academic term, potentially affecting purchasing patterns at all sites. It is possible participants in the study did not prioritize healthy eating, particularly during this time of the term, and instead emphasized convenience and taste. Due to the limited number of studies to inform *a priori* hypotheses,[86] we did not adjust for multiple comparisons and the results may demonstrate false positives. While repeat responses were excluded potentially raising concerns about power, a post-hoc power analysis of the study sample and *a priori* estimates from our initial sample size calculation demonstrated that the study was powered to detect a 10% difference in calories purchased. Some comparisons were outside of this magnitude, for example, there was a 1.2% difference in calories purchased at the TLL site compared to the control. Therefore, we suspect that any replication studies using a similar study design may find effects and differences that we were unable to in this study. The findings should be interpreted in the context of assumptions with respect to the food and beverage purchasing data. For the TLL categories, we imposed a proportional weighting system to account for add-ons to customizable entrées and enable comparability across similar items. However, this structure may have disproportionately affected add-ons that were a prominent component of the full item (e.g., breads and sauces were treated as comparable add-ons). Similarly, the proportional weights were affected by the total number of add-ons for the overall item; for example, 3 red-labelled items in a sandwich of 10 customizable add-ons received a weight of 0.3, whereas 3 red-labelled items on another sandwich of 5 customizable options had a weight of 0.6. Further, TLL systems based on calories alone are flawed;[84] for example, some foods and beverages that are nutrient-dense but higher in calories (e.g., avocados, eggs) may receive an amber or red indicator, whereas highly processed foods with lower calories (e.g., white bread) may receive a green indicator.

Foods and beverages reported in the surveys were matched to similar food codes within the Canadian Nutrient File and FNDDS and FPED. The food codes available in these databases may not accurately represent the specific foods and beverages offered within the cafeterias, potentially blunting differences in composition with respect to added sugars and other dietary components of interest. Of the 1280 foods and beverages offered at the cafeteria, only ~7% were deemed to be distant matches to their assigned food code (e.g., bruschetta was matched to garlic bread). Serving weights for all foods and beverages were based on a pre-determined default serving size provided by the on-campus food service operations and variations in amounts purchased are possible, especially in the context of items such as the salad bar. Examination of food and beverage purchasing at a single eating occasion is limited in terms of providing evidence on how labels may support overall healthy eating patterns.

Overall, while the study may suggest that numeric and TLL had little impact on green-, amber-, and red-labelled items and minimal impact on change in food groups and nutrients purchase, we observed unexpected noise across sites. A future analysis will use sales data over a longer period of time to identify potential sources of confounding. Further research from real-world studies is needed to understand the potential effects of an emphasis on calories in food policies, such as calorie labelling, and the implications for overall healthy and sustainable eating patterns.

Figure 13. Interaction plot for subjective social status on number of red-labelled items purchased by phase (N=1698 respondents; pre=828, post=870)

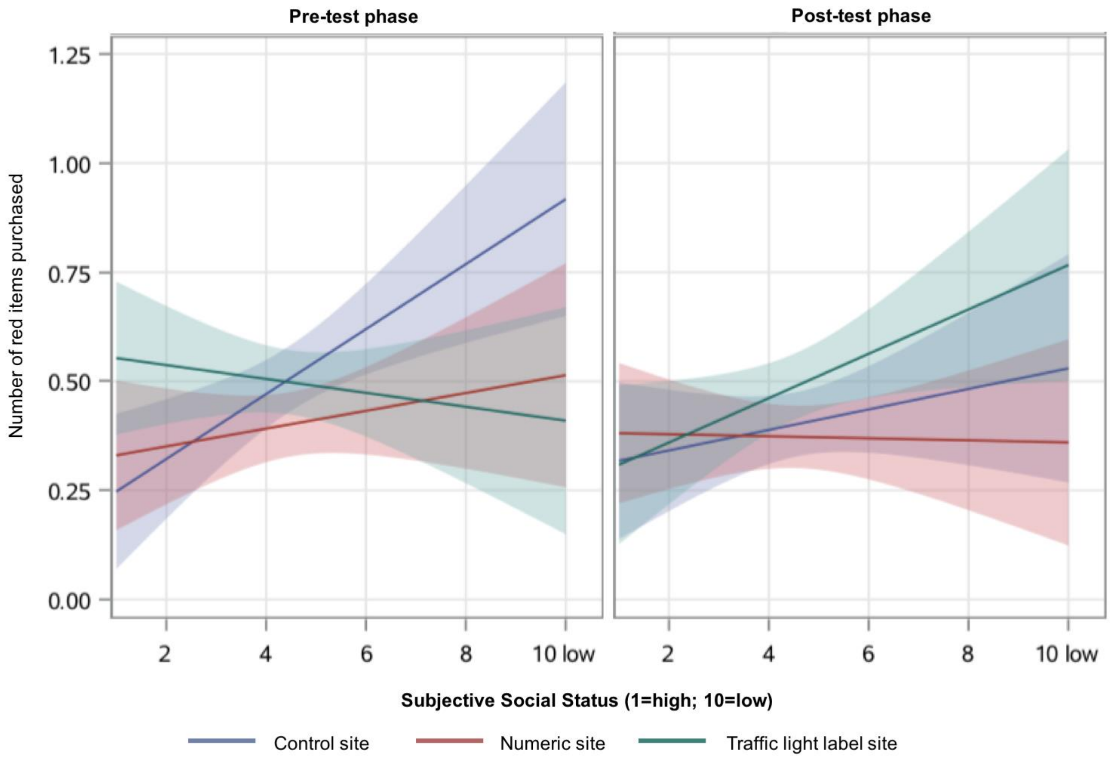


Table 7. Sample characteristics of participants by site and phase (N=1698 respondents; pre=828, post=871)

	Control		Numeric		Traffic light	
	Pre-test (n=274)	Post-test (n=307)	Pre-test (n=287)	Post-test (n=337)	Pre-test (n=293)	Post-test (n=301)
Eating occasion n(%)						
Lunch	104 (38.9)	98 (33.9)	122 (43.9)	115 (37.8)	126 (44.5)	117 (42.2)
Dinner	163 (61.1)	191 (66.1)	156 (56.1)	189 (62.2)	157 (55.5)	160 (57.8)
Frequency of visits per week M(SD)	13.6 (7.72)	13.3 (8.15)	13.6 (8.84)	12.24(8.42)	12.7 (8.89)	10.5 (8.26)
Age (year) M(SD)	19.3 (1.86)	19.2 (0.62)	19.4 (0.95)	19.3 (1.32)	19.4 (0.95)	19.3 (1.01)
Gender n(%)						
Woman	121 (45.3)	141 (48.8)	138 (49.6)	1544 (47.4)	114 (40.28)	132 (47.7)
Man	144 (53.9)	143 (49.5)	136 (48.9)	157 (51.6)	167 (59.0)	138 (49.8)
Specified identity	1 (0.37)	3 (1.04)	2 (0.72)	2 (0.66)	1 (0.35)	4 (1.44)
Not reported	1 (0.37)	2 (0.69)	2 (0.72)	1 (0.33)	1 (0.35)	3 (1.08)
Race n(%)						
White	88 (32.9)	59 (20.4)	47 (16.9)	46 (15.1)	51 (18.0)	31 (11.2)
Person of colour	179 (67.2)	230 (79.6)	231 (83.1)	258 (84.9)	232 (82.0)	246 (88.8)
Health literacy (NVS)[1] n(%)						
High likelihood of limited literacy (0-1)	67 (25.1)	83 (28.7)	78 (28.1)	92 (30.3)	87 (30.7)	66 (23.8)
Low likelihood of limited literacy (2-3)	95 (35.6)	77 (26.6)	95 (34.2)	80 (26.3)	91 (32.2)	74 (26.7)
Adequate (4-6)	105 (39.3)	129 (44.6)	105 (33.3)	132 (33.2)	105 (37.1)	137 (49.5)
Subjective social status[2] M (SD)	4.47 (1.64)	4.55 (1.61)	4.48 (1.67)	4.51 (1.74)	4.50 (1.63)	4.57 (1.63)
Disordered eating (SCOFF)[3] n(%)						
Unlikely disordered eating (0-1)	182 (68.1)	196 (67.8)	182 (65.5)	212 (69.7)	206 (72.8)	193 (69.7)
Likely disordered eating (2-5)	85 (31.8)	93 (32.2)	96 (34.5)	92 (30.3)	77 (27.2)	83 (30.3)

[1]Health literacy was assessed using the Newest Vital Sign, yielding a score out of 6 based on responses to questions about a nutrition label provided for a pint of ice cream (4-6=adequate health literacy; 2-3=low likelihood of limited literacy; 0-1=high likelihood of limited literacy).
[2]Subjective social status was used as an indicator for socioeconomic status. Participants rank their perceived social status on a 10-point scale (1=high; 10=low).
[3]Disordered was assessed using SCOFF, a 5-item questionnaire for eating disorder symptomology among non-clinical populations. Affirmation of 2 or more questions indicated high likelihood of disordered eating risk (0-1=unlikely disordered eating; likely disordered eating).

Table 8. Group- and individual-level purchases for TLL categories by site and phase (N=1698 respondents; pre=828, post=871)

	Control		**Numeric**		**Traffic light**	
	Pre-test (n=274)	**Post-test (n=307)**	**Pre-test (n=287)**	**Post-test (n=337)**	**Pre-test (n=293)**	**Post-test (n=301)**
Purchases at group-level[1,2] n (%)						
Green	513.1 (58.9)	502.3 (62.8)	531.8 (64.2)	452.8 (59.3)	538.0 (64.3)	434.1 (60.0)
Amber	220.2 (25.3)	183.1 (22.9)	185.8 (22.4)	195.4 (25.6)	156.6 (18.7)	158.0 (21.8)
Red	137.7 (15.8)	114.6 (14.3)	111.4 (13.4)	115.7 (15.1)	142.4 (17.0)	131.9 (18.2)
Total	871	800	829	764	837	724
Full purchase at individual-level[1,3] Median (Range: Q1-Q3; Maximum)						
Lunch and dinner						
Green	1.7 (0.8-3.0; 10.7)	1.0 (0.6-2.6; 15.3)	1.5 (0.6-3.0; 8.9)	1.0 (0.5-2.0; 7.7)	1.7 (0.7-3.0; 8.1)	1.0 (0.5-2.6; 6.4)
Amber	1.0 (0.4-1.1; 4.8)	0.4 (0.0-1.1; 3.0)	0.4 (0.0-1.0; 4.0)	0.3 (0.0-1.0; 5.8)	0.2 (0.0-1.0; 3.3)	0.3 (0.0-1.0; 4.3)
Red	0.2 (0.0-1.0; 3.4)	0.1 (0.0-0.8; 2.8)	0.1 (0.0-0.9; 3.7)	0.0 (0.0-0.7; 6.6)	0.2 (0.0-1.0; 3.4)	0.2 (0.0-1.0; 3.2)
Lunch only						
Green	1.8 (0.8-3.0; 8.3)	1.0 (0.6-2.0; 15.3)	1.5 (0.7-3.0; 8.3)	1.0 (0.6-2.0; 6.2)	1.7 (0.7-3.0; 8.1)	1.0 (0.5-2.4; 6.4)
Amber	1.0 (0.0-1.1; 3.7)	1.0 (0.0-1.0.; 3.0)	0.3 (0.0-1.0; 3.2)	1.0 (0.0-1.0; 3.3)	0.1 (0.0-1.0; 3.3)	1.0 (0.0-1.0; 4.3)
Red	0.1 (0.0-1.0; 3.4)	0.0 (0.0-0.6; 2.3)	0.0 (0.0-0.5; 3.7)	0.0 (0.0-1.0; 6.6)	0.2 (0.0-1.0; 3.3)	0.1 (0.0-0.5; 3.2)
Dinner only						
Green	1.6 (0.8-3.0; 10.7)	1.0 (0.6-3.0; 8.0)	1.6 (0.6-3.0; 8.9)	1.0 (0.4-2.0; 7.7)	1.8 (0.6-3.0; 7.0)	1.0 (0.5-3.0; 5.6)
Amber	1.0 (0.0-1.1; 4.8)	0.3 (0.0-1.1; 3.0)	0.4 (0.0-1.0; 4.0)	0.5 (0.0-1.3; 5.8)	0.2 (0.0-1.0; 3.0)	0.3 (0.0-1.0; 3.0)
Red	0.3 (0.0-1.0; 3.0)	0.1 (0.0-1.0; 2.8)	0.1 (0.0-1.0; 2.7)	0.0 (0.0-0.7; 2.5)	0.2 (0.0-1.0; 3.4)	0.3 (0.0-1.0; 2.4)

[1]Median scores for group-level and individual-level purchases of green-, amber-, and red-labelled items were calculated using a proportional weighting and scoring system. Weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to the total number of add-ons in the full entrée. For example, a customizable sandwich with 5 green-labelled add-ons, 3 amber-labelled add-ons, and 2 red-labelled add-ons would receive a score of 0.5 for green, 0.3 for amber, and 0.2 for red. Similarly, a lasagna with 1 amber indicator would receive a score of 1 for the amber category and 0 for green and red categories.

[2]Represents the total number and proportion of green-, amber-, and red-labelled items purchased at each site and phase. Includes all meals and customizable add-ons, beverages, and snacks.

[3]Represents the median scores of green-, amber-, and red-labelled items purchased per individual at each site and phase. Includes all meals and customizable add-ons, beverages, and snacks.

Table 9. Density ratios for food groups and nutrients, for lunch and dinner periods combined and separated, by site and phase (N=1698 respondents; pre=828, post=871); mean (SD) per 1000 kcal, median (range) per 1000 kcal

	Control		Numeric		Traffic light	
	Pre-test (n=274)	Post-test (n=307)	Pre-test (n=287)	Post-test (n=337)	Pre-test (n=293)	Post-test (n=301)
Food groups (per 1000 kcal)[1]	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**
Fruit (cup equivalents)[2]						
Overall	0.67 (1.83)	0.85 (2.53)	0.78 (2.28)	0.85 (2.77)	0.72 (1.97)	0.77 (2.34)
	0.00 (0.00-13.0)	0.00 (0.00-20.0)	0.00 (0.00-20.0)	0.0 (0.0-20.0)	0.00 (0.00-15.8)	0.00 (0.0-20.0)
Lunch only	0.73 (1.53)	1.06 (2.80)	0.86 (2.58)	1.12 (3.39)	0.75 (2.01)	0.84 (2.58)
	0.00 (0.00-8.13)	0.00 (0.00-16.9)	0.00 (0.00-20.0)	0.00 (0.00-20.0)	0.00 (0.00-15.8)	0.00 (0.00-15.8)
Dinner only	0.62 (2.01)	0.73 (2.37)	0.73 (2.02)	0.68 (2.31)	0.70 (1.94)	0.72 (2.15)
	0.00 (0.00-13.0)	0.00 (0.00-20.0)	0.00 (0.00-13.8)	0.00 (0.00-16.0)	0.00 (0.00-13.8)	0.00 (0.00-20.0)
Vegetables (cup equivalents)[2]						
Overall	1.72 (1.92)	1.75 (2.22)	2.10 (2.92)	2.14 (2.79)	2.25 (2.56)	2.01 (2.23)
	1.24 (0.00-11.2)	1.20 (0.00-14.7)	1.20 (0.26-19.9)	1.20 (0.00-19.9)	1.43 (0.23-3.26)	1.48 (0.00-11.4)
Lunch only	1.79 (1.97)	1.90 (2.67)	1.72 (2.64)	2.28 (3.02)	2.45 (2.76)	1.97 (2.25)
	1.38 (0.00-11.2)	1.25 (0.00-14.7)	1.05 (0.00-19.9)	1.38 (0.00-19.9)	1.49 (0.00-14.2)	1.47 (0.00-11.4)
Dinner only	1.68 (1.90)	1.67 (1.95)	2.40 (3.10)	2.06 (2.64)	2.08 (2.38)	2.05 (2.22)
	1.16 (0.00-10.6)	1.19 (0.00-10.4)	1.35 (0.00-19.9)	1.13 (0.00-19.9)	1.42 (0.00-13.8)	1.49 (0.00-10.9)
Whole grains (oz equivalents)[2]						
Overall	0.52 (1.41)	0.60 (1.62)	0.32 (0.88)	0.35 (1.18)	0.23 (0.67)	0.43 (1.22)
	0.00 (0.00-13.8)	0.00 (0.00-9.64)	0.00 (0.00-6.41)	0.00 (0.00-10.2)	0.00 (0.00-5.86)	0.00 (0.00-12.4)
Lunch only	0.51 (1.33)	0.65 (1.78)	0.35 (0.99)	0.22 (0.73)	0.23 (0.70)	0.52 (1.22)
	0.00 (0.00-8.15)	0.00 (0.00-8.07)	0.00 (0.00-6.42)	0.00 (0.00-3.65)	0.00 (0.00-3.98)	0.00 (0.00-7.06)
Dinner only	0.52 (1.47)	0.58 (1.54)	0.30 (0.79)	0.43 (1.38)	0.22 (0.65)	0.36 (1.22)
	0.00 (0.00-13.8)	0.00 (0.00-9.64)	0.00 (0.00-5.97)	0.00 (0.00-10.2)	0.00 (0.00-5.86)	0.00 (0.00-12.4)
Refined grains (oz equivalents)[2]						
Overall	2.95 (3.13)	3.52 (3.42)	3.13 (3.14)	2.97 (3.14)	3.37 (3.18)	2.80 (2.75)
	2.53 (0.00-22.9)	2.90 (0.00-18.2)	2.58 (0.00-19.0)	2.56 (0.00-21.3)	2.58 (0.00-19.0)	2.46 (0.00-11.3)
Lunch only	2.85 (3.23)	3.79 (3.72)	3.11 (3.23)	3.19 (3.47)	3.28 (3.18)	2.69 (2.90)
	2.37 (0.00-22.0)	2.07 (0.00-16.0)	2.58 (0.00-16.5)	2.69 (0.00-21.3)	2.67 (0.00-16.8)	2.00 (0.00-11.3)
Dinner only	3.02 (3.06)	3.38 (3.26)	3.14 (3.08)	2.834 (2.92)	3.45 (3.18)	2.87 (2.63)

	2.82 (0.00-22.9)	2.77 (0.00-18.2)	2.56 (0.00-19.0)	2.20 (0.00-13.7)	2.82 (0.00-16.5)	2.79 (0.00-10.8)
Plant-based proteins (oz equivalents)[2]						
Overall	0.41 (1.36)	0.45 (1.44)	0.29 (0.94)	0.26 (0.91)	0.46 (1.30)	0.55 (1.78)
	0.00 (0.00-12.3)	0.00 (0.00-10.1)	0.00 (0.00-6.55)	0.00 (0.00-7.16)	0.00 (0.00-9.30)	0.00 (0.00-12.3)
Lunch only	0.38 (1.48)	0.44 (1.40)	0.36 (1.04)	0.16 (0.74)	0.40 (1.26)	0.76 (2.42)
	0.00 (0.00-12.3)	0.00 (0.00-7.05)	0.00 (0.00-6.55)	0.00 (0.00-5.41)	0.00 (0.00-9.30)	0.00 (0.00-12.3)
Dinner only	0.43 (1.28)	0.46 (1.46)	0.24 (0.87)	0.31 (0.99)	0.51 (1.34)	0.39 (1.06)
	0.00 (0.00-11.6)	0.00 (0.00-10.1)	0.00 (0.00-6.13)	0.00 (0.00-7.16)	0.00 (0.00-7.74)	0.00 (0.00-5.91)
Red meat (oz equivalents)[2]						
Overall	0.75 (1.88)	0.61 (1.53)	0.81 (1.76)	0.71 (1.71)	0.87 (1.81)	1.06 (2.26)
	0.00 (0.00-18.1)	0.00 (0.00-9.57)	0.00 (0.00-12.8)	0.00 (0.00-13.8)	0.00 (0.00-14.8)	0.00 (0.00-15.4)
Lunch only	0.62 (1.25)	0.60 (1.72)	0.57 (1.44)	0.67 (1.62)	0.79 (1.45)	1.09 (2.59)
	0.00 (0.00-7.78)	0.00 (0.00-9.57)	0.00 (0.00-6.27)	0.00 (0.00-7.40)	0.00 (0.00-7.91)	0.00 (0.00-15.4)
Dinner only	0.83 (2.16)	0.61 (1.43)	0.99 (1.97)	0.74 (1.77)	0.93 (2.05)	1.03 (1.99)
	0.00 (0.00-18.1)	0.00 (0.00-6.75)	0.00 (0.00-12.8)	0.00 (0.00-13.8)	0.00 (0.00-14.8)	0.00 (0.00-12.8)
Nutrients (per 1000 kcal)[1]	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**	**Mean (SD) Med (Range)**
Saturated fat (g)[3]						
Overall	11.9 (9.87)	12.5 (10.8)	13.2 (21.1)	13.4 (16.0)	13.7 (12.0)	11.8 (9.68)
	10.6 (0.00-102.8)	10.9 (0.00-76.1)	10.7 (0.00-325.1)	10.5 (0.00-164.8)	11.4 (0.00-114.4)	10.0 (0.00-48.8)
Lunch only	10.2 (6.78)	12.4 (10.5)	11.4 (8.60)	15.3 (22.0)	14.4 (14.4)	12.3 (10.0)
	9.63 (0.00-37.2)	10.8 (0.00-69.6)	10.3 (0.00-41.81)	9.80 (0.00-164.8)	11.0 (0.00-114.4)	11.4 (0.00-46.6)
Dinner only	12.9 (11.3)	12.5 (11.0)	14.5 (27.0)	12.2 (10.7)	13.1 (9.73)	11.4 (9.43)
	11.1 (0.00-102.8)	10.9 (0.00-76.1)	11.2 (0.00-325.1)	10.5 (0.00-68.6)	11.57 (0.00-47.3)	9.32 (0.00-48.8)
Sodium (g)[3]						
Overall	1912 (1222)	2040 (1388)	2033 (1158)	2120 (1543.1)	2242 (1377)	2080 (1388)
	1826 (10.5-8444)	1935 (10.5-8444)	1928 (8.00-8443)	1842 (0.00-8877)	2097 (17.4-6755)	1972 (2.67-8657)
Lunch only	1916 (1138)	2087 (1398)	1927 (965)	2215 (1700)	2284 (1440)	2044.1 (1512.6)
	1879 (10.5-7128)	2087 (10.5-8444)	1886 (13.3-4418)	1857 (0.00-8445)	2091 (17.4-6766)	1783 (17.4-8657)
Dinner only	1909 (1276)	2015 (1386)	2117 (1286)	2062 (1440)	2209(1328)	2106 (1292)
	1790 (10.5-8444)	1904 (10.5-8444)	1983 (8.00-8444)	1842 (10.5-8877)	2188 (20.5-6206)	2117 (2.67-6014)
Added sugars (tsp equivalents)[2]						
Overall	8.53 (14.2)	6.41 (12.1)	5.84 (14.2)	8.29 (21.0)	5.56 (16.3)	5.94 (14.1)
	2.59 (0.00-70.1)	1.62 (0.00-86.2)	1.30 (0.00-160.1)	1.25 (0.00-148.0)	1.20 (0.00-160.1)	1.28 (0.00-148.0)
Lunch only	5.98 (11.9)	4.63 (7.49)	5.89 (9.32)	7.13 (21.3)	5.40 (17.1)	5.91 (17.0)

	1.44 (0.00-70.1)	1.70 (0.00-45.0)	1.49 (0.00-49.6)	0.51 (0.00-148.0)	0.95 (0.00-160.1)	1.21 (0.00-148.0)
Dinner only	10.2 (15.3)	7.36 (13.9)	5.81 (17.1)	9.00 (20.8)	5.69 (15.8)	5.97 (11.6)
	3.43 (0.00-69.7)	1.51 (0.00-86.2)	1.25 (0.00-160.1)	2.09 (0.00-147.4)	1.66 (0.00-160.1)	1.35 (0.00-79.6)

[1]Nutrient density ratios were calculated by dividing the amount of food groups and nutrients for foods and beverages per individual by the total number of calories. All ratios were multiplied by 1000 kcal to aid interpretability.
[2]Amounts in cup, ounce, or teaspoon equivalents provided in the 2017-2018 Food Patterns Equivalents Database.
[3]Amounts in cup, ounce, or teaspoon equivalents provided in the 2017-2018 Food and Nutrient Database for Dietary Studies.

7.6 References

1. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019;393(10184):1958-1972.

2. Black JL, Billette J-M. Fast food intake in Canada: Differences among Canadians with diverse demographic, socio-economic and lifestyle characteristics. *Can J Public Heal*. 2015;106(2):52-58.

3. Powell LM, Chaloupka FJ, Bao Y. The Availability of Fast-Food and Full-Service Restaurants in the United States. *Am J Prev Med*. 2007;33(4):S240-S245.

4. Scourboutakos MJ, L'Abbé MR. Restaurant Menus. *Am J Prev Med*. 2012;43(3):249-255.

5. US Department of Agriculture. Food and Consumers [Internet]. 2021 [cited 2021 Oct 29]. Available from: https://www.ers.usda.gov/covid-19/food-and-consumers/

6. Todd JE, Mancino L, Lin B-H. The Impact of Food Away from Home on Adult Diet quality [Internet]. 2010 [cited 2021 Jul 8]. Available from: https://www.ers.usda.gov/webdocs/publications/46352/8170_err90_1_.pdf?v=3358.1

7. Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. *Obes Rev*. 2013;14:159-168.

8. Vandevijvere S, Swinburn B, International Network for Food and Obesity/non-communicable diseases (NCDs) Research, Monitoring and Action Support (INFORMAS. Towards global benchmarking of food environments and policies to reduce obesity and diet-related non-communicable diseases: design and methods for nation-wide surveys. *BMJ open*. 2014;4(5).

9. Health Canada. Healthy Eating Strategy [Internet]. [cited 2021 Jul 21]. Available from: https://www.canada.ca/

10. Bernell B. The history and impact of the New York City menu labeling law. *Food Drug Law J*. 2010;65:839.

11. Ministry of Ontario. Healthy Menu Choices Act, 2015, S.O. 2015, c. 7, Sched. 1 [Internet]. Ontario, Canada: Ministry of Health and Long-Term Care; 2017 [cited 2021 Jun 28]. Available from: https://www.ontario.ca/laws/statute/15h07

12. Kanter R, Vanderlee L, Vandevijvere S. Front-of-package nutrition labelling policy: global progress and future directions. Public Health Nutrition. 2018 Jun;21(8):1399-408.

13. Mhurchu CN, Eyles H, Choi Y-H. Effects of a Voluntary Front-of-Pack Nutrition Labelling System on Packaged Food Reformulation: The Health Star Rating System in New Zealand. *Nutrients*. 2017;9(8).

14. Bablani L, Mhurchu CN, Neal B, Skeels CL, Staub KE, Blakely T. The impact of voluntary front-of-pack nutrition labelling on packaged food reformulation: A difference-in-differences analysis of the Australasian Health Star Rating scheme. *PLoS Med*. 2020;17(11):e1003427.

15. National Health Services. Food labels: Eat well [Internet]. United Kingdom: Department of Health; 2018 [cited 2021 Jul 28]. Available from: https://www.nhs.uk/Livewell/Goodfood/Pages/food-labelling.aspx

16. World Cancer Research Fund International. Building on momentum: lessons on implementing a robust front-of-pack food label [Internet]. London, United Kingdom; 2019 [cited 2021 May 21]. Available from: https://www.wcrf.org/policy/our-publications/building-momentum-series/lessons-implementing-robust-front-of-pack-food-label

17. Food Standards Agency. Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets [Internet]. United Kingdom; 2016 [cited 2021 May 21]. Available from: https://www.food.gov.uk/sites/default/files/multimedia/pdfs/pdf-ni/fop-guidance.pdf

18. Ellison B, Lusk JL, Davis D. Looking at the label and beyond: The effects of calorie labels, health consciousness, and demographics on caloric intake in restaurants. *Int J Behav Nutr Phys Act*. 2013;10(1):1-9.

19. Ellison B, Lusk JL, Davis D. The impact of restaurant calorie labels on food choice: Results from a field experiment. *Econ Inq*. 2014;52(2):666-681.

20. Hammond D, Goodman S, Hanning R, Daniel S. A randomized trial of calorie labeling on menus. *Prev Med*. 2013;57(6):860-6.

21. Liu PJ, Roberto CA, Liu LJ, Brownell KD. A test of different menu labeling presentations. *Appetite*. 2012 Dec 1;59(3):770-7.

22. Prowse RJL, Lee KM, Chen E, Zuo F, Hammond D, Hobin E. Testing the efficacy of and parents' preferences for nutrition labels on children's menus from a full-service chain restaurant: Results of an online experiment. *Public Health Nutr*. 2020;23(10):1820-1831.

23. VanEpps EM, Downs JS, Loewenstein G. Calorie label formats: using numeric and traffic light calorie labels to reduce lunch calories. *J Public Policy Mark*. 2016;35(1):26-36.

24. Emrich TE, Qi Y, Lou WY, L'Abbe MR. Traffic-light labels could reduce population intakes of calories, total fat, saturated fat, and sodium. *PLoS One*. 2017;12(2).

25. Morley B, Scully M, Martin J, Niven P, Dixon H, Wakefield M. What types of nutrition menu labelling lead consumers to select less energy-dense fast food? An experimental study. *Appetite*. 2013;67:8-15.

26. Dodds P, Wolfenden L, Chapman K, Wellard L, Hughes C, Wiggers J. The effect of energy and traffic light labelling on parent and child fast food selection: A randomised controlled trial. *Appetite*. 2014;73:23-30.

27. Hobin E, Lillico H, Zuo F, Sacco J, Rosella L, Hammond D. Estimating the impact of various menu labeling formats on parents' demand for fast-food kids' meals for their children: An experimental auction. *Appetite*. 2016;105:582-590.

28. Sinclair SE, Cooper M, Mansfield ED. The Influence of Menu Labeling on Calories Selected or Consumed: A Systematic Review and Meta-Analysis. *J Acad Nutr Diet*. 2014;114(9):1375-1388.e15.

29. Fernandes AC, Oliveira RC, Proença RPC, Curioni CC, Rodrigues VM, Fiates GMR. Influence of menu labeling on food choices in real-life settings: a systematic review. *Nutr Rev*. 2016;74(8):534-548.

30. Bleich SN, Economos CD, Spiker ML, Vercammen KA, VanEpps EM, Block JP, Elbel B, Story M, Roberto CA. A Systematic Review of Calorie Labeling and Modified Calorie Labeling Interventions: Impact on Consumer and Restaurant Behavior. *Obesity*. 2017;25(12):2018-2044.

31. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019 Feb;393(10170):447-92.

32. Heller MC, Willits-Smith A, Meyer R, Keoleian GA RD. Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. *Environ Res Lett*. 2018;13:1-11.

33. Auestad N, Fulgoni VL. What Current Literature Tells Us about Sustainable Diets: Emerging Research Linking Dietary Patterns, Environmental Sustainability, and Economics. *Adv Nutr*. 2015;6(1).

34. Reinhardt SL, Boehm R, Blackstone NT, El-Abbadi NH, McNally Brandow JS, Taylor SF, DeLonge MS. Systematic review of dietary patterns and sustainability in the United States. *Adv Nutr*. 2020;11(4):1016-31.

35. Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. *Adv Nutr An Int Rev J*. 2016;7(6).

36. Elbel B, Kersh R, Brescoll VL, Dixon LB. Calorie labeling and food choices: A first look at the effects on low-income people in New York City: Calorie information on menus appears to increase awareness of calorie content, but not necessarily the number of calories people purchase. *Health Aff*. 2009;28(6):w1110-w1121.

37. Harnack LJ, French SA, Michael JM, Story MT, Jeffery RW, Rydell SA. Effects of calorie labeling and value size pricing on fast food meal choices: Results from an experimental trial. *Int J Behav Nutr Phys Act*. 2008;5.

38. Gruner J, Ohri-Vachaspati P. Food and beverage selection patterns among menu label users and nonusers: results from a cross-sectional study. *J Acad Nutr Diet*. 2017;117(6):929-36.

39. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2015 [Internet]. Washington, DC; 2015. Available from: https://www.dietaryguidelines.gov/about-dietary-guidelines/previous-editions/2015-dietary-guidelines

40. Sarink D, Peeters A, Freak-Poli R, Beauchamp A, Woods J, Ball K, Backholer K. The impact of menu energy labelling across socioeconomic groups: A systematic review. *Appetite*. 2016;99:59-75.

41. Sinclair S, Hammond D, Goodman S. Sociodemographic Differences in the Comprehension of Nutritional Labels on Food Products. *J Nutr Educ Behav*. 2013;45(6):767-772.

42. Lillico HG, Hanning R, Findlay S, Hammond D. The effects of calorie labels on those at high-risk of eating pathologies: a pre-post intervention study in a University cafeteria. *Public Health*. 2015;129(6):732-9.

43. Larson N, Haynos AF, Roberto CA, Loth KA, Neumark-Sztainer D. Calorie Labels on the Restaurant Menu: Is the Use of Weight-Control Behaviors Related to Ordering Decisions? *J Acad Nutr Diet*. 2018;118(3):399-408.

44. Haynos AF, Roberto CA. The effects of restaurant menu calorie labeling on hypothetical meal choices of females with disordered eating. *Int J Eat Disord*. 2017;50(3):275-283.

45. Roberto CA, Haynos AF, Schwartz MB, Brownell KD, White MA. Calorie estimation accuracy and menu labeling perceptions among individuals with and without binge eating and/or purging disorders. *Eat Weight Disord - Stud Anorexia, Bulim Obes*. 2013;18(3):255-261.

46. McGeown L. The calorie counter-intuitive effect of restaurant menu calorie labelling. *Can J Public Heal*. 2019;110(6):816-820.

47. Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias: a mixed methods study. *Obes Sci Pract*. 2018;4(2):159-177.

48. Seward MW, Block JP, Chatterjee A. A Traffic-Light Label Intervention and Dietary Choices in College Cafeterias. *Am J Public Health*. 2016;106(10):1808-1814.

49. The American Association for Public Opinion Research. Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys, 9th edition. 2016 [cited 2021 May 21]. Available from: https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf

50. Olstad DL, Vermeer J, McCargar LJ, Prowse RJL, Raine KD. Using traffic light labels to improve food selection in recreation and sport facility eating environments. *Appetite*. 2015;91:329-335.

51. Beatty PC, Willis GB. Research Synthesis: The Practice of Cognitive Interviewing. *Public Opin Q*. 2007;71(2):287-311.

52. Lenzner T, Neuert C, Otto W. Cognitive pretesting. *GESIS Survey Guidelines*. 2016:3.

53. University of Waterloo. Food Services: Product Information Database [Internet]. Ontario, Canada; 2019 [cited 2021 May 21]. Available from: https://uwaterloo.ca/food-services/menu/search.

54. Health Canada. Canadian Nutrient File [Internet]. Ontario, Canada; 2018 [cited 2021 May 21]. Available from: https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp.

55. Malam S, Clegg S, Kirwan S, McGinigal S, Raats M, Shepherd R, Barnett J, Senior V, Hodgkins C, Dean M. Comprehension and use of UK nutrition signpost labelling schemes [Internet]. London, Food Standards Agency; 2009 [cited 2021 Jul 8]. Available from: https://www.foodwatch.org/fileadmin/_migrated/content_uploads/FSA-Studie_2009_original_englisch.pdf

56. Qualtrics. Qualtrics Software, version March 2019. Utah, USA; 2020 [cited 2021 May 21]. Available from: https://qualtrics.com

57. Hammond D, Lillico HG, Vanderlee L, White CM, Reid JL. The impact of nutrition labeling on menus: A naturalistic cohort study. *Am J Health Behav*. 2015;39(4):540-548.

58. Goodman S, Vanderlee L, White CM, Hammond D. A quasi-experimental study of a mandatory calorie-labelling policy in restaurants: Impact on use of nutrition information among youth and young adults in Canada. *Prev Med*. 2018 Nov 1;116:166-72.

59. Heath Canada. Canadian Community Health Survey [Internet]. Ottawa, Canada; 2018 [cited 2021 May 21]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs.html

60. Powers BJ, Trinh J V., Bosworth HB. Can this patient read and understand written health information? *JAMA - J Am Med Assoc*. 2010;304(1):76-84.

61. Bradshaw M, Kent BV, Henderson WM, Setar AC. Subjective social status, life course SES, and BMI in young adulthood. *Heal Psychol*. 2017;36(7):682-694.

62. Hill LS, Reid F, Morgan JF, Lacey JH. SCOFF, the development of an eating disorder screening questionnaire. *Int J Eat Disord*. 2009;43(4):344-351.

63. Ewing W, Weir S, Sanusi A. Unique Identifier Codes: Guidelines for use with key populations [Internet]. *Unique Identifier Codes: Guidelines for Use with Key Populations*. 2016. Available from:

https://www.fhi360.org/sites/default/files/media/documents/resource-linkages-uic-guidance.pdf

64. Lorden AL, Radcliff TA, Jiang L, Horel SA, Smith ML, Lorig K, Howell BL, Whitelaw N, Ory M. Leveraging administrative data for program evaluations: A method for linking data sets without unique identifiers. *Eval Health Prof*. 2016 Jun;39(2):245-59.

65. Health Canada. Canada's Food Guide [Internet]. Ottawa, ON; 2019 [cited 2021 Jul 8]. Available from: https://food-guide.canada.ca/en/.

66. Lee KM, Marcinow ML, Minaker LM, Kirkpatrick SI. The healthfulness of eateries at the University of Waterloo: a comparison across 2 time points. *Can J Diet Pract Res*. 2019 Nov 18;81(2):72-9.

67. U.S. Department of Agriculture, Agricultural Research Service. USDA Food and Nutrient Database for Dietary Studies 2017-2018 [Database]. 2017 [cited 2021 Jul 8]. Available from: http://www.ars.usda.gov/nea/bhnrc/fsrg

68. U.S. Department of Agriculture, Agricultural Research Service. USDA Food Patterns Equivalents Database 2017-2018 [Database]. 2017 [cited 2021 Jul 8]. Available from: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/

69. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: considerations and caveats. *J Acad Nutr Diet*. 2018 Sep 1;118(9):1603-21.

70. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, Wilson MM, Reedy J. Update of the healthy eating index: HEI-2015. *J Acad Nutr Diet*. 2018 Sep 1;118(9):1591-602.

71. Schwingshackl L, Hoffmann G. Diet Quality as Assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension Score, and

Health Outcomes: A Systematic Review and Meta-Analysis of Cohort Studies. *J Acad Nutr Diet*. 2015;115(5):780-800.e5.

72. National Cancer Institute. Division of Cancer Control and Population Sciences. ASA24-Canada-2018 [Internet]. 2020 [cited 2021 Jul 8]. Available from: https://epi.grants.cancer.gov/asa24/respondent/asa24-canada-2018.html

73. Feng W, Fox A. Menu labels, for better, and worse? Exploring socio-economic and race-ethnic differences in menu label use in a national sample. *Appetite*. 2018;128:223-232.

74. Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias: a mixed methods study. *Obes Sci Pract*. 2018;4(2):159-77.

75. Mansfield ED, Wahba R, Gillis DE, Weiss BD, L'Abbé M. Canadian adaptation of the newest vital sign©, a health literacy assessment tool. *Cambridge Archaeol J*. 2018;21(11):2038-2045.

76. Erola J, Jalonen S, Lehti H. Parental education, class and income over early life course and children's achievement. *Res Soc Stratif Mobil*. 2016;44:33-43.

77. Kim Y, Steiner P. Quasi-Experimental Designs for Causal Inference. *Educ Psych*. 2016;51(3-4):395-405.

78. Stuart EA, Rubin DB. Best practices in quasi-experimental methods: Matching methods for causal inference. In: Best Practices in Quantitative Social Science. Thousand Oaks, CA: Sage Publications; 2007 [cited 2021 Oct 22]. p. 155–76.

79. Handley MA, Lyles CR, Mcculloch C, Cattamanchi A. Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research. *Public Health*. 2018;39:5-25.

80. Shadish WR, Cook TD, Campbell DT. Experiments and Generalized Causal Inference. In: *Experimental and Quasi-Experimental Designs For Generalized Causal Inference*. 2nd ed. Houghton Mifflin; 2002:1-26.

81. Seward MW, Block JP, Chatterjee A. A Traffic-Light Label Intervention and Dietary Choices in College Cafeterias AJPH RESEARCH. *Public Health*. 2016;106(10):1808-1814.

82. Sonnenberg L, Gelsomin E, Levy DE, Riis J, Barraclough S, Thorndike AN. A traffic light food labeling intervention increases consumer awareness of health and healthy choices at the point-of-purchase. *Prev Med (Baltim)*. 2013;57(4):253-257.

83. Thorndike AN, Gelsomin ED, McCurley JL, Levy DE. Calories Purchased by Hospital Employees after Implementation of a Cafeteria Traffic Light-Labeling and Choice Architecture Program. *JAMA Netw Open*. 2019;2(7).

84. Levy DE, Riis J, Sonnenberg LM, Barraclough SJ, Thorndike AN. Food Choices of Minority and Low-Income Employees: A Cafeteria Intervention. 2012.

85. Lemos TC, Almo A, Campagnoli RR, Pereira MG, Oliveira L, Volchan E, Krutman L, Delgado R, Fernández-Santaella MC, Khandpur N, et al. A red code triggers an unintended approach motivation toward sweet ultra-processed foods: Possible implications for front-of-pack labels. *Food Qual Prefer*. 2020;79:103784.

86. Althouse AD. Adjust for Multiple Comparisons? It’s Not That Simple. *Ann Thorac Surg*. 2016;101(5):1644-1645.

CHAPTER 8: General Discussion

8.1 Overview

Food and nutrition interventions have traditionally prioritized healthy eating;[7] however, co-benefits of supporting sustainable eating are increasingly being recognized to optimize both human and planetary health.[1,2,21,44] Real-world evidence on the effectiveness of interventions is needed to inform implementation of policies and programming to support human and planetary health.[10–12] This dissertation investigated the potential for food and nutrition interventions to support healthy and sustainable eating among young Canadian adults in post-secondary settings, with a review of the evidence on varied interventions in post-secondary settings and an in-depth consideration of calorie labelling. The main objectives were to: (1) explore the current state of knowledge on food and nutrition interventions to address human and planetary health in the context of post-secondary settings; (2) compare the impact of numeric calorie labelling versus TLL on noticing, use, and perceptions of nutrition information and calories purchased among post-secondary students; and (3) examine the effect of calorie labelling on quality of food and beverage purchases by post-secondary students, with respect to dietary guidance related to human and planetary health.

8.2 Summary of key findings

Chapter 5 describes a scoping review of food and nutrition interventions implemented and evaluated on post-secondary campuses. To date, syntheses of existing evidence have considered approaches to promote healthy and sustainable eating in isolation, but there has been little consideration of the extent to which health and sustainability have been jointly considered in the design, implementation, and evaluation of interventions.[92–99] By integrating this focus, the scoping review provides insight into what is known about the effectiveness of a range of food and nutrition interventions in supporting human and planetary health, as well as evidence gaps.

The review (n=37 food interventions, described in 38 articles) found that most interventions were focused on supporting human health, whereas fewer considered environmental sustainability and no interventions considered both. Among interventions focused on supporting human health, a majority were focused on altering elements of the food environment (e.g., providing nutrition labelling at the point-of-purchase, moving healthy foods to accessible locations, economic tools) and improving nutrition knowledge through education strategies. Interventions related to environmental sustainability were often focused on reducing food waste, with less emphasis on shifting eating patterns toward those that align with planetary health, for example, by encouraging increased intake of fruits, vegetables, whole grains, and plant-based proteins, and reduced consumption of animal-based proteins. Several authors highlighted potential co-benefits and trade-offs of interventions for human health and environmental sustainability; for example, drawing connections between the implications of food waste for land and water use and nutrient loss.[234,235] The findings suggest substantial progress is needed to address calls for integrated interventions to protect both human and planetary health.

In response to significant policy interest related to nutrition labelling at the point-of-purchase,[111,113,117] **Chapters 6 and 7** investigated the impacts of numeric calorie labelling versus TLL on noticing, use, and perceptions of nutrition information and food and beverage purchasing among post-secondary students. Using a quasi-experimental controlled design, the study was conducted in real-world post-secondary cafeterias to examine implications of the labels on outcomes relevant to supporting healthy and sustainable eating patterns. Of note, the findings on food and beverage purchases by calories, TLL categories, food groups, and nutrients were inconclusive given the assumption of parallel trends across sites could not be satisfied. We observed large differences in calories purchased at all sites during pre-test, as well as a large unexplained difference at the control site between pre-test and post-test. A supplemental investigation of all offerings revealed only minor differences in calories among menu offerings across sites; for example, the difference in calories across offerings was within 5% and the difference in proportion of green-, amber-, and red-labelled items were within 1% (**Appendix C**). At all sites, purchasing patterns may have been affected by the timing of the data collection period, with the post-test period overlapping with the end of the academic term. A summary of the trends observed in **Chapters 6 and 7** are described below; however, an investigation to identify the extent that confounding may have influenced these findings will be undertaken using group-level sales data. The subsequent analysis will assess pre-existing differences and trends across the three sites over a longer period of time, allowing for examination of site-specific effects that may have influenced food and beverage purchasing during the post-test period.

Chapter 6 examined the impact of numeric versus traffic light calorie label formats on consumer noticing, use, and perceptions of nutrition information; calories purchased; and total sales. The study found that numeric labels and TLL led to increased noticing and use of nutrition information, with TLL outperforming numeric labels in terms of self-reported use. A greater proportion of respondents at the TLL site who reported noticing calorie information indicated the nutrition information was easy to use and understand. A consistent pattern in calories purchased was not observed; however, these findings are inconclusive due to a large decrease in calories purchased at the control site. The findings from the sales data suggests that if the labels had an effect, neither format would affect sales as some industry advocates have suggested. A greater proportion of participants in the adequate health literacy and high SSS groups indicated noticing and using nutrition information, consistent with existing evidence.[134,171–174] However, the GEE models revealed no differences in outcomes by health literacy, SSS, gender, and risk of disordered eating, potentially ameliorating existing public health concerns surrounding the potential for calorie labelling to exacerbate differences among these subgroups. Thus, calorie labelling may improve awareness of nutrition information, and potentially stimulate reformulation of foods and beverages and changes to offerings, with limited impact on differences among subgroups by health literacy, SSS, gender, and disordered eating risk. Of note, a brief measure of eating disorder symptomology[220] was used and participants with eating disorders were not identified, potentially overlooking experiences among those with clinically diagnosed eating disorders.

Chapter 7 examined implications of numeric labels versus TLL on purchasing of foods and beverages labelled red, amber, and green according to the TLL criteria, as well as quality of purchases with respect to amounts of key food groups (i.e., fruits, vegetables, whole grains, refined grains, plant-based proteins, and red meats) and nutrients (i.e., saturated fats, added sugars, sodium) per 1000 kcal. No changes in purchasing of foods and beverages labelled as red, amber, and green relative to the control were observed. At the TLL site, purchases of red-labelled items increased among those with lower SSS, with no changes to purchasing of green- or amber-labelled items. The findings for nutrients and food groups per 1000 kcal suggest low purchasing of dietary components recommended for health, such as fruit and whole grains, and high purchases of components that should be consumed in moderation, such as sodium and added sugars. There was a decrease in purchasing of added sugars at the numeric site and refined grains at the TLL site; however, the magnitude of these effects was small and the significant difference from the control site could be explained by decreases observed at the control.

8.3 Limitations

The research presented in this dissertation should be interpreted in the context of several limitations and caveats. In **Chapter 5**, the review excluded grey literature, potentially omitting efforts on campuses that have been undertaken by campus stakeholders without the involvement of academic researchers. University food service operations and sustainability offices are increasingly committing to initiatives, such as *Menus of Change*,[78] potentially demonstrating increasing engagement in activities related to promoting health and sustainability in campus settings. Associated internal reports from universities or related non-government organizations, such as Meal Exchange,[77] may provide information about how campuses are aiming to support healthy and sustainable eating on campuses. The findings of this review may also be affected by publication bias, in which articles that show null effects may not have been published in the literature. As with all scoping reviews, the interpretations of the included literature may demonstrate author bias. However, we aimed to maintain objectivity and transparency in reporting by using a consistent data extraction approach for each article, with independent screening and validation of extraction conducted by at least one other reviewer.[202]

Chapters 6 and 7 are limited by caveats inherent to the lack of randomization in quasi-experimental studies.[236–238] The study was limited to students at three residence cafeterias within a single university and the findings may not be generalizable to other settings, such as fast-food outlets. The sample is not representative of all young adults in Canada, primarily consisting of individuals ~18-19 years of age and pursuing a university-level education.

Although we aimed to control for differences in the samples through our study design decisions (e.g., limiting to residence cafeterias) and by adjusting for socio-demographics identified *a priori* (e.g., gender, health literacy, SSS, disordered eating risk), quasi-experimental studies are at risk for uncontrolled confounding. Minor differences across cafeterias in offerings may have biased our findings toward the null or explained the observed decrease in calories purchased at the control site. However, an additional investigation of all offerings revealed minimal differences in calories across sites; the differences in calories for daily hot meals were within 5% and the differences in proportions of green-, amber-, and red-labelled items were within 1% (**Appendix C**). Characteristics of patrons at specific cafeterias may have also influenced the findings. For example, the control site was farther away from the main campus, potentially affecting the frequency of visits to the cafeteria; patrons may have opted to select grab-and-go meals and snacks and/or purchase larger meals elsewhere. At the same time, participants may have been exposed to other forms of nutrition information in the cafeteria (e.g., labels indicating vegan and vegetarian options) or calorie labelling in other settings, such as branded outlets on and off campus, potentially dampening the impact of the labelling interventions. At all sites, purchasing patterns may have been affected by the timing of data collection as the post-test phase overlapped with the end of the term, approaching exam period. While repeat responses were excluded potentially raising concerns about power, a post-hoc power analysis of the study sample and *a priori* estimates from our initial sample size calculation demonstrated that the study was powered to detect a 10% difference in calories purchased. Of note, a 10% difference is a large effect size to observe for dietary outcomes (e.g., calories purchased) and some comparisons were outside of this magnitude. For example, there was a 1.2% difference in calories purchased at the TLL site compared to the control. Therefore, we suspect that any replication studies using a similar study design may find effects and differences that we were unable to in this study.

The data on food and beverage purchasing used in **Chapters 6 and 7** were limited to a single eating occasion and do not illustrate how labels may impact overall eating patterns. Further, respondents who noticed and used the labels indicated they led them to consume less food or order something different, suggesting some impacts that may not have been detected by the analysis of purchasing. Nonetheless, less than 1 in 10 participants indicated that the labels influenced their purchasing decisions 'a lot'. Future research should utilize robust dietary assessment methods to collect information dietary intake at multiple time-points and examine implications on compensatory behaviours.[146,239] However, the collection of individual-level data on food and beverage purchasing and socio-demographics was a strength of the study, expanding on current literature, which primarily reports on group-level differences in purchasing using aggregate sales data. While this study also made use of sales data, only total sales and sales per transaction rather than itemized sales were available, and it was not possible to corroborate the purchasing data by examining whether sales of different foods and beverages changed from the pre-test to post-test periods.

Using GEE modelling allowed for examination of differences across sites from pre-test to post-test,[240] ameliorating 'missing' data from participants who only participated at one test phase. We aimed to alleviate inherent biases from self-reporting; for example, minimizing recall bias by prompting for specific details about purchases and mitigating social desirability bias by only partially disclosing information about the focus on calorie labelling. However, measures of health literacy, SSS, and disordered eating risk were brief and do not entirely capture the complexity of these constructs. Additionally, participants who completed the survey at both phases may have been subject to social desirability bias at post-test given prior knowledge of the survey questions.

The findings in **Chapter 7** should be considered within the context of assumptions made with respect to the food and beverage purchasing data. For the analysis of changes in purchasing of red-, amber-, and green-labelled categories, a proportional weighting system was used to account for add-ons to customizable entrées and enable comparability across similar items. However, this structure may have disproportionately affected add-ons that were a prominent component of the full item (e.g., the bread versus sauces in a sandwich were treated as equal and comparable add-ons). Proportional weights were also affected by the total number of options within the overall item; for example, 3 red-labelled items within a sandwich with 10 add-ons had a weight of 0.3, whereas 3 red-labelled items on another sandwich with 5 add-ons had a weight of 0.6. Foods and beverages reported in the surveys were matched to similar food codes within food composition databases.[214,223,224] The food codes available in these databases may not accurately represent the specific foods and beverages offered within the cafeterias, potentially blunting differences in composition with respect to dietary components of interest. Serving weights for all foods and beverages were based on a default serving and variations in amounts purchased are possible, especially in the context of self-serve stations, such as the salad bar.

8.4 Implications for policy and research

The research presented in this dissertation has several implications for policy and future research, including informing the implementation of nutrition labelling at the point-of-purchase in the Canadian context; underscoring the need for the application of a systems thinking lens to design and implement interventions to support healthy and sustainable eating patterns; and emphasizing the importance of evaluating the impacts of interventions on factors related to both human and planetary health, as well as to consider trade-offs between the two.

Informing the implementation of nutrition labelling at the point-of-purchase in Canada

Within *Canada's Healthy Eating Strategy*,[197] nutrition labelling is prioritized as a strategy to support healthy eating by informing food selection and purchasing decisions. Some provincial jurisdictions, such as Ontario and British Columbia,[111,117] have mandated calorie labelling in restaurants, fast-food chains, and food retail stores in healthcare settings. Health Canada is moving toward an interpretive format using 'high-in' warning labels on front-of-packages to indicate foods and beverages that have a high amount of sugars, saturated fats, and sugars.[241] The research in this dissertation examines the TLL system; however, the messaging surrounding the red-label category is similar to that of a warning label. Both systems indicate foods that are high in a dietary component and that should be chosen less often. Although nutrition labelling at the point-of-purchase is not currently under consideration by the federal government because it is provincially mandated, calorie labelling remains relevant to current policy discussions surrounding a harmonized nutrition labelling system (e.g., use of interpretive formats for both point-of-purchase and front-of-package formats).

The findings on noticing, use, and perceptions in **Chapters 6** suggest numeric and TLL formats are salient in improving consumer awareness of nutrition information. A greater proportion of respondents at the TLL site who reported noticing calorie information indicated the nutrition information was easy to use and understand. While the analyses of the impact of the labels on purchasing of calories, TLL categories, food groups and nutrients were inconclusive, prior literature has shown minimal and inconsistent effects on calories purchased and consumed.[142–163,169] The findings are limited to purchasing data at a single eating occasion, which are not representative of an individual's total eating pattern.

Given the potential to stimulate reformulation,[105–108] it is possible that consistent implementation of labels across contexts may be helpful in supporting healthy eating. Policy decisions about whether nutrition labels at the point-of-purchase should use numeric or TLL formats are largely dependent on the priorities of the jurisdiction. For example, a key recommendation in the 2019 *Canada's Food Guide*[29] was to limit consumption of highly processed foods by choosing healthy menu options when eating out. The *Food Guide*[29] also suggests using food labels to help consumers compare and choose products to make an informed purchasing decision. In **Chapter 6**, a greater proportion of respondents at the numeric site indicated the labels led them to consume less food whereas those at the TLL site ordered something different. Several studies have suggested consumers utilize a red-avoidance strategy when interpreting TLL, further suggesting potential differences in how the labels may be used to inform food and beverage decision making.[164–166] Given the emphasis on selecting foods to support eating patterns as a whole (rather than consuming fewer calories), implementation of an interpretive format, such as TLL, may align more closely with Canadian priorities.[29,31,197] For example, traffic light labels could be used to communicate other values for food and beverages that reflect criteria beyond calorie amounts, including considerations for food groups and nutrients that are highlighted in *Canada's Food Guide*[29] or environmental sustainability. Evaluations should continue to be conducted ensure the policy achieves its goals, with consideration for potential consequences and trade-offs related to purchasing among specific sub-group populations and sustainability.

Of note, the focus on calories for the labels examined in **Chapters 6 and 7** was a study design choice to enable direct comparison between numeric and TLL formats. However, TLL systems based on calories alone are inherently flawed from the perspective of guidance for healthy eating.[193] Some foods and beverages that are nutrient-dense but higher in calories (e.g., avocados, eggs) receive an amber or red indicator, whereas highly processed foods with lower calories (e.g., white bread) may receive a green indicator. These considerations may have been observed in **Chapter 7**, where there were high purchases of green-labelled items overall, but food group and nutrient profiles were not ideal (e.g., low purchases of whole grains and fruits). Several studies have used TLL to integrate multiple dietary components, including nutrients[155,160,161,164,170] and food groups.[152,154,156] Given the study design decision to focus on calories, **Chapters 6 and 7** did not examine the implications of a multi-component labelling system, though existing experimental studies suggest limited impacted on purchasing when comparing formats with multiple dietary components (e.g., calories and sodium) versus calories only.[135,159–161]

Another important consideration for interpretive formats is the potential to unintentionally stigmatize foods and beverages; some foods and beverages that may receive a red or amber label may be more affordable for and accessible to groups with lower SES. This consideration is of particular concern given the finding that purchases of red-labelled items increased among groups with lower SSS at the TLL site. Relatedly, no other differences were observed in the impacts of the labels on purchasing by health literacy, SSS, or disordered eating risk. However, as noted in **Section 8.3**, we used brief measures of health literacy, SSS, and disordered eating risk. Future research should consider the use of comprehensive and well-evaluated measures that are informed by theory and capture the complexity of concepts related to health literacy, SES, and disordered eating (e.g., measures of disordered eating risk that consider weight bias and stigma[242,243]), and analytic procedures that consider intersectionality (e.g., interactions between health literacy and SES with race/ethnicity[244]).

Underscoring the need for the application of systems thinking lens to the design and implementation of interventions

Building on interpretations presented in **Chapter 5**, as well as the limited impact of labelling on food and beverage purchasing found in **Chapters 6 and 7**, nutrition labelling at the point-of-purchase is likely insufficient on its own to support healthy and sustainable eating patterns.[5,6,55] All nutrition labelling formats aim to help individuals navigate a complex food environment and food system by ‘making the healthy choice the easy choice’.[197]

Nutrition labelling solely focused on calories in particular represents a reductionist approach that overlooks the overall quality of foods and beverages (as described above) and does not address the array of determinants of eating patterns, such as those at individual (e.g., stress and time constraints)[88–90] and environmental (e.g., availability, accessibility, and affordability of foods and beverages on campus) levels.[65,66,68–70,91,93] Thus, despite being posited as a population-level intervention, nutrition labelling (including labels that solely provide calorie amounts) on its own emphasizes individual-level choice and agency without addressing the structural determinants that shape our food system and eating patterns (e.g., availability and affordability of the food supply). However, labelling schemes have been shown to stimulate manufacturers to reformulate products and changes to offerings, potentially playing a role in improving eating patterns within a suite of integrated and reinforcing food and nutrition policies.[105,108,245,246]

Despite the need for a holistic approach, multiple food policies and other public health interventions are typically not implemented simultaneously due to political cycles and other considerations. It is promising that nutrition labelling is being considered in the context of a suite of interventions within *Canada's Healthy Eating Strategy*[197] (e.g., reducing marketing to children, sodium reduction strategies), particularly given suggestions to use multiple interventions to support healthy and sustainable eating patterns.[4,55,57] Indeed, policy approaches that integrate a suite of reinforcing interventions are needed to embrace the complexity of eating patterns and their interactions with human and planetary health;[57] though, **Chapter 5** indicates there is substantial progress to be made in terms of integrating both. Interventions that target informed choice and require relatively few resources to implement, such as nutrition labelling at the point-of-purchase, can potentially play a role in helping individuals navigate a complex food system that is not supportive of healthy and sustainable eating patterns in the interim. However, it is critical that interventions continue to be evaluated for their intended and unintended effects, including consideration of how interventions may interact with each other.

To contribute to a food system transformation, policy approaches that integrate multiple strategies will need to be implemented and evaluated from a 'whole-of-systems' lens to minimize potential trade-offs between human and planetary health. Drawing upon frameworks such as NOURISHING[5] can provide insight into the types of interventions that can be designed and implemented to jointly support healthy and sustainable eating patterns. Although the framework does not explicitly address sustainability, it identifies leverage points for intervening within food environments and food systems to effectively support human and planetary health. For example, supply chain incentives may support food production systems that contribute to improved dietary quality and lower greenhouse gas emissions[247] and food-based dietary guidelines can provide guidance on healthy eating patterns with lower impacts on greenhouse gas emissions and water and land use.[15,192] Moving forward, a 'de-siloed' approach to food and nutrition policy that considers the 'whole-of-system', including engagement of actors and stakeholders across multiple levels, sectors, and disciplines, will be critical for jointly considering human and planetary health.[19,26,33,48,53]

Evaluating the impact of interventions on factors related to both human and planetary health, as well as trade-offs

Complementing recommendations for designing and implementing interventions, data collection tools and analytic methods will need to be expanded to appropriately measure impacts of interventions on human and planetary health. Evidence from real-world settings, such as post-secondary settings,[62–64] provides a valuable testing ground for 'whole-of-systems' policy approaches by examining the effectiveness of interventions within the context of existing food environments and food systems. Real-world evidence provides insight into the scalability of interventions by informing the contexts in which they may be most effective; for example, real-world evidence on calorie labelling suggests greater impacts in cafeteria settings compared to restaurants or fast-food chains because consumers are often daily visitors.[145,146] However, the limitations of real-world evaluations (e.g., uncontrolled confounding) can provide challenges for interpretation[236–238] and it is critical to examine the extent of their generalizability by interpreting the findings within the context they are evaluated.[248] For instance, interpretation of real-world evidence of interventions examined in post-secondary settings should consider the setting (i.e., cafeterias in residences versus quick-service coffee shops) and individual-level characteristics of patrons (e.g., age, socio-economic status, health literacy) to understand the generalizability of the findings to inform policies that may impact the general Canadian population.

The analytic approach presented in **Chapter 7** aimed to address both human and planetary health by examining food groups and nutrients relevant to both; however, other approaches are increasingly possible.[189,249,250] Integrating interpretations from both can address whether an intervention that creates positive health and/or environmental outcomes at the food consumption stage may have negative health and environmental impacts at other points along the supply chain;[26,33,48,53,190,251] for instance, interventions that promote healthy options but may also be heavily packaged and processed.[68] There is a growing body of evidence that uses a combination of diet quality indices[225,226] and data on the environmental sustainability of foods;[189,251–253] for example, drawing upon life cycle assessment to examine impacts on greenhouse gas emissions as foods and beverages move through the food supply chain.[189,253] Several modelling studies have used combined measures to examine alignment of eating patterns[189,254–256] and food-based dietary guidelines[254] with human and planetary health. Careful consideration is needed to ensure measures do not fall into a reductionist approach of considering limited indicators, for example, focusing only on calories or on greenhouse gases rather than considering the various facets of healthy and sustainable eating patterns and food systems.[257] Measures will also need to be expanded to capture other interconnected dimensions of healthy and sustainable eating patterns, such as considerations of culture and heritage, to more holistically measure implications on human and planetary health.[4,34] Thus, measures and metrics for evaluating interventions need to consider the multi-dimensional nature of healthy and sustainable eating and there is substantial progress to be made in terms of identifying best practices for jointly measuring both.

8.5 Conclusions

Drawing upon real-world evidence from post-secondary settings, the findings of this dissertation contribute to our understanding of the range of food and nutrition interventions that can potentially support healthy and sustainable eating patterns among young adults. The scoping review demonstrates that interventions to support both healthy and sustainable eating patterns in post-secondary settings are currently limited, with a greater emphasis on human health versus planetary health. The findings of the empirical studies of calorie labelling suggest numeric and TLL formats, on their own, may improve awareness of nutrition information. The analyses of effects of the labels on calories, food groups, and nutrients purchased were inconclusive due to a lack of parallel trends across sites. Future analyses will use sales data over a longer period of time to assess the impact of the labels on calories purchased at the group-level and to investigate the extent that uncontrolled confounding may have influenced the results. The research presented in this dissertation provides a blueprint for future evaluations of food and nutrition policies and interventions to jointly consider human and planetary health. Further work is needed to expand data collection and analytical metrics and methods to appropriately measure the impact of interventions that aim to support healthy and sustainable eating patterns, as well as their trade-offs for human and planetary health.

REFERENCES

1. Burlingame B, Dernini S, Nutrition and Consumer Protection Division, Food and Agriculture Organization, editors. Sustainable Diets and Biodiversity: Directions and solutions for policy, research, and action [Internet]. Rome; c2010 [cited 2021 Jul 8].

2. Gonzalez Fischer C, Garnett T. Plates, pyramids and planets Developments in national healthy and sustainable dietary guidelines: a state of play assessment [Internet]. University of Oxford; 2016 [cited 2021 Jul 8]. Available from: www.fao.org/

3. Clark M, Hill J, Tilman D. The Diet, Health, and Environment Trilemma. *Annu Rev Environ Resour*. 2018;43(1):109-134.5

4. Mason P, Lang T. Sustainable diets: How ecological nutrition can transform consumption and the food system. 1st ed. New York, NY: Routledge; 2017.

5. Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. *Obes Rev*. 2013;14:159-168.

6. Swinburn B, Kraak V, Rutter H, Vandevijvere S, Lobstein T, Sacks G, Gomes F, Marsh T, Magnusson R. Strengthening of accountability systems to create healthy food environments and reduce global obesity. *Lancet*. 2015;385(9986):2534-45.

7. Ridgway E, Baker P, Woods J, Lawrence M. Historical developments and paradigm shifts in public health nutrition science, guidance and policy actions: A narrative review. *Nutrients*. 2019;11(3).

8. Barnish M, Turner S. The value of pragmatic and observational studies in health care and public health. *Pragmatic Obs Res*. 2017;8:49-55.

9. Shelton JD. Evidence-based public health: Not only whether it works, but how it can be made to work practicably at scale. *Glob Heal Sci Pract*. 2014;2(3):253-258.

10. Hansen SS, Savage C. Campus Living Laboratory [Internet]. Macalester College, MN [cited 2021 Jul 8]. Available from: https://serc.carleton.edu/sp/library/campusbased/index.html

11. Evans J, Jones R, Karvonen A, Millard L, Wendler J. Living labs and co-production: University campuses as platforms for sustainability science. *Curr Opin Environ Sustain*. 2015;16:1-6.

12. Hansen SS. The Campus as a Living Laboratory: Macalester College Case Study. 2017.

13. Health Canada. Healthy Eating Strategy [Internet]. Ottawa, ON; 2021 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/services/health/campaigns/vision-healthy-canada/healthy-eating.html

14. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019 May;393(10184):1958–72.

15. Springmann M, Spajic L, Clark MA, Poore J, Herforth A, Webb P, Rayner M, Scarborough P. The healthiness and sustainability of national and global food based dietary guidelines: modelling study. *BMJ*. 2020;370:m2322.

16. Friel S, Barosh LJ, Lawrence M. Towards healthy and sustainable food consumption: an Australian case study. *Public Health Nutr*. 17(5):1156-1166.

17. Food and Agriculture Organization. The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. Rome, Italy; 2021 [cited 2021 Jul 8]. Available from: https://www.who.int/publications/m/item/the-state-of-food-security-and-nutrition-in-the-world-2021

18. Crippa M, Solazzo E, Guizzardi D, Monforti-Ferrario F, Tubiello FN, Leip A. Food systems are responsible for a third of global anthropogenic GHG emissions. *Nat Food*. 2021;1-12.

19. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet*. 2019;393(10170):447-92.

20. Campbell BM, Beare DJ, Bennett EM, Hall-Spencer JM, Ingram JSI, Jaramillo F, Rodomiro O, Ramankutty N, Sayer JA, Shindell D. Agriculture production as a major driver of the earth system exceeding planetary boundaries. *Ecol Soc*. 2017;22(4).

21. Dangour AD, Mace G, Shankar B. Food systems, nutrition, health and the environment. *Lancet Planet*. 2017;1(1):e8-9.

22. Intergovernmetnal Panel on Climate Change. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker TF, Qin G-K, Plattner M, Tignore SK, Allen J, Boschung A, Nauels Y, Xia V, Midgley PM, editors. Cambridge, UK and New York, NY: Cambridge University Press; 2013.

23. Garnett T. Changing what we eat: A call for research & action on widespread adoption of sustainable healthy eating [Internet]. Food Climate Research Network; 2014 [cited 2021 Jul 8]. Available from: https://www.tabledebates.org/research-library/changing-what-we-eat-call-research-action-widespread-adoption-sustainable-healthy

24. United Nations. Sustainable Development Goals [Internet]. [cited 2021 Jul 8]. Available from: https://sustainabledevelopment.un.org

25. Fanzo J. Healthy and Sustainable Diets and Food Systems: the Key to Achieving Sustainable Development Goal 2? *Food Ethics*. 2019;4(2):159-174.

26. International Panel of Experts on Sustainable Food Systems. The New Science of Sustainable Food Systems: Overcoming Barriers to Food Systems Reform [Internet]. Brussels, Belgium; 2015 [cited 2021 May 28]. Available from: www.ipes-food.org

27. International Panel of Experts on Sustainable Food Systems. Unravelling the food-health nexus: Addressing practices, political economy, and power relations to build healthier

food systems [Internet]. Brussels, Belgium; 2017 [cited 2021 May 28]. Available from: www.ipes-food.org

28. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2015 [Internet]. Washington, DC; 2015. Available from: https://www.dietaryguidelines.gov/about-dietary-guidelines/previous-editions/2015-dietary-guidelines

29. Health Canada. Canada’s Food Guide [Internet]. Ottawa, ON; 2019 [cited 2021 Jul 8]. Available from: https://food-guide.canada.ca/en/.

30. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025 [Internet]. Washington, DC; 2020. Available from: https://www.dietaryguidelines.gov/sites/default/files/2021-03/Dietary_Guidelines_for_Americans-2020-2025.pdf

31. Health Canada. Canada’s Dietary Guidelines for Health Professionals and Policy Makers [Internet]. Ottawa, ON; 2019 [cited 2021 Jul 8]. Available from: https://food-guide.canada.ca/en/guidelines/section-2-foods-and-beverages-that-undermine-healthy-eating/.

32. World Health Organization. Healthy diet [Internet]. 2020 [cited 2021 Jul 8]. Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet.

33. Food and Agriculture Organization of the United Nations. Sustainable food systems: Concept and framework [Internet]. 2016 [cited 2021 Jul 8]. Available from: http://www.fao.org/3/ca2079en/CA2079EN.pdf

34. Johnston JL, Fanzo JC, Cogill B. Understanding Sustainable Diets: A Descriptive Analysis of the Determinants and Processes That Influence Diets and Their Impact on Health, Food Security, and Environmental Sustainability. *Adv Nutr*. 2014;5(4):418-429.

35. Gussow J, Clancy K. Dietary guidelines for sustainability. *J Nutr Educ*. 1986;18(10):1-5.

36. Food and Agriculture Organization of the United Nations. Food-based dietary guidelines [Internet]. Rome, Italy; 2021 [cited 2021 Jul 8]. Available from: http://www.fao.org/nutrition/nutrition-education/food-dietary-guidelines/en/

37. Kirkpatrick S, Vanderlee L, Dias GM, Hanning R. Can dietary guidelines support the transformation of food systems to foster human and planetary health? In: Campeau C, Costa Coitinho Delume D, Onema S, eds. *Food Environments: Where People Meet the Food System*. United Nations System Standing Committee on Nutrition; 2019:122-128.

38. Pan-American Health Organization and World Health Organization. Dietary Guidelines for the Brazilian Population [Internet]. 2014 [cited 2021 Jul 8]. Available from: https://www3.paho.org/hq/index.php?option=com_content&view=article&id=11564:dietary-guidelines-brazilian-population&Itemid=4256&lang=en

39. Monteiro CA, Cannon G, Moubarac JC, Martins AP, Martins CA, Garzillo J, Canella DS, Baraldi LG, Barciotte M, da Costa Louzada ML, et al. Dietary guidelines to nourish humanity and the planet in the twenty-first century. A blueprint from Brazil. *Pub Hlth Nutr*. 2015;18(13):2311-22.

40. Hirvonen K, Bai Y, Headey D, Masters WA. Affordability of the EAT–Lancet reference diet: a global analysis. *Lancet Glob Health*. 2020;8(1):e59-e66.

41. Verkerk R. EAT-Lancet-is there such a thing as “one-size-fits-all” sustainability? *J Hollistic Health.* 2019; 16(3):15.

42. Blackstone NT, Conrad Z. Comparing the Recommended Eating Patterns of the EAT-Lancet Commission and Dietary Guidelines for Americans: Implications for Sustainable Nutrition. *Curr Dev Nutr*. 2020;4(3).

43. Zagmutt FJ, Pouzou JG, Costard S. The EAT-Lancet Commission’s Dietary Composition May Not Prevent Noncommunicable Disease Mortality. *J Nutr*. 2020;150(5):985.

44. Cobiac LJ, Scarborough P. Modelling the health co-benefits of sustainable diets in the UK, France, Finland, Italy and Sweden. *Eur J Clin Nutr.* 2019;73(4):624-633.

45. Vandevijvere S, Swinburn B. Towards global benchmarking of food environments and policies to reduce obesity and diet-related non-communicable diseases: design and methods for nation-wide surveys: Table 1. *BMJ Open*. 2014;4(5):e005339.

46. Gorski MT, Roberto CA. Public health policies to encourage healthy eating habits: Recent perspectives. *J Healthc Leadersh*. 2015;7:81-90.

47. International Network for Food and Obesity. INFORMAS Modules [Internet]. [cited 2021 Feb 3]. Available from: https://www.informas.org/

48. Hammond RA, Dubé L. A systems science perspective and transdisciplinary models for food and nutrition security. *PNAS*. 2012;109(31):12356-12363.

49. Hammond RA. Complex systems modeling for obesity research. *Prev Chronic Dis*. 2009;6(3):A97.

50. Lee BY, Bartsch SM, Mui Y, Haidari LA, Spiker ML, Gittelsohn J. A systems approach to obesity. *Nutr Rev*. 2017;75:94-106.

51. Majowicz SE, Meyer SB, Kirkpatrick SI, et al. Food, health, and complexity: towards a conceptual understanding to guide collaborative public health action. *BMC Public Health*. 2016;16(1):487.

52. Food and Agriculture Organization of the United Nations. Sustainable heatlhy diet: guiding principles [Internet]. Rome, Italy; 2019 [cited 2021 Jul 8]. Available from: https://www.who.int/publications/i/item/9789241516648

53. Bhunnoo R. The need for a food-systems approach to policy making. *Lancet*. 2019;393(10176):1097-8.

54. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q*. 1988;15(4):351-77.

55. Afshin A, Penalvo J, Del Gobbo L, Kashaf M, Micha R, Morrish K, Pearson-Stuttard J, Rehm C, Shangguan S, Smith JD, et al. CVD prevention through policy: a review of mass media, food/menu labeling, taxation/subsidies, built environment, school

procurement, worksite wellness, and marketing standards to improve diet. *Curr Cardiol Rep*. 2015 Nov;17(11):1-2.

56. Golden SD, McLeroy KR, Green LW, Earp JA, Lieberman LD. Upending the social ecological model to guide health promotion efforts toward policy and environmental change. *Health Educ Behav.* 2015;42(1 Suppl):8S-14S.

57. Forouhi NG, Unwin N. Global diet and health: old questions, fresh evidence, and new horizons. *Lancet*. 2019;393:1916-1918.

58. Frieden TR. Evidence for Health Decision Making — Beyond Randomized, Controlled Trials. *N Engl J Med*. 2017;377(5):465-475.

59. Cockcroft A. Randomised controlled trials and changing public health practice. *BMC Public Health*. 2017;17(1):409.

60. Victora CG, Habicht J-P, Bryce J. Evidence-based public health: moving beyond randomized trials. *Am J Public Health*. 2004;94(3):400-405.

61. Hébert JR, Frongillo EA, Adams SA, Turner-McGrievy GM, Hurley TG, Miller DR, Ockene IS. Perspective: Randomized controlled trials are not a panacea for diet-related research. *Adv Nutr*. 2016;7(3):423-432.

62. Mcmillin J, Dyball R. Developing a Whole-of-University Approach to Educating for Sustainability. *J Educ Sustain Dev*. 2009;3(1):55-64.

63. Alshuwaikhat HM, Abubakar I. An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *J Clean Prod*. 2008 Nov;16(16):1777-85.

64. Doherty S, Cawood J, Dooris M. Applying the whole-system settings approach to food within universities. *Perspect Public Health*. 2011 Sep;131(5):217–24.

65. Tseng M, Degreef K, Fishler M, Gipson R, Koyano K, Neill DB. Assessment of a University Campus Food Environment, California, 2015. *Prev Chronic Dis*. 2016;13(E18).

66. Lo BKC, Minaker L, Chan ANT, Hrgetic J, Mah CL. Adaptation and Validation of a Nutrition Environment Measures Survey for University Grab-and-Go Establishments. *Can J Diet Pract Res.* 2016;77(1):17-24.

67. Roy R, Hebden L, Kelly B, Gois T De, Ferrone EM, Samrout M, Vermont S, Allman-Farinelli M. Description, measurement and evaluation of tertiary-education food environments. *Br J Nutr*. 2016;115(1598-1606):1589-1606.

68. Lee KM, Marcinow ML, Minaker LM, Kirkpatrick SI. The healthfulness of eateries at the University of Waterloo: a comparison across 2 time points. *Can J Diet Pract Res*. 2019 Nov 18;81(2):72-9.

69. Horacek TM, Erdman MB, Byrd-Bredbenner C, Carey G, Colby SM, Greene GW, Guo W, Kattelmann KK, Olfert M, Walsh J, et al. Assessment of the dining environment on and near the campuses of fifteen post-secondary institutions. *Public Health Nutr*. 2013;16(7):1186-1196.

70. Horacek TM, Erdman MB, Reznar MM, Olfert M, Brown-Esters ON, Kattelman KK, Kidd T, Koenings M, Philips B, Quick V, et al. Evaluation of the Food Store Environment on and near the Campus of 15 Postsecondary Institutions. *Nutr Promot Community Des*. 2013;27(4):81-90.

71. Fuchs D, Kalfagianni A, Arentsen M. Retail Power, Private Standards, and Sustainability in the Global Food System. In: Clapp J, Fuchs D, eds. *Corporate Power in Global Agrifood Governance*. New York, NY: The MIT Press; 2009:28-59.

72. Clapp J, Fuchs DA. Corporate power in global agrifood governance. MIT Press; 2009

73. Okanagan Charter: An international charter for health promoting universities and colleges [Internet]. University of British Columbia; c2015 [cited 2020 May 27]. Available from: https://wellbeing.ubc.ca/okanagan-charter

74. Barlett PF. Campus Sustainable Food Projects: Critique and Engagement. *Am Anthropol*. 2011 Mar;113(1):101–15.

75. Lozano R, Ceulemans K, Alonso-Almeida M, Huisingh D, Lozano FJ, Waas T, Lambrechts W, Lukman R, Hugé J. A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey. *J Clean Prod*. 2015;108:1-8.

76. The Association for the Advancement of Sustainability in Higher Education. STARS, Sustainability Tracking Assessment & Rating System [Internet]. 2020 [cited 2021 Jul 8]. Available from: https://stars.aashe.org/

77. Maynard M, Lahey D, Abraham A. Campus food report card: The state of food on Ontario university campuses [Internet]. Toronto, ON; 2018 [cited 2020 May 28]. Available from: https://www.mealexchange.com/reportcard/

78. The Culinary Institute of America. Menus of Change Initiative [Internet]. 2021 [cited 2021 Jul 8]. Available from: https://www.menusofchange.org/

79. Winpenny EM, van Sluijs EMF, White M, Klepp K-I, Wold B, Lien N. Changes in diet through adolescence and early adulthood: longitudinal trajectories and association with key life transitions. *Int J Behav Nutr Phys Act*. 2018;15(1):86.

80. Poobalan AS, Aucott LS, Clarke A, Smith WCS. Diet behaviour among young people in transition to adulthood (18–25 year olds): a mixed method study. *Heal Psychol Behav Med*. 2014;2(1):909-928

81. Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA. Emerging Adulthood and College-aged Youth: An Overlooked Age for Weight-related Behavior Change. *Obesity*. 2008;16(10):2205-2211.

82. Statistics Canada. Table 37-10-0103-01 Participation rate in education, population aged 18 to 34, by age group and type of institution attended [Internet]. Ottawa, ON; 2018 [cited 2021 Jul 8]. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3710010301.

83. Wiggers D, Vanderlee L, White CM, Reid JL, Minaker L, Hammond D. Food sources among young people in five major Canadian cities. *Can J Public Health*. 2018;109(4):506-515.

84. Ahmed M, Ng AP, L'Abbe MR. Nutrient intakes of Canadian adults: results from the Canadian Community Health Survey (CCHS)–2015 Public Use Microdata File. *Am J Clin Nutr*. 2021;114(3):1131-1140.

85. Hack S, Jessri M, L'Abbé MR. Evaluating Diet Quality of Canadian Adults Using Health Canada's Surveillance Tool Tier System: Findings from the 2015 Canadian Community Health Survey-Nutrition. *Nutrients.* 2020;12(4):1113.

86. Harrison S, Brassard D, Lemieux S, Lamarche B. Consumption and Sources of Saturated Fatty Acids According to the 2019 Canada Food Guide: Data from the 2015 Canadian Community Health Survey. *Nutrients.* 2019;11(9):1964.

87. Lieffers JRL, Ekwaru JP, Ohinmaa A, Veugelers PJ. The economic burden of not meeting food recommendations in Canada: The cost of doing nothing. *PLoS One*. 2018;13(4):e0196333.

88. Deliens T, Clarys P, de Bourdeaudhuij I, Deforche B. Determinants of eating behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health.* 2014;14(53).

89. Sogari G, Velez-Argumedo C, Gómez MI, Mora C. College Students and Eating Habits: A Study Using An Ecological Model for Healthy Behavior. *Nutrients*. 2018;10(12).

90. Mascioli BA, Davis R. Health-Protective Eating Style Among Students at a Canadian University. *Can J Behav Sci.* 2019;51(4):269.

91. Marquis M, Talbot A, Sabourin A, Riopel C. Exploring the environmental, personal and behavioural factors as determinants for university students' food behaviour. *Int J Cons Stud*. 2019;43(1):113-22.

92. Kelly NR, Mazzeo SE, Bean MK. Systematic Review of Dietary Interventions With College Students: Directions for Future Research and Practice. *J Nutr Educ Behav*. 2013;45:304-313.

93. Roy R, Kelly B, Rangan A, Allman-Farinelli M. Food Environment Interventions to Improve the Dietary Behavior of Young Adults in Tertiary Education Settings: A Systematic Literature Review. *J Acad Nutr Diet*. 2015;115(10):1647-1681.

94. Grech A, Howse E, Boylan S. A scoping review of policies promoting and supporting sustainable food systems in the university setting. *Nutr J*. 2020;19(1):97.

95. De Young R, Scheuer K, Roush J, Kozeleski K. Student interest in campus community gardens: Sowing the seeds for direct engagement with sustainability. In: *World Sustainability Series*. Springer; 2016:161-175.

96. Laycock Pedersen R, Robinson Z. Reviewing University Community Gardens for Sustainability: taking stock, comparisons with urban community gardens and mapping research opportunities. *Local Environ*. 2018;23(6):652-671.

97. Levkoe CZ, Erlich S, Archibald S. Campus Food Movements and Community Service-Learning: Mobilizing Partnerships through the Good Food Challenge in Canada. *Engag Sch J Community-Engaged Res Teaching, Learn*. 2019;5(1):57-76.

98. Vaughter P, Wright T, McKenzie M, Lidstone L. Greening the Ivory Tower: A Review of Educational Research on Sustainability in Post-Secondary Education. *Sustainability*. 2013;5(5):2252-2271.

99. Findler F, Schönherr N, Lozano R, Reider D, Martinuzzi A. The impacts of higher education institutions on sustainable development: A review and conceptualization. *Int J Sustain High Educ*. 2019;20(1):23-38.

100. Health Canada. Nutrition Labelling [Internet]. Ottawa, ON; 2015 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/food-labelling/nutrition-labelling.html

101. Health Canada. Nutrition facts tables [Internet]. Ottawa, ON; 2019 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/health-canada/services/understanding-food-labels/nutrition-facts-tables.html

102. Health Canada. Food labelling changes [Internet]. Ottawa, ON; 2021 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/health-canada/services/food-labelling-changes.html.

103. Institute of Medicine. Dietary Reference Intakes: Guiding Principles for Nutrition Labelling and Fortification [Internet]. Washington, DC: The National Academies Press; 2003 [cited 2019 Nov 25].

104. Health Canada. Percent daily value [Internet]. Ottawa, ON; 2019 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/health-canada/services/understanding-food-labels/percent-daily-value.html

105. Mhurchu CN, Eyles H, Choi Y-H. Effects of a Voluntary Front-of-Pack Nutrition Labelling System on Packaged Food Reformulation: The Health Star Rating System in New Zealand. *Nutrients*. 2017;9(8).

106. Bablani L, Mhurchu CN, Neal B, Skeels CL, Staub KE, Blakely T. The impact of voluntary front-of-pack nutrition labelling on packaged food reformulation: A difference-in-differences analysis of the Australasian Health Star Rating scheme. *PLoS Med*. 2020;17(11):e1003427.

107. Otite FO, Jacobson MF, Dahmubed A, Mozaffarian D. Trends in trans fatty acids reformulations of US supermarket and brand-name foods from 2007 through 2011. *Prev Chronic Dis*. 2013;10.

108. van der Bend DLM, Jansen L, van der Velde G, Blok V. The influence of a front-of-pack nutrition label on product reformulation: A ten-year evaluation of the Dutch Choices programme. *Food Chem X*. 2020;6:100086.

109. Black JL, Billette J-M. Fast food intake in Canada: Differences among Canadians with diverse demographic, socio-economic and lifestyle characteristics. *Can J Public Heal*. 2015;106(2):52-58.

110. Todd JE, Mancino L, Lin B-H. The Impact of Food Away from Home on Adult Diet quality [Internet]. 2010 [cited 2021 Jul 8]. Available from: https://www.ers.usda.gov/webdocs/publications/46352/8170_err90_1_.pdf?v=3358.1

111. Ministry of Ontario . Healthy Menu Choices Act, 2015, S.O. 2015, c. 7, Sched. 1 [Internet]. Ontario, Canada; 2017 [cited 2021 Jul 8]. Available from: https://www.ontario.ca/laws/statute/15h07

112. Ministry of British Columbia. Informed Dining [Internet]. British Columbia, Canada; 2020 [cited 2021 Jul 8]. Available from: https://www.healthyfamiliesbc.ca/home/informed-dining

113. Bernell B. The history and impact of the New York City menu labeling law. Food Drug Law J. 2010;65:839.

114. Powell LM, Chaloupka FJ, Bao Y. The Availability of Fast-Food and Full-Service Restaurants in the United States. *Am J Prev Med*. 2007;33(4):S240-S245.

115. Scourboutakos MJ, L'Abbé MR. Restaurant Menus. *Am J Prev Med*. 2012;43(3):249-255.

116. Burton S, Creyer EH, Kees J, Huggins K. Attacking the obesity epidemic: the potential health benefits of providing nutrition information in restaurants. *Am J Public Health*. 2006;96(9):1669-1675.

117. Government of the United Kingdom. Mandating calorie labelling in the out-of-home sector: Government response to public consultation [Internet]. United Kingdom: Department of Health and Social Care; 2020 [cited 2021 Jul 8]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/903714/Calorie_Labelling_-_Consultation_Response.pdf

118. National Health Services. Food labels: Eat well [Internet]. United Kingdom: Department of Health; 2018 [cited 2021 Jul 8]. Available from: https://www.nhs.uk/Livewell/Goodfood/Pages/food-labelling.aspx

119. Food Standards Agency. Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets [Internet]. United Kingdom; 2016 [cited 2021 Jul 8]. Available from: https://www.food.gov.uk/sites/default/files/multimedia/pdfs/pdf-ni/fop-guidance.pdf

120. World Cancer Research Fund International. Building on momentum: lessons on implementing a robust front-of-pack food label [Internet]. London, United Kingdom; 2019 [cited 2021 Jul 8]. Available from: https://www.wcrf.org/policy/our-publications/building-momentum-series/lessons-implementing-robust-front-of-pack-food-label

121. Food Standards Agency. Check the label [Internet]. United Kingdom; 2020 [cited 2021 Jul 8]. Available from: https://www.food.gov.uk/safety-hygiene/check-the-label

122. Hagmann D, Siegrist M, Hartmann C. Taxes, labels, or nudges? Public acceptance of various interventions designed to reduce sugar intake. *Food Policy*. 79AD:156-165.

123. Roberto CA, Bragg MA, Schwartz MB, Seamans MJ, Musicus A, Novak N, Brownell KD. Facts up front versus traffic light food labels: a randomized controlled trial. *Am J Prev Med*. 2012;43(2):134-41.

124. Kanter R, Vanderlee L, Vandevijvere S. Front-of-package nutrition labelling policy: global progress and future directions. *Pub Hlth Nutr*. 2018 Jun;21(8):1399-408.

125. Hawley KL, Roberto CA, Bragg MA, Liu PJ, Schwartz MB, Brownell KD. The science on front-of-package food labels. *Public Health Nutr*. 16(3):430-439.

126. Temple NJ. Front-of-package food labels: A narrative review. *Appetite*. 2020;144.

127. Packer J, Russell SJ, Ridout D, Hope S, Conolly A, Jessop C, Robinson OJ, Stoffel ST, Viner RM, Croker H. Assessing the Effectiveness of Front of Pack Labels: Findings from

an Online Randomised-Controlled Experiment in a Representative British Sample. *Nutrients*. 2021;13(3):900.

128. Sinclair S, Hammond D, Goodman S. Sociodemographic Differences in the Comprehension of Nutritional Labels on Food Products. *J Nutr Educ Behav*. 2013;45(6):767-772.

129. Dumanovsky T, Huang CY, Bassett MT, Silver LD. Consumer awareness of fast-food calorie information in new york city after implementation of a menu labeling regulation. *Am J Public Health*. 2010;100(12):2520-2525.

130. Elbel B, Mijanovich T, Dixon LB, Abrams C, Weitzman B, Kersh R, Auchincloss AH, Ogedegbe G. Calorie labeling, fast food purchasing and restaurant visits. *Obesity*. 2013;21(11):2172-9.

131. Elbel B, Kersh R, Brescoll VL, Dixon LB. Calorie labeling and food choices: A first look at the effects on low-income people in New York City: Calorie information on menus appears to increase awareness of calorie content, but not necessarily the number of calories people purchase. *Health Aff*. 2009;28(6):1110-1121.

132. Krieger JW, Chan NL, Saelens BE, Ta ML, Solet D, Fleming DW. Menu labeling regulations and calories purchased at chain restaurants. *Am J Prev Med*. 2013;44(6):595-604.

133. Pulos E, Leng K. Evaluation of a voluntary menu-labeling program in full-service restaurants. *Am J Public Health*. 2010;100(6):1035-1039.

134. Breck A, Cantor J, Martinez O, Elbel B. Who reports noticing and using calorie information posted on fast food restaurant menus? *Appetite*. 2014;81:30-36.

135. Hammond D, Lillico HG, Vanderlee L, White CM, Reid JL. The impact of nutrition labeling on menus: A naturalistic cohort study. *Am J Health Behav*. 2015;39(4):540-548.

136. Goodman S, Vanderlee L, White CM, Hammond D. A quasi-experimental study of a mandatory calorie-labelling policy in restaurants: Impact on use of nutrition information among youth and young adults in Canada. *Prev Med*. 2018;116:166-72.

137. Vanderlee L. Examining the Impact of a Nutrition Labelling Program on Menus in a Cafeteria Setting [Thesis]. 2016. Available from: https://uwspace.uwaterloo.ca/handle/10012/10401

138. Bassett MT, Dumanovsky T, Huang C, et al. Purchasing behavior and calorie information at fast-food chains in New York City, 2007. *Am J Public Health*. 2008;98(8):1457-1459.

139. Tandon PS, Zhou C, Chan NL, Lozano P, Couch SC, Glanz K, Krieger J, Saelens BE. The impact of menu labeling on fast-food purchases for children and parents. *Am J Prev Med*. 2011;41(4):434-438.

140. Vadiveloo MK, Dixon LB, Elbel B. Consumer purchasing patterns in response to calorie labeling legislation in New York City. *Int J Behav Nutr Phys Act*. 2011;8.

141. Webb KL, Solomon LS, Sanders J, Akiyama C, Crawford PB. Menu labeling responsive to consumer concerns and shows promise for changing patron purchases. *J Hung Env Nutr*. 2011;6(2):166-78.

142. Harnack LJ, French SA. Effect of point-of-purchase calorie labeling on restaurant and cafeteria food choices: A review of the literature. *Int J Behav Nutr Phys Act*. 2008;5.

143. Swartz JJ, Braxton D, Viera AJ. Calorie menu labeling on quick-service restaurant menus: an updated systematic review of the literature. *Int J Behav Nutr Phys Act*. 2011;8(1):135.

144. Kiszko KM, Martinez OD, Abrams C, Elbel B. The Influence of Calorie Labeling on Food Orders and Consumption: A Review of the Literature. *J Community Health*. 2014;39(6):1248-1269.

145. Fernandes AC, Oliveira RC, Proença RPC, Curioni CC, Rodrigues VM, Fiates GMR. Influence of menu labeling on food choices in real-life settings: a systematic review. *Nutr Rev*. 2016;74(8):534-548.

146. Bleich SN, Economos CD, Spiker ML, Vercammen KA, VanEpps EM, Block JP, Elbel B, Story M, Roberto CA. A systematic review of calorie labeling and modified calorie

labeling interventions: impact on consumer and restaurant behavior. *Obesity*. 2017;25(12):2018-44.

147. Sinclair SE, Cooper M, Mansfield ED. The Influence of Menu Labeling on Calories Selected or Consumed: A Systematic Review and Meta-Analysis. *J Acad Nutr Diet*. 2014;114(9):1375-1388.e15.

148. Nikolaou CK, McPartland M, Demkova L, Lean MEJ. Supersize the label: The effect of prominent calorie labeling on sales. *Nutrition*. 2017;35:112-113.

149. Long MW, Tobias DK, Cradock AL, Batchelder H, Gortmaker SL. Systematic review and meta-analysis of the impact of restaurant menu calorie labeling. *Am J Public Health*. 2015;105(5):e11-24

150. Littlewood JA, Lourenço S, Iversen CL, Hansen GL. Menu labelling is effective in reducing energy ordered and consumed: A systematic review and meta-analysis of recent studies. *Public Health Nutr*. 2016;19(12):2106-2121.

151. Crockett RA, King SE, Marteau TM, Prevost AT, Bignardi G, Roberts NW, Stubbs B, Hollands GJ, Jebb SA. Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption. *Cochrane Database Syst Rev*. 2018(2).

152. Sonnenberg L, Gelsomin E, Levy DE, Riis J, Barraclough S, Thorndike AN. A traffic light food labeling intervention increases consumer awareness of health and healthy choices at the point-of-purchase. *Prev Med (Baltim)*. 2013;57(4):253-257.

153. Thorndike AN, Riis J, Sonnenberg LM, Levy DE. Traffic-light labels and choice architecture: Promoting healthy food choices. *Am J Prev Med*. 2014;46(2):143-149.

154. Thorndike AN, Gelsomin ED, McCurley JL, Levy DE. Calories Purchased by Hospital Employees after Implementation of a Cafeteria Traffic Light-Labeling and Choice Architecture Program. *JAMA Netw Open*. 2019;2(7).

155. Olstad DL, Vermeer J, McCargar LJ, Prowse RJL, Raine KD. Using traffic light labels to improve food selection in recreation and sport facility eating environments. *Appetite*. 2015;91:329-335.

156. Seward MW, Block JP, Chatterjee A. A Traffic-Light Label Intervention and Dietary Choices in College Cafeterias. *Am J Public Health*. 2016;106(10):1808-1814.

157. Liu PJ, Roberto CA, Liu LJ, Brownell KD. A test of different menu labeling presentations. *Appetite*. 2012;59(3):770-7.

158. Morley B, Scully M, Martin J, Niven P, Dixon H, Wakefield M. What types of nutrition menu labelling lead consumers to select less energy-dense fast food? An experimental study. *Appetite*. 2013;67:8-15.

159. Dodds P, Wolfenden L, Chapman K, Wellard L, Hughes C, Wiggers J. The effect of energy and traffic light labelling on parent and child fast food selection: A randomised controlled trial. *Appetite*. 2014;73:23-30.

160. Hobin E, Lillico H, Zuo F, Sacco J, Rosella L, Hammond D. Estimating the impact of various menu labeling formats on parents' demand for fast-food kids' meals for their children: An experimental auction. *Appetite*. 2016;105:582-590.

161. Prowse RJL, Lee KM, Chen E, Zuo F, Hammond D, Hobin E. Testing the efficacy of and parents' preferences for nutrition labels on children's menus from a full-service chain restaurant: Results of an online experiment. *Public Health Nutr*. 2020;23(10):1820-1831.

162. Ellison B, Lusk JL, Davis D. Looking at the label and beyond: The effects of calorie labels, health consciousness, and demographics on caloric intake in restaurants. *Int J Behav Nutr Phys Act*. 2013;10(1):1-9.

163. VanEpps EM, Downs JS, Loewenstein G. Calorie label formats: using numeric and traffic light calorie labels to reduce lunch calories. *J Public Policy Mark*. 2016;35(1):26-36.

164. Emrich TE, Qi Y, Lou WY, L'Abbe MR. Traffic-light labels could reduce population intakes of calories, total fat, saturated fat, and sodium. *PLoS One*. 2017;12(2).

165. Lemos TC, Almo A, Campagnoli RR, Pereira MG, Oliveira L, Volchan E, Krutman L, Delgado R, Fernández-Santaella MC, Khandpur N, et al. A red code triggers an

unintended approach motivation toward sweet ultra-processed foods: Possible implications for front-of-pack labels. *Food Qual Prefer*. 2020;79:103784.

166. Scarborough P, Matthews A, Eyles H, Kaur A, Hodgkins C, Raats MM, Rayner M. Reds are more important than greens: how UK supermarket shoppers use the different information on a traffic light nutrition label in a choice experiment. *Int J Behav Nutr Phys Act*. 2015;12(1):1-9.

167. Seward MW, Block JP, Chatterjee A. Student experiences with traffic-light labels at college cafeterias: a mixed methods study. *Obes Sci Pract*. 2018;4(2):159-177.

168. Government of Alberta. Alberta nutrition guidelines for children and youth: a childcare, school and recreation/community centre resource manual [Internet]. 2012 [cited 2021 Jul 8]. Available from: https://open.alberta.ca/publications/5906406.

169. Crockett RA, King SE, Marteau TM, Prevost AT, Bignardi G, Roberts NW, Stubbs B, Hollands GJ, Jebb SA. Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption. *Cochrane Database Syst Rev*. 2018;2(2):CD009315.

170. Hammond D, Goodman S, Hanning R, Daniel S. A randomized trial of calorie labeling on menus. Prev Med. 2013;57(6):860-6.

171. Chen R, Smyser M, Chan N, Ta M, Saelens BE, Krieger J. Changes in awareness and use of calorie information after mandatory menu labeling in restaurants in King County, Washington. *Am J Public Health*. 2015;105(3):546-553.

172. Green JE, Brown AG, Ohri-Vachaspati P. Sociodemographic Disparities among Fast-Food Restaurant Customers Who Notice and Use Calorie Menu Labels. *J Acad Nutr Diet*. 2015;115(7):1093-1101.

173. Lee-Kwan SH, Pan L, Maynard LM, McGuire LC, Park S. Factors Associated with Self-Reported Menu-Labeling Usage among US Adults. *J Acad Nutr Diet*. 2016;116(7):1127-1135.

174. Feng W, Fox A. Menu labels, for better, and worse? Exploring socio-economic and race-ethnic differences in menu label use in a national sample. *Appetite*. 2018;128:223-232.

175. Stormacq C, Van Den Broucke S, Wosinski J. Does health literacy mediate the relationship between socioeconomic status and health disparities? Integrative review. *Health Promot Int*. 2019;34(5):E1-E17.

176. Svendsen MT, Bak CK, Sørensen K, Pelikan J, Riddersholm SJ, Skals RK, Mortensen RN, Maindal JT, Boggild H, et al. Associations of health literacy with socioeconomic position, health risk behavior, and health status: A large national population-based survey among Danish adults. *BMC Public Health*. 2020;20(1):1-12.

177. Lastrucci V, Lorini C, Caini S, Florence Health Literacy Research Group, Bonaccorsi G. Health literacy as a mediator of the relationship between socioeconomic status and health: A cross-sectional study in a population-based sample in Florence. *PLoS One*. 2019;14(12):e0227007.

178. Campos S, Doxey J, Hammond D. Nutrition labels on pre-packaged foods: a systematic review. *Public Health Nutr.* 2011;14(18):1496-506.

179. Cowburn G, Stockley L. Consumer understanding and use of nutrition labelling: a systematic review. *Pub Hlth Nutr*. 2005 Feb;8(1):21-8.

180. Sarink D, Peeters A, Freak-Poli R, Beauchamp A, Woods J, Ball K, Backholer K. The impact of menu energy labelling across socioeconomic groups: A systematic review. *Appetite*. 2016;99:59-75.

181. Levy DE, Riis J, Sonnenberg LM, Barraclough SJ, Thorndike AN. Food choices of minority and low-income employees: a cafeteria intervention. *Am J Prev Med*. 2012 Sep 1;43(3):240-8.

182. VanEpps EM, Roberto CA, Park S, Economos CD, Bleich SN. Restaurant Menu Labeling Policy: Review of Evidence and Controversies. *Curr Obes Rep*. 2016;5(1):72-80.

183. McGeown L. The calorie counter-intuitive effect of restaurant menu calorie labelling. *Can J Public Heal*. 2019;110(6):816-820.

184. Roberto CA, Haynos AF, Schwartz MB, Brownell KD, White MA. Calorie estimation accuracy and menu labeling perceptions among individuals with and without binge eating and/or purging disorders. *Eat Weight Disord - Stud Anorexia, Bulim Obes*. 2013;18(3):255-261.

185. Lillico HG, Hanning R, Findlay S, Hammond D. The effects of calorie labels on those at high-risk of eating pathologies: a pre-post intervention study in a University cafeteria. *Public Health*. 2015;129(6):732-9.

186. Haynos AF, Roberto CA. The effects of restaurant menu calorie labeling on hypothetical meal choices of females with disordered eating. *Int J Eat Disord*. 2017;50(3):275-283.

187. Larson N, Haynos AF, Roberto CA, Loth KA, Neumark-Sztainer D. Calorie Labels on the Restaurant Menu: Is the Use of Weight-Control Behaviors Related to Ordering Decisions? *J Acad Nutr Diet*. 2018;118(3):399-408.

188. Nagata JM, Garber AK, Tabler JL, Murray SB, Bibbins-Domingo K. Prevalence and Correlates of Disordered Eating Behaviors Among Young Adults with Overweight or Obesity. *J Gen Intern Med*. 2018;33(8):1337-1343.

189. Heller MC, Willits-Smith A, Meyer R, Keoleian GA RD. Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. *Environ Res Lett*. 2018;13:1-11.

190. Auestad N, Fulgoni VL. What Current Literature Tells Us about Sustainable Diets: Emerging Research Linking Dietary Patterns, Environmental Sustainability, and Economics. *Adv Nutr*. 2015;6(1).

191. Reinhardt SL, Boehm R, Blackstone NT, El-Abbadi NH, Brandow JS, Taylor SF, DeLonge MS. Systematic review of dietary patterns and sustainability in the United States. *Adv Nutr*. 2020;11(4):1016-1031.

192. Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. *Adv Nutr An Int Rev J*. 2016;7(6).

193. Lucan SC, DiNicolantonio JJ. How calorie-focused thinking about obesity and related diseases may mislead and harm public health. An alternative. *Public Health Nutr*. 2015;18(4):571-581.

194. Gruner J, Ohri-Vachaspati P. Food and beverage selection patterns among menu label users and nonusers: results from a cross-sectional study. *J Acad Nutr Diet*. 2017;117(6):929-36.

195. Harnack LJ, French SA, Michael JM, Story MT, Jeffery RW, Rydell SA. Effects of calorie labeling and value size pricing on fast food meal choices: Results from an experimental trial. *Int J Behav Nutr Phys Act*. 2008;5.

196. Cantu-Jungles TM, McCormack LA, Slaven JE, Slebodnik M, Eicher-Miller HA. A Meta-Analysis to Determine the Impact of Restaurant Menu Labeling on Calories and Nutrients (Ordered or Consumed) in U.S. Adults. *Nutrients*. 2017;9(10).

197. Auchincloss AH, Mallya GG, Leonberg BL, Ricchezza A, Glanz K, Schwarz DF. Customer responses to mandatory menu labeling at full-service restaurants. *Am J Prev Med*. 2013;45(6):710-719.

198. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci*. 2010;5(69):1-9.

199. Colquhoun HL, Levac D, O'Brien KK, Straus S, Tricco AC, Perrier L, Kastner M, Moher D. Scoping reviews: time for clarity in definition, methods, and reporting. *J Clin Epi*. 2014;67(12):1291-4.

200. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015;13(3):141-146.

201. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018;18(1):143.

202. Arksey H, O'Malley L. Scoping Studies: Towards a Methodological Framework. *Int J Soc Res Methodol*. 2005;8(1):1364-5579.

203. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Ann Intern Med*. 2018;169(7):467-473.

204. Keller LO, Strohschein S, Lia-Hoagberg B, Schaffer MA. Population-based public health interventions: Practice-based and evidence-supported. Part I. *Public Health Nurs*. 2004;21(5):453-68.

205. Global Alliance for Improved Nutrition and Johns Hopkins University. The Food Systems Dashboard [Internet]. 2020. Geneva, Switzerland. Available from: https://www.foodsystemsdashboard.org.

206. Parsons K, Hakes C, Wells R. What is the food system? A food policy perspective [Internet]. 2019 [cited 2021 Jul 8]. Available from: www.city.ac.uk

207. Covidence. Covidence systematic review. Version v1532 8c1129e3 [software]. Veritas Health Innovation: Melbourne, Australia. 2020 May 26 [cited 2021 Jul 8]. Available from: www.covidence.org6

208. Belur J, Tompson L, Thornton A, Simon M. Interrater reliability in systematic review methodology: exploring variation in coder decision-making. *Sociol Methods Res*. 2018;50(2).

209. McHugh ML. Interrater reliability: The kappa statistic. *Biochem Medica*. 2012;22(3):276-282.

210. Food Standards Agency. Building on the success of front-of-pack nutrition labelling in the UK: a public consultation [Internet]. United Kingdom; 2020 [cited 2021 May 21]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905096/front-of-pack-labelling-consultation-document-english.pdf

211. Beatty PC, Willis GB. Research synthesis: The practice of cognitive interviewing. *Public Opin Q*. 2007;71(2):287-311

212. Lenzner T, Neuert C, Otto W. Cognitive pretesting. *GESIS Survey Guidelines*. 2016:3.

213. University of Waterloo. Food Services: Product Information Database [Internet]. Ontario, Canada; 2019 [cited 2021 May 21]. Available from: https://uwaterloo.ca/food-services/menu/search.

214. Health Canada. Canadian Nutrient File [Internet]. Ontario, Canada; 2018 [cited 2021 May 21]. Available from: https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp.

215. Malam S, Clegg S, Kirwan S, McGinigal S, Raats M, Shepherd R, Barnett J, Senior V, Hodgkins C, Dean M. Comprehension and use of UK nutrition signpost labelling schemes [Internet]. London: Food Standards Agency; 2009 [cited 2021 May 21]. Available from: https://www.foodwatch.org/fileadmin/_migrated/content_uploads/FSA-Studie_2009_original_englisch.pdf

216. Qualtrics. Qualtrics Software, version March 2019. Utah, USA; 2020 [cited 2021 May 21]. Available from: https://qualtrics.com

217. Heath Canada. Canadian Community Health Survey [Internet]. Ottawa, Canada; 2018 [cited 2021 May 21]. Available from: https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs.html

218. Powers BJ, Trinh J V., Bosworth HB. Can this patient read and understand written health information? *J Am Med Assoc*. 2010;304(1):76-84.

219. Bradshaw M, Kent BV, Henderson WM, Setar AC. Subjective social status, life course SES, and BMI in young adulthood. *Heal Psychol*. 2017;36(7):682-694.

220. Hill LS, Reid F, Morgan JF, Lacey JH. SCOFF, the development of an eating disorder screening questionnaire. *Int J Eat Disord*. 2009;43(4):344-351.

221. Ewing W, Weir S, Sanusi A. Unique Identifier Codes: Guidelines for use with key populations [Internet]. *Unique Identifier Codes: Guidelines for Use with Key Populations*. 2016. Available from: https://www.fhi360.org/sites/default/files/media/documents/resource-linkages-uic-guidance.pdf

222. Lorden AL, Radcliff TA, Jiang L, Horel SA, Smith ML, Lorig K, Howell BL, Whitelaw N, Ory M. Leveraging administrative data for program evaluations: A method for linking data sets without unique identifiers. *Eval Health Prof*. 2016 Jun;39(2):245-59.

223. U.S. Department of Agriculture, Agricultural Research Service. USDA Food and Nutrient Database for Dietary Studies 2017-2018 [Database]. 2017 [cited 2021 Jul 8]. Available from: http://www.ars.usda.gov/nea/bhnrc/fsrg

224. U.S. Department of Agriculture, Agricultural Research Service. USDA Food Patterns Equivalents Database 2017-2018 [Database]. 2017 [cited 2021 Jul 8]. Available from: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/

225. Kirkpatrick SI, Reedy J, Krebs-Smith SM, Pannucci TE, Subar AF, Wilson MM, Lerman JL, Tooze JA. Applications of the Healthy Eating Index for surveillance, epidemiology, and intervention research: considerations and caveats. *J Acad Nutr Diet*. 2018;118(9):1603-21.

226. Krebs-Smith SM, Pannucci TE, Subar AF, Kirkpatrick SI, Lerman JL, Tooze JA, Wilson MM, Reedy J. Update of the healthy eating index: HEI-2015. *J Acad Nutr Diet*. 2018;118(9):1591-602.

227. Schwingshackl L, Hoffmann G. Diet Quality as Assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension Score, and Health Outcomes: A Systematic Review and Meta-Analysis of Cohort Studies. *J Acad Nutr Diet*. 2015;115(5):780-800.e5.

228. National Cancer Institute. Division of Cancer Control and Population Sciences. ASA24-Canada-2018 [Internet]. 2020 [cited 2021 Jul 8]. Available from: https://epi.grants.cancer.gov/asa24/respondent/asa24-canada-2018.html

229. American Psychological Association. Measuring socioeconomic status and subjective social status. Public Interest Directorate, Socioeconomic Status Office, Resources and Publication [Internet]. 2018 [cited 2021 Jul 8]. Available from: https://www.apa.org/pi/ses/resources/class/measuring-status

230. Berzofsky M, Smiley-McDonald H, Moore A, Krebs C. Measuring socioeconomic status (SES) in the NCVS: Background, options, and recommendations [Internet]. Washington, DC; 2014 [cited 2021 Jul 8]. Available from: https://www. bjs. gov/content/pub/pdf/Measuring_SES-Paper_authorship_corrected. pdf. 2014 Jan 6.

231. Mansfield ED, Wahba R, Gillis DE, Weiss BD, L'Abbé M. Canadian adaptation of the newest vital sign©, a health literacy assessment tool. *Cambridge Archaeol J*. 2018;21(11):2038-2045.

232. Erola J, Jalonen S, Lehti H. Parental education, class and income over early life course and children's achievement. *Res Soc Stratif Mobil*. 2016;44:33-43.

233. Kerins C, McHugh S, McSharry J, Reardon CM, Hayes C, Perry IJ, Geeaney F, Seery S, Kelly C. Barriers and facilitators to implementation of menu labelling interventions from a food service industry perspective: A mixed methods systematic review. *Int J Behav Nutr Phys Act*. 2020;17(1):1-15.

234. Ahmed S, Byker Shanks C, Lewis M, Leitch A, Spencer C, Smith EM, Hess D. Meeting the food waste challenge in higher education. *Int J Sustain High Educ*. 2018;19(6):1075-1094.

235. Vermote M, Versele V, Stok M, Mullie P, D'Hondt E, Deforche B, Clarys P, Deliens T. The effect of a portion size intervention on French fries consumption, plate waste, satiety and compensatory caloric intake: an on-campus restaurant experiment. *Nutr J*. 2018 Dec;17(1):43.

236. Kim Y, Steiner P. Quasi-Experimental Designs for Causal Inference. *Educ Psychol*. 2016;51(3-4):395-405.

237. Handley MA, Lyles CR, Mcculloch C, Cattamanchi A. Selecting and Improving Quasi-Experimental Designs in Effectiveness and Implementation Research. *Public Health*. 2018;39:5-25.

238. Osborne J, Stuart EA, Rubin DB. Best Practices in Quasi–Experimental Designs: Matching Methods for Causal Inference. In: Best Practices in Quantitative Methods. SAGE Publications, Inc.; 2011:155-176.

239. Roberto CA, Larsen PD, Agnew H, Baik J, Brownell KD. Evaluating the impact of menu labeling on food choices and intake. *Am J Public Health*. 2010;100(2):312-318.

240. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika*. 1986;73(1):13-22.

241. Health Canada. Toward Front-of-Package Nutrition Labels for Canadians [Internet]. Ottawa, ON; 2021 [cited 2021 Jul 8]. Available from: https://www.canada.ca/en/health-canada/programs/front-of-package-nutrition-labelling/consultation-document.html.

242. Mendelson BK, Mendelson MJ, White DR. Body-esteem scale for adolescents and adults. *J Pers Assess*. 2001;76(1):90-106.

243. EAT-26. Eating Attitudes Test & Eating Disorder Testing [Internet]. 2020 [cited 2021 Jul 8]. Available from: https://www.eat-26.com/. Accessed July 13, 2021.

244. Potter L, Zawadzki MJ, Eccleston CP, Cook JE, Snipes SA, Silwinski MJ, Smyth JM. The Intersections of Race, Gender, Age, and Socioeconomic Status: Implications for Reporting Discrimination and Attributions to Discrimination. *Stig Hlth.* 2018;4(3):264-281.

245. Spiteri M, Soler L-G. Food reformulation and nutritional quality of food consumption: an analysis based on households panel data in France. *Eur J Clin Nutr*. 2018;72(2):228-235.

246. Rincón-Gallardo PS, Zhou M, Da Silva GF, Lemaire R, Hedrick V, Serrano E. Effects of menu labeling policies on transnational restaurant chains to promote a healthy diet: A scoping review to inform policy and research. *Nutrients*. 2020;12(6).

247. Hawkes C. Identifying innovative interventions to promote healthy eating using consumption-oriented food supply chain analysis. *J Hunger Environ Nutr*. 2009;4(3-4):336-356.

248. Booth A, Moore G, Flemming K, Garside R, Rollins N, Tunçalp Ö, Noyes J. Taking account of context in systematic reviews and guidelines considering a complexity perspective. *BMJ Global Health*. 2019;4(Suppl 1):e000840.

249. Eme PE, Douwes J, Kim N, Foliaki S, Burlingame B. Review of methodologies for assessing sustainable diets and potential for development of harmonised indicators. *Int J Environ Res Public Health*. 2019;16(7).

250. Herforth A, Frongillo EA, Sassi F, Mclean MS, Arabi M, Tirado C, Remans R, Mantilla G, Thomson M, Pingali P. Toward an integrated approach to nutritional quality, environmental sustainability, and economic viability: research and measurement gaps. *Ann NY Acad Sci*. 2014;1332(1):1-21.

251. Jones AD, Hoey L, Blesh J, Miller L, Green A, Fink Shapiro L. A Systematic Review of the Measurement of Sustainable Diets. *Am Soc Nutr*. 2016;7:641-664.

252. Guinee J, Jeijungs R, Huppes G, Zamagni A, Masoni P, Buonamici R, Ekvall T, Rydberg T. Life Cycle Assessment: Past, Present, and Future. *Env Sci Technol*. 2011;45:90-96.

253. Heller MC, Keoleian GA, Willett WC. Toward a Life Cycle-Based, Diet-level Framework for Food Environmental Impact and Nutritional Quality Assessment: A Critical Review. *Environ Sci Technol*. 2013;47(22):12632-12647.

254. Kovacs B, Miller L, Heller MC, Rose D. The carbon footprint of dietary guidelines around the world: a seven country modeling study. *Nutr J*. 2021;20(1):1-10.

255. Rose D, Heller MC, Willits-Smith AM, Meyer RJ. Carbon footprint of self-selected US diets: nutritional, demographic, and behavioral correlates. *Am J Clin Nutr*. 2019;109(3):526-534.

256. Conrad Z, Johnson LK, Peters CJ, Jahns L. Capacity of the US Food System to Accommodate Improved Diet Quality: A Biophysical Model Projecting to 2030. *Curr Dev Nutr*. 2018;2(4).

257. Lang T. The Sustainable Diet Question. *Int J Sociol Agric Food*. 2021;27(1):12-34.

APPENDICES

Appendix A. Search strategy for scoping review

Concepts	Food and nutrition	Environmental sustainability	Intervention	Post-secondary settings
Author keywords	Food; nutrition*; diet*; eating	Environment*; waste*; sustainab*; carbon*; greenhouse gas*; climate change; global warming	Intervention*; program*; initiative*; education*;	Post-secondary; universit*; university student*; college student*; campus*; cafeteria*; food service*
Controlled subject headings *Based on MeSH for MEDLINE*	Nutritional sciences; Diet, food, and nutrition		Health policy; health education; health promotion	Food services
Limits	• English only • Publication date January 2000 – present			
Basic search	(food OR nutrition OR sustainability) AND (intervention) AND (post-secondary)			

Advanced search (MEDLINE) *December 2019*	***#1 Search: Nutrition and environmental sustainability*** → 853,444 results food [tiab] OR nutrition* [tiab] OR diet* [tiab] OR eating [tiab] OR Nutritional sciences [mesh] OR Diet, Food, and Nutrition[mesh] OR environment*[tiab] OR waste*[tiab] OR sustainab*[tiab] OR carbon*[tiab] OR greenhouse gas* [tiab] OR climate change [tiab] OR global warming [tiab] ***#2 Search: Intervention*** → 699,620 results intervention*[tiab] OR program* [tiab] OR initiative* [tiab] OR education* [tiab] OR health policy [mesh] OR health education [mesh] OR health promotion [mesh] ***#3 Search:*** Post-secondary settings → 22,571 results post-secondary [tiab] OR universities [mesh] OR university student*[tiab] OR college student* [tiab] OR campus*[tiab] OR cafeteria* [tiab] OR food service* [tiab] OR Food services [mesh] ***Final search*** → 2,855 results #1 AND #2 AND #3 (filter for January 2015 onwards)
Advanced search (SCOPUS)[1,2] *December 2019*	***#1 Search: Nutrition and environmental sustainability*** → 201,051 results TITLE-ABS-KEY (food AND (nutrition* OR diet* OR eating OR environment* OR waste* OR sustainab* OR carbon* OR "greenhouse gas" OR "climate change" OR "global warming")) ***#2 Search: Intervention*** → 1,729,357 results TITLE-ABS-KEY (intervention* OR program* OR initiative* OR education* OR trayless) ***#3 Search: Post-secondary settings*** → 12,698 results TITLE-ABS-KEY (post-secondary OR universit* OR college* OR university student* OR college student* OR campus* OR cafeteria* OR food service*) ***Final search*** → 215 results #1 AND #2 AND #3 (filter for January 2015 onwards)
Advanced search (CINAHL)1[1] *December 2019*	***#1 Search: Nutrition and environmental sustainability*** → 23,472 results (TI food OR AB food) AND (TI nutrition* OR AB nutrition* OR TI diet* OR AB diet* OR TI eating OR AB eating OR TI environment* OR AB environment* OR TI waste* OR AB waste* OR TI sustainab* OR AB sustainab* OR TI carbon* OR AB carbon* OR TI "greenhouse gas" OR AB "greenhouse gas" OR TI "climate change" OR AB "climate change" OR TI "global warming" OR AB "global warming" OR MM diet) ***#2 Search: Intervention*** → 361,209 results TI intervention* OR AB intervention* OR TI program* OR AB program* OR TI initiative* OR AB initiative* OR TI education* OR AB education* OR MM health promotion OR MM nutrition policy

	#3 Search: Post-secondary settings → 81,521 results TI post-secondary OR AB post-secondary OR TI universit* OR AB universit* OR TI college* OR AB college* OR TI university student* OR AB university student* OR TI college student* OR AB college student* OR TI campus* OR AB campus* OR TI cafeteria* OR AB cafeteria* OR TI food service* OR AB food service* OR MM Students, College OR MM Students, Undergraduate ***Final search*** → 867 results #1 AND #2 AND #3 (filter for January 2015 onwards)
Advanced search (ERIC)[1,3] *December 2019*	***#1 Search: Nutrition and environmental sustainability*** → 851 results noft(food) AND (noft(nutrition*) OR noft(diet*) OR noft(eating) OR noft(environment*) OR noft(waste*) OR noft(sustainab*) OR noft(carbon*) OR noft("greenhouse gas") OR noft("climate change") OR noft("global warming") OR mainsubject(nutrition)) ***#2 Search: Intervention*** → 122,223 results noft(intervention*) OR noft(program*) OR noft(initiative*) OR noft(education*) OR mainsubject(health education) OR mainsubject(health promotion) ***#3 Search: Post-secondary settings*** → 47,740 noft(post-secondary) OR noft(universit*) OR noft(college*) OR noft(university student*) OR noft(college student*) OR noft(campus*) OR noft(cafeteria*) OR noft(food service*) OR mainsubject(postsecondary education) ***Final search*** → 339 results #1 AND #2 AND #3 (filter for January 2000 onwards)

[1]To narrow scope, food was included as a separate concept to nutrition and environmental sustainability.
[2]"Trayless" was included to capture interventions related to environmental sustainability that were not captured in PubMed. This term specifically targets interventions that removed the use of trays from cafeterias to monitor changes to food waste. These interventions were identified as relevant following a basic search, however, did not appear in the initial PubMed search.
[3]Limits were placed to retrieve peer-reviewed articles only.

Appendix B. Data charting form for scoping review

Data field	Description
Article information	Author(s), year of publication, title, journal.
Study location and setting	Where was the intervention implemented? (e.g., university/college name and/or country) What was the setting of the intervention?
Study objectives	What was the objective of the study?
Intervention description	What was the intervention? Did the authors compare the intervention to a control group?
Intervention type	What was the intervention type according to the NOURISHING framework?
Duration of intervention	How long was the intervention and study period? Was there a follow-up period?
Study populations	Who was the intervention intended for? (e.g., students, staff, faculty)
Study design	What was the study design?
Outcome measures and evidence on effectiveness	What was the outcome of interest and how was it measured? Did the intervention influence the outcome of interest?
Considerations for human and planetary health	Did the authors consider human health and/or environmental sustainability in the implementation and evaluation of the intervention? Did the authors discuss implications on other food system challenges?
Limitations and gaps	What are the knowledge or methodological gaps in the literature?
Funding source	How was the study funded? Did the authors have any conflicts of interest?

Appendix C. Comparison of offerings at each site and phase

Table C-1. Description of offerings at each site

	Control site	Numeric site	Traffic light label site
Meals	• **Hot meal stations**: daily offerings; menus were on weekly rotation that differed across sites and phases • **Customizable sandwich station**: standard station of add-ons • **Customizable bowl station**: standard station of add-ons • **Customizable pizza station**: standard station of add-ons • **Grill**: standard menu • **Customizable salad bar**: all pre-made salads and add-ons consistent across sites • **Grab and go station**: all offerings consistent across sites	• **Hot meal stations**: daily offerings; menus were on weekly rotation that differed across sites and phases • **Customizable sandwich station**: standard station of add-ons • **Customizable bowl station**: standard station of add-ons • **Customizable pizza station**: standard station of add-ons • **Grill**: standard menu • **Customizable salad bar**: all pre-made salads and add-ons consistent across sites • **Grab and go station**: all offerings consistent across sites	• **Hot meal stations**: daily offerings; menus were on weekly rotation that differed across sites and phases • **Customizable sandwich station**: standard station of add-ons • **Customizable bowl station**: standard station of add-ons • **Customizable pizza station**: standard station of add-ons • **Grill**: standard menu + additional burger and poutine options • **Customizable salad bar**: all pre-made salads and add-ons consistent across sites • **Grab and go station**: all offerings consistent across sites
Beverages	• Standard inventory	• Standard inventory	• Standard inventory
Snacks	• Standard inventory + UW Food Services smoothies	• Standard inventory + UW Food Services smoothies	• Standard inventory + branded smoothie outlet

Table C-2. Calorie amounts and proportion of items for traffic light labelling categories by site and phase

	Control site		Numeric site		Traffic light label site	
	Pre-test (Total=1289)	**Post-test (Total=1295)**	**Pre-test (Total=1289)**	**Post-test (Total=1295)**	**Pre-test (Total=1327)**	**Post-test (Total=1332)**
Calorie amounts[1,2] (kcal) Mean (Range: Q1-Q3; Maximum)						
Overall	177 (80-240; 1200)	176 (80-230; 1200)	176 (80-232; 1120)	175 (80-240; 830)	184 (80-250; 1200)	185 (80-250; 1200)
Meals	173 (30-225; 1200)	173 (30-220; 1200)	170 (30-220; 1120)	169 (30-221; 830)	183 (30-240; 1200)	185 (33-231; 1200)
Hot meals	283 (125-340; 1200)	272 (120-270;1200)	261 (140-325; 1120)	247 (140-300; 810)	250 (130-290; 1200)	263 (120-290; 1200)
Sandwiches	85 (10-120; 383)	85 (10-120; 383)	85 (10-120; 383)	85 (10-120; 383)	85 (10-120; 383)	85 (10-120; 383)
Bowls	89 (10-170; 330)	89 (10-170; 330)	89 (10-170; 330)	89 (10-170; 330)	89 (10-170; 330)	89 (10-170; 330)
Pizzas	49 (10-90; 150)	49 (10-90; 150)	49 (10-90; 150)	49 (10-90; 150)	49 (10-90; 150)	49 (10-90; 150)
Grill	235 (90-341; 830)	235 (90-341; 830)	235 (90-341; 830)	235 (90-341; 830)	329 (120-450; 980)	329 (120-450; 980)
Salad	80 (5-120; 490)	80 (5-120; 490)	80 (5-120; 490)	80 (5-120; 490)	80 (5-120; 490)	80 (5-120; 490)
Grab-and-go stations	408 (240-570; 800)	408 (240-570; 800)	408 (240-570; 800)	408 (240-570; 800)	408 (240-570; 800)	408 (240-570; 800)
Beverages	100 (40-140; 550)	100 (40-140; 550)	100 (40-140; 550)	100 (40-140; 550)	100 (40-140; 550)	100 (40-140; 550)
Snacks	199 (131-260; 600)	199 (131-260; 600)	199 (131-260; 600)	199 (131-260; 600)	205 (131-270; 650)	205 (131-270; 650)
Proportion of items by traffic light labelling categorization[3] n(%)						
Meals	N=511	N=517	N=511	N=517	N=527	N=532
Green	253 (49.5)	258 (49.9)	253 (49.5)	256 (49.5)	260 (49.3)	264 (49.6)
Amber	111 (21.7)	116 (22.4)	117 (22.9)	116 (22.4)	117 (22.2)	120 (22.6)
Red	147 (28.8)	143 (27.7)	141 (27.6)	145 (28.1)	150 (28.5)	148 (27.8)
Beverages	N=157	N=157	N=157	N=157	N=157	N=157
Green	90 (57.3)	90 (57.3)	90 (57.3)	90 (57.3)	90 (57.3)	90 (57.3)

Amber	66 (42.0)	66 (42.0)	66 (42.0)	66 (42.0)	66 (42.0)	66 (42.0)
Red	1 (0.64)	1 (0.64)	1 (0.64)	1 (0.64)	1 (0.64)	1 (0.64)
Snacks	N=621	N=621	N=621	N=621	N=643	N=643
Green	122 (20.0)	122 (20.0)	122 (20.0)	122 (20.0)	122 (19.0)	122 (19.0)
Amber	286 (46.1)	286 (46.1)	286 (46.1)	286 (46.1)	298 (46.4)	298 (46.4)
Red	213 (34.3)	213 (34.3)	213 (34.3)	213 (34.3)	223 (34.7)	223 (34.7)

[1]Hot menu offerings rotated daily and were on a separate weekly rotation at each site.

[2]Offerings at customizable stations for sandwiches, bowls, pizzas, and salads included add-ons that were standardized across all sites.

[3]Scores of green-, amber-, and red-labelled items were calculated using a proportional weighting and scoring system. Weights were calculated based on the proportion of green-, amber-, and red-labelled items relative to the total number of add-ons in the full entrée. For example, a customizable sandwich with 5 green-labelled items, 3 amber-labelled items, and 2 red-labelled items would receive a score of 0.5 for green, 0.3 for amber, and 0.2 for red. Similarly, a lasagna with 1 amber indicator would receive a score of 1 for the amber category and 0 for green and red categories.

Table C-3. Absolute and percent difference for calories and proportion of items by traffic light categories between phases at each site

	Control site	Numeric site	Traffic light label site
Difference in calorie amounts between pre and post[1,2] kcal (%)			
Overall	1 (-0.57)	1 (-0.57)	1 (+0.54)
Meals	0 (0.00)	1 (-0.59)	2 (+1.08)
Hot meals	11 (-3.96)	14 (-5.51)	13 (+5.07)
Sandwiches	0 (0.00)	0 (0.00)	0 (0.00)
Bowls	0 (0.00)	0 (0.00)	0 (0.00)
Pizzas	0 (0.00)	0 (0.00)	0 (0.00)
Grill	0 (0.00)	0 (0.00)	0 (0.00)
Salad	0 (0.00)	0 (0.00)	0 (0.00)
Grab-and-go stations	0 (0.00)	0 (0.00)	0 (0.00)
Beverages	0 (0.00)	0 (0.00)	0 (0.00)
Snacks	0 (0.00)	0 (0.00)	0 (0.00)
Difference in proportion of items by traffic light labelling categorization between pre and post[3] (% difference)			
Meals			
Green	0.00	0.00	+0.3
Amber	+0.7	-0.5	+0.4
Red	-1.1	+0.5	-0.7
Beverages			
Green	0.00	0.00	0.00
Amber	0.00	0.00	0.00
Red	0.00	0.00	0.00
Snacks			
Green	0.00	0.00	0.00
Amber	0.00	0.00	0.00
Red	0.00	0.00	0.00

[1]Hot menu offerings rotated daily and were on a separate weekly rotation at each site.
[2]Offerings at customizable stations for sandwiches, bowls, pizzas, and salads included add-ons that were standardized across all sites.
[3]Scores of green-, amber-, and red-labelled items were calculated using a proportional weighting and scoring system. Weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to total number of add-ons in the full entrée. For example, a sandwich with 5 green add-ons, 3 amber add-ons, and 2 red add-ons would receive a score of 0.5 for green, 0.3 for amber, and 0.2 for red. Similarly, a lasagna with 1 amber indicator would receive a score of 1 for amber, 0 for green and 0 for red.

Table C-4. Absolute and percent difference in calories and proportion of items by traffic light categories between sites at each phase

	Pre-test	Post-test
Numeric versus control site		
Difference in calorie amounts[1,2] kcal (% difference)		
Overall	1 (-0.57)	1 (-0.57)
Meals	3 (-1.75)	4 (-2.33)
Hot meals	22 (-8.09)	25 (-9.63)
Sandwiches	0 (0.00)	0 (0.00)
Bowls	0 (0.00)	0 (0.00)
Pizzas	0 (0.00)	0 (0.00)
Grill	0 (0.00)	0 (0.00)
Salad	0 (0.00)	0 (0.00)
Grab-and-go stations	0 (0.00)	0 (0.00)
Beverages	0 (0.00)	0 (0.00)
Snacks	0 (0.00)	0 (0.00)
Difference in proportion of items by traffic light labelling categorization[3] (% difference)		
Meals		
Green	0.00	0.00
Amber	+1.2	0.00
Red	-1.2	+0.4
Beverages		
Green	0.00	0.00
Amber	0.00	0.00
Red	0.00	0.00
Snacks		
Green	0.00	0.00
Amber	0.00	0.00
Red	0.00	0.00
Traffic light versus control site		
Difference in calorie amounts[1,2] kcal (% difference)		
Overall	7 (+3.88)	9 (+4.99)
Meals	10 (+5.62)	12 (+6.70)
Hot meals	33 (-12.4)	9 (-3.36)
Sandwiches	0 (0.00)	0 (0.00)
Bowls	0 (0.00)	0 (0.00)
Pizzas	0 (0.00)	0 (0.00)
Grill	94 (+33.3)	94 (+33.3)
Salad	0 (0.00)	0 (0.00)
Grab-and-go stations	0 (0.00)	0 (0.00)
Beverages	0 (0.00)	0 (0.00)
Snacks	6 (+2.97)	6 (+2.97)
Difference in proportion of items by traffic light labelling categorization[3] (% difference)		
Meals		
Green	-0.2	-0.3
Amber	+0.5	+0.2
Red	-0.3	+0.1

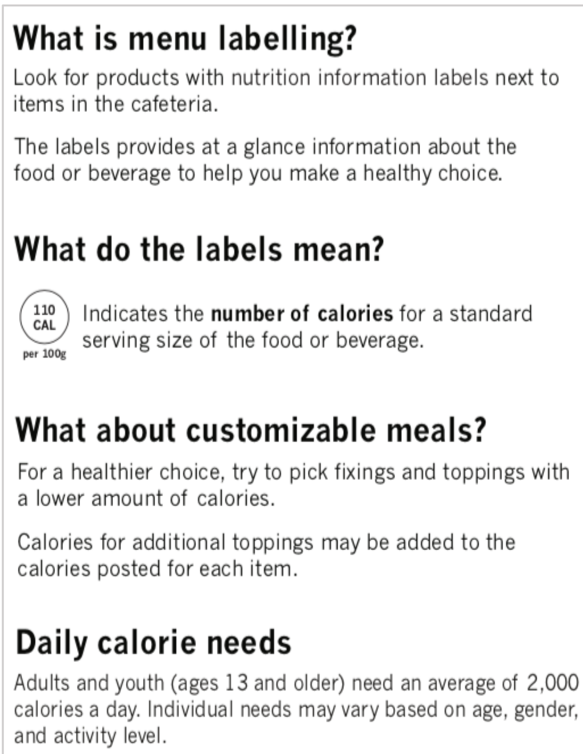
Beverages		
Green	0.00	0.00
Amber	0.00	0.00
Red	0.00	0.00
Snacks		
Green	-1.0	-1.0
Amber	+0.3	+0.3
Red	+0.3	+0.3
Traffic light versus numeric site		
Difference in calorie amounts[1,2] kcal (% difference)		
Overall	8 (+4.44)	10 (+5.55)
Meals	13 (+7.37)	6 (+9.04)
Hot meals	11 (-4.31)	16 (+6.27)
Sandwiches	0 (0.00)	0 (0.00)
Bowls	0 (0.00)	0 (0.00)
Pizzas	0 (0.00)	0 (0.00)
Grill	94 (+33.3)	94 (+33.3)
Salad	0 (0.00)	0 (0.00)
Grab-and-go stations	0 (0.00)	0 (0.00)
Beverages	0 (0.00)	0 (0.00)
Snacks	6 (2.97)	6 (2.97)
Difference in proportion of items by traffic light labelling categorization[3] (% difference)		
Meals		
Green	-0.2	+0.1
Amber	-0.7	+0.2
Red	+0.9	-0.3
Beverages		
Green	0.00	0.00
Amber	0.00	0.00
Red	0.00	0.00
Snacks		
Green	-1.0	-1.0
Amber	+0.3	+0.3
Red	+0.3	+0.3

[1]Hot menu offerings rotated daily and were on a separate weekly rotation at each site.
[2]Offerings at customizable stations for sandwiches, bowls, pizzas, and salads included add-ons that were standardized across all sites.
[3]Scores of green-, amber-, and red-labelled items were calculated using a proportional weighting and scoring system. Weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to the total number of add-ons in the full entrée. For example, a customizable sandwich with 5 green-labelled add-ons, 3 amber-labelled add-ons, and 2 red-labelled add-ons would receive a score of 0.5 for green, 0.3 for amber, and 0.2 for red. Similarly, a lasagna with 1 amber indicator would receive a score of 1 for the amber category and 0 for green and red categories.

Appendix D. Plain-language educational poster

Sample for one-page handout to educate consumers on how to use of numeric and TLL, which were made available in the intervention cafeterias.

Modified from: Government of Ontario (2018). Calories on menus. Available from: **https://www.ontario.ca/page/calories-menus**



What is menu labelling?

Look for products with nutrition information labels next to items in the cafeteria.

The labels provides at a glance information about the food or beverage to help you make a healthy choice.

What do the labels mean?

110 CAL per 100g — Indicates the **number of calories** for a standard serving size of the food or beverage.

What about customizable meals?

For a healthier choice, try to pick fixings and toppings with a lower amount of calories.

Calories for additional toppings may be added to the calories posted for each item.

Daily calorie needs

Adults and youth (ages 13 and older) need an average of 2,000 calories a day. Individual needs may vary based on age, gender, and activity level.

What is menu labelling?

Look for products with **green**, **amber** or **red** coloured labels next to items in the cafeteria.

The colours show you at a glance if the food or beverage is **low**, **medium**, or **high** in calories for a standard serving to help you make a healthy choice.

What do the colours mean?

RED means choose this food less often
Indicates the item is high in calories

AMBER means choose this food on occasion
Indicates the item has a medium number of calories

GREEN means choose this food more often
Indicates the item is low in calories

What about customizable meals?

For a healthier choice, try to pick fixings and toppings with more **greens** and **ambers** and fewer **reds**.

Calories for additional toppings may be added to the calories posted for each item.

Daily calorie needs

Adults and youth (ages 13 and older) need an average of 2,000 calories a day. Individual needs may vary based on age, gender, and activity level.

Appendix E. Interview guide cognitive testing of labels

INTRODUCTION & CONSENT

[Greeting and Introductions – Hi, I'm Kirsten, thanks for coming in today.]

"Thanks again for your help with our menu labels. First, I would like to provide you with some information on the study and review the consent form with you."

[*Provide information letter and consent form*]

"To begin, I just have a couple of questions for you."

WARMUP QUESTIONS

[Intro 1] In a typical week, how often do you eat at a residence cafeteria?	Probe: How easy or hard is it to answer this question? Follow-up probe: How sure or unsure are you of this number?
[Intro 2] The last time you visited any eating establishment (e.g., fast-food chain, cafeteria, restaurant, etc.), did you notice any nutrition information posted?	Probe: How easy or hard is it to answer this question? Follow-up probe**:** How sure or unsure are your response?

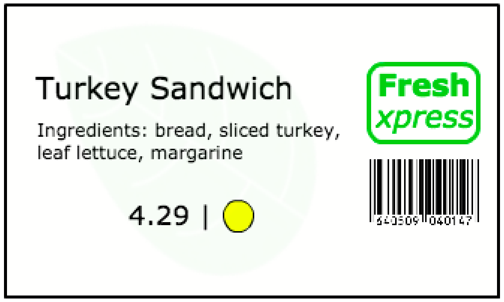
LABELS

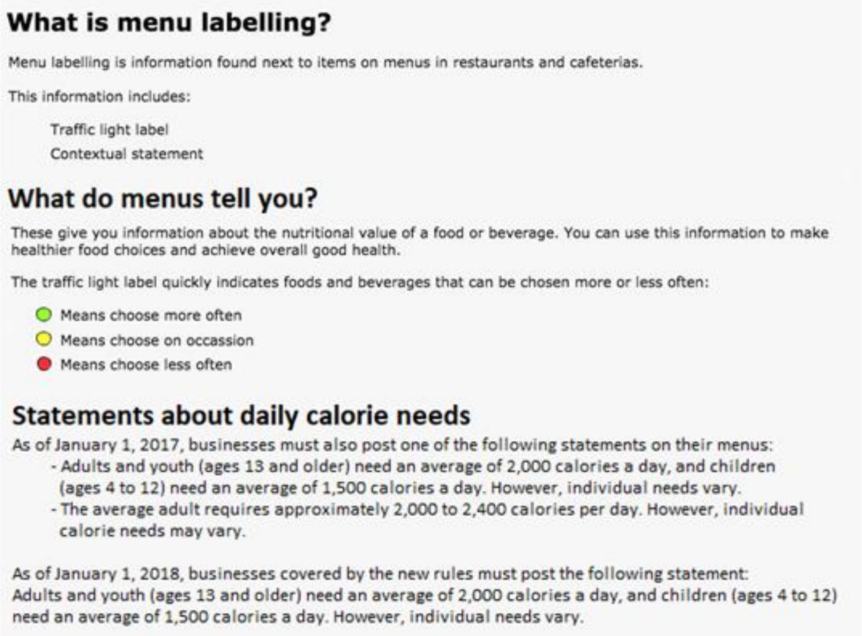
"Now, we're going to show you some images of menus in a residence cafeteria on our slide deck. We would like you to pretend that this is a typical visit to a residence cafeteria and you are making an order for lunch on a weekday. Please write down your order on the piece of paper provided. I just want to reiterate that there are no right or wrong answers here and we really appreciate your feedback for our study materials."

<table>
<tr>
<td>IMAGE SET 1

Traffic light label scenario</td>
<td>[Image set 1: Photo of Ron Eydt Village cafeteria to set the stage, an image of a sample hot menu, two images of packaged sandwich labels (vegetable sandwich and turkey sandwich), two images of beverage options (milk and fruit juice), two images of snack options (apple and chips). All food and beverages will have a traffic light label to indicate calorie amounts. An image of our educational handout will also be displayed.]

Small subset of images (subject to change upon consultation with Food Services):




<h3>What is menu labelling?</h3>
Menu labelling is information found next to items on menus in restaurants and cafeterias.

This information includes:
Traffic light label
Contextual statement
<h3>What do menus tell you?</h3>
These give you information about the nutritional value of a food or beverage. You can use this information to make healthier food choices and achieve overall good health.

The traffic light label quickly indicates foods and beverages that can be chosen more or less often:
Means choose more often
Means choose on occassion
Means choose less often
<h3>Statements about daily calorie needs</h3>
As of January 1, 2017, businesses must also post one of the following statements on their menus:
- Adults and youth (ages 13 and older) need an average of 2,000 calories a day, and children (ages 4 to 12) need an average of 1,500 calories a day. However, individual needs vary.
- The average adult requires approximately 2,000 to 2,400 calories per day. However, individual calorie needs may vary.

As of January 1, 2018, businesses covered by the new rules must post the following statement:
Adults and youth (ages 13 and older) need an average of 2,000 calories a day, and children (ages 4 to 12) need an average of 1,500 calories a day. However, individual needs vary.</td>
<td>Probe:
This scenario takes place in Ron Eydt Village cafeteria, which is approximately an 8-10 minute walk to the main campus. You have time to grab lunch at 12pm before your next class at 1:30pm. You plan to eat lunch in the dining area with a few of your floor-mates.

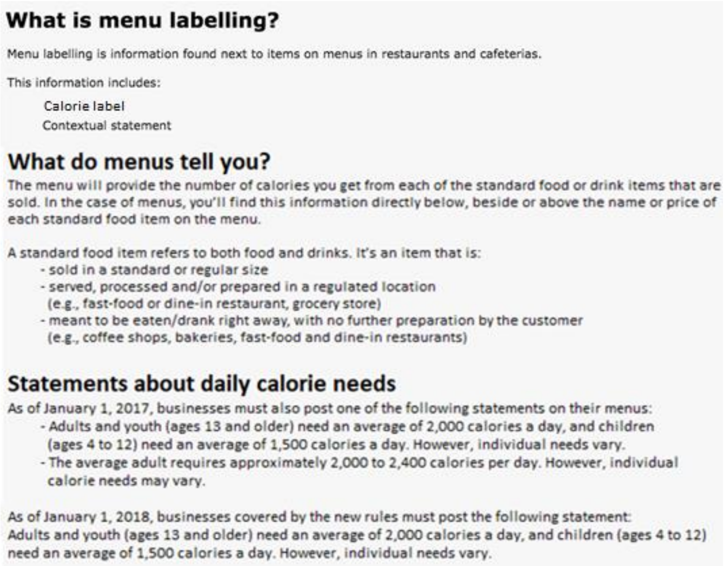
Please write down your food and beverage order.

[INITIAL INTERPRETATION]</td>
</tr>
</table>

<table>
<tr>
<td>IMAGE SET 2

Numeric calorie label scenario</td>
<td>[Image set 2: Photo of Village 1 cafeteria to set the stage, an image of a sample hot menu, two images of packaged sandwich labels (vegetable sandwich and ham sandwich), two images of beverage options (water and pop), two images of snack options (banana and cookies). All food and beverages will have a traffic light label to indicate calorie amounts. An image of a contextual statement and the educational handout will also be displayed.]

Small subset of images (subject to change upon consultation with Food Services):

What is menu labelling?
Menu labelling is information found next to items on menus in restaurants and cafeterias.
This information includes:
Calorie label
Contextual statement
What do menus tell you?
The menu will provide the number of calories you get from each of the standard food or drink items that are sold. In the case of menus, you'll find this information directly below, beside or above the name or price of each standard food item on the menu.
A standard food item refers to both food and drinks. It's an item that is:
- sold in a standard or regular size
- served, processed and/or prepared in a regulated location (e.g., fast-food or dine-in restaurant, grocery store)
- meant to be eaten/drank right away, with no further preparation by the customer (e.g., coffee shops, bakeries, fast-food and dine-in restaurants)
Statements about daily calorie needs
As of January 1, 2017, businesses must also post one of the following statements on their menus:
- Adults and youth (ages 13 and older) need an average of 2,000 calories a day, and children (ages 4 to 12) need an average of 1,500 calories a day. However, individual needs vary.
- The average adult requires approximately 2,000 to 2,400 calories per day. However, individual calorie needs may vary.
As of January 1, 2018, businesses covered by the new rules must post the following statement: Adults and youth (ages 13 and older) need an average of 2,000 calories a day, and children (ages 4 to 12) need an average of 1,500 calories a day. However, individual needs vary.
Government of Ontario (2018). Calories on menus. Available from:
https://www.ontario.ca/page/calories-menus</td>
<td>Probe:
This scenario takes place in Village 1 cafeteria, which is approximately a 2-5 minute walk to the main campus. You have time to grab lunch at 12pm before your next class at 1:30pm. You plan to eat lunch in the dining area with a few of your floor-mates.

Please write down your food and beverage order.

[INITIAL INTERPRETATION]</td>
</tr>
</table>

INTERVIEW

"Thank you for doing that. To begin, we would like to ask you some questions about your food order and how you made your decisions. After that, we will ask you some questions about the labels and how you understood them. Sometimes, it will seem like we are asking the same question repeatedly. Please be patient with us—we want to get as much detail as possible about ways that we can improve our scenarios.

For some of the questions, I will ask you how you came up with your answer. Again, this is not because we do not believe you, but because we want to understand how you think through your answer to a question. When I ask you to explain how you came up with your answer, it will be like my asking you to tell me how many windows you have in your house by closing your eyes, visualizing your house, and your telling me how you go from room to room of your house in order to count the windows there. As an exercise, let's try that now. Please close your eyes, and tell me how many windows are in your house, by taking me from room to room."

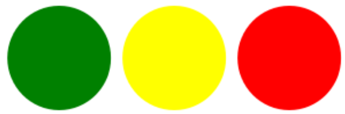
[Participant response]

"Thanks. Now, when we show you some scenarios and ask you questions about them, I would like you to do the same thing. You can tell me your understanding of the labels and talk me through how you decided your food order."

"Ok, let's get started. I'm going to show you some images that you have already seen."

[NOTE: The interviewer will use a semi-structured interview protocol, using the following types of probes, as appropriate to the questionnaire items and interview responses. Actual questions will be shown on a screen, without programming or interviewer notes.]

TRAFFIC LIGHT LABELS (IMAGE SET 1)

ORDER	If you are willing, can you please share with us the order you made at REV. [Participant shares order]	Probe: Can you walk me through how you decided your order? What information did you use to make your decision? *(Use probes if needed)* [INTERPRETATION]
INTERPRETATION *Interpretation of colours*	When you see these symbols, can you tell me what you think they mean? 	Probe: What does the green circle mean to you? What does the yellow circle mean to you? What does the red circle mean to you? What do you think of when you see these colours? What do you associate these colours with? [INTERPRETATION: To identify what participants associate these colours with.]
INTERPRETATION *Grab-and-go item*	What do you think this red circle means when it is on a food or beverage item? *(Show image with red label)*	Probe: Try to visualize this label in a residence cafeteria and tell me what you are seeing and thinking when you see this label. [INTERPRETATION: To identify how participants interpret a red symbol without education.]
INTERPRETATION *Gran-and-go item*	What do you think this green circle means when it is on a food or beverage item? *(Show image with green label)*	Probe: Try to visualize this label in a residence cafeteria and tell me what you are seeing and thinking when you see this label. [INTERPRETATION: To identify how participants interpret a green symbol without education.]

INTERPRETATION *Grab-and-go item*	What do you think this yellow circle means when it is on a food or beverage item? *(Show image with yellow label)*	Probe: Try to visualize this label in a residence cafeteria and tell me what you are seeing and thinking when you see this label. [INTERPRETATION: To identify how participants interpret a yellow symbol without education.]
INTERPRETATION *Grab-and-go item with handout*	After reading this handout, what do you think the green, yellow, and red circles mean when included on a food or beverage label? *(Show image of handout)*	Probe: How easy or hard was it understand the information provided here? What nutrition information is considered for the traffic lights? How sure are you of this answer? How did you arrive at that answer? *(Use specific probes if needed)* [INTERPRETATION & CLARITY]
INTERPRETATION *Handout*	From this handout, can you tell me what the purpose of menu labelling is? *(Show image of handout)*	Probe: Can you summarize what this handout means? How confident are you of this summary? Is there anything that you are confused about? Was this easy or hard to answer? *(Use specific probes if needed)* [INTERPRETATION & CLARITY]
COMPUTATION *Menu*	Based on the handout we showed previously, can you tell me what this menu means to you? *(Show image of handout and contextual statement)*	Probe: Can you walk me through your thought process behind this menu? What do you think the green colour means? What about the red? What about the yellow? What nutrition information determines the colour of these symbols? Which days would you consider purchasing a special? Why? How well do you remember the information provided in the handout? [INTERPRETATION & COMPUTATION]

PREFERENCE *Grab-and-go items*	We are going to show you two different labels, can you tell me which label you prefer and why? [If respondent chooses traffic light label with numbers] We are going to show you a menu with different types of labels, can you tell me which you prefer and why? (*Sample labels are subject to change based on consultation with Food Services.*)	Probe: What do you think the yellow colour means in the first label? What do you think the yellow colour means in the second label? How confident are you of your answer for each label? How did you arrive at that answer? Was that easy or hard to interpret? (Use specific probes if needed) Which label is the most clear to you? Which label grabs your attention? Which aspects do you like in each of the labels? What is confusing about these labels? [PREFERENCE]
FORMAT	*(Show all images for set 1)*	Probe: Do you have any concerns regarding the formatting of our labels or handout? Please comment on font size, placement, brightness of colours, etc. Was there anything that confused you during your initial order at the start of the session? [INTERPRETATION & PREFERENCE]

"Ok, we're more than halfway done. We'll now look at some of the images from the second scenario that you saw at the start of the session."

NUMERIC LABELS (IMAGE SET 2)

ORDER	If you are willing, can you please share with us the order you made at V1. [Participant shares order]	Probe: Can you walk me through how you decided your order? What information did you use to make your decision? [Follow-up with specific probes if needed] [INTERPRETATION]
INTERPRETATION	Can you walk me through the information provided on this label?	Probe: Do you associate this number with being good or bad?

Interpretation of numbers	*(Show image of numeric labels)*	Tell me what is confusing about this label. [INTERPRETATION]
INTERPRETATION *Handout*	After reading this handout, what does this tell you about the menu labels? *(Show image of handout)*	Probe: Can you summarize what this handout means? How confident are you of this summary? Is there anything that you are confused about? How easy or hard was it easy for you to summarize this blurb? (Use specific probes if needed) [INTERPRETATION & CLARITY]
INTERPRETATION *Grab-and-go item with handout*	What does this contextual statement mean to you? *(Show image of handout)*	Probe: How easy or hard was it understand the information provided here? How do you use this statement in context with the labels? [INTERPRETATION & CLARITY]
COMPUTATION *Menu*	Based on the handout and contextual statement we showed previously, can you tell me what this menu means to you? *(Show image of handout and contextual statement)*	Probe: Can you walk me through your thought process behind this menu? What do you think the numbers mean? What nutrition information is being displayed? [INTERPRETATION & COMPUTATION]
PREFERENCE *Grab-and-go items*	We are going to show you a menu with several different versions of labels, can you tell me which label you prefer and why? (*Sample labels are subject to change based on consultation with Food Services.*)	Probe: Which label is the clearest? Which label grabs your attention? Which aspects do you like in each of the labels? What is confusing about these labels? [PREFERENCE]

FORMAT	*(Show all images for set 2)*	Probe: Do you have any concerns regarding the formatting of our labels or handout? Please comment on font size, placement, colours, etc. Was there anything that confused you during your initial order at the start of the session? [INTERPRETATION & PREFERENCE]

GENERAL COMMENTS AND CONCERNS
"Ok, now I just have a few final questions for you before we finish up."

LABEL USE	Does nutrition information impact your food and beverage choices? In the last 6 months, did you ever change your behaviour because you saw nutrition labels on menus?	[If yes, follow up.]
OTHER CONCERNS	Did you have any difficulty/issue with any aspects of the labels, educational handout, or statements that I haven't asked you about?	[Follow-up if necessary.]

[***Provide feedback letter and remuneration, and thank*** **participant]**

INTERVIEWER DEBRIEF FORM

[RECORD: time taken to finish the interview, facial/body expressions when reading the labels or handouts, make notes of responses to interview questions. Notes on facial/body expressions will help to provide context to the responses given by the participant. For example, if a participant shows signs of confusion when reading the handout, this may indicate that the wording or formatting may need to be improved. Notes will only be made if indicating a potentially positive or negative response to the study materials.]

[INCLUDE AUDIO RECORDING]

1. (ACT) In general, how did the respondent act toward you during the interview?
    1. Not at all attentive
    2. Somewhat attentive
    3. Very attentive

2. (QUESTION) How much difficulty do you think the respondent had in understanding most of the questions?
    1. A lot of difficulty
    2. Some difficulty
    3. No difficulty

Appendix F. Materials for recruiting cognitive interviews

School of Public Health and Health Systems
University of Waterloo

PARTICIPANTS NEEDED FOR RESEARCH

Comparing the impact of calorie labelling formats among young adults:
Pre-testing study materials

We are seeking volunteers to take part in a pre-testing phase to assess the readability of study materials. Participants will test either the labels or surveys to be used in a study on calorie labelling. Students who not currently live in a UW residence are eligible.

As a participant in this study, you will be asked to participate in an open-ended interview of approximately 20-30 minutes in duration. The questions are designed to assess your understanding and perceptions of study materials.

Participants will receive $5 cash in appreciation of their time.

For more information about this study, please contact:
Kirsten Lee
School of Public Health and Health Systems
Email: ***kirsten.lee@uwaterloo.ca***

To inquire about participating this study, please contact:
Miriam Price
School of Public Health and Health Systems
Email: ***m2price@uwaterloo.ca***

This study has been reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee.

UNIVERSITY OF WATERLOO

Information letter and consent form for cognitive interviews

Study title: Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality

Study investigators: Kirsten Lee (**kirsten.lee@uwaterloo.ca**) and Sharon Kirkpatrick (**sharon.kirkpatrick@uwaterloo.ca**), School of Public Health and Health Systems, University of Waterloo *This study is being conducted as part of Kirsten Lee's PhD thesis.*

Dear student,

Thank you for your interest in this study, funded by the Canadian Foundation for Dietetic Research. We are working in collaboration with Food Services to evaluate the impact of different menu labelling formats on food and beverage purchasing among post-secondary students. During Winter 2019, three residence cafeterias on campus will take part in our study, in which two cafeterias will receive different calorie labels (i.e., either traffic lights or numbers to indicate calorie information) and one cafeteria will not receive any labelling. We are inviting you to take part in the pre-testing phase of this study, during which we will be assessing the readability of study materials that we plan to use in an upcoming study.

Your participation in this study is voluntary. The information provided in this letter will help you make an informed decision regarding your participation.

<u>What will happen during this project?</u>

Students who agree to participate will be involved in *<u>either</u>*:

i) A 30-minute interview during which we will ask you about the label formats and handouts that we present to you. We will ask you to:
   - Select a hypothetical meal from a variety of options and answer questions about what influenced your choice; and
   - Verbalize your thought processes and preferences for different food label formats. (*e.g., "Can you walk me through the information provided on this label?"*)

ii) A 30-minute interview during which we will ask you questions about a survey. We will ask you to:
   - Select a hypothetical meal from a variety of options and complete a survey with questions about your meal selection and eating habits; and
   - Explain your understanding of specific survey questions and verbalize your thought processes behind the multiple choice responses. (*e.g., "The last time you visited any food establishment, did you notice any nutrition information posted?"*)

The feedback you provide today will help us to improve our study materials. We will also be observing your facial/body expressions and attention level to understand your reaction to study materials.

<u>Will I receive anything for participating in this study?</u>

In appreciation of your time, you will receive $5 cash. By participating in the pre-testing phase, you will not be eligible to take part in a study that we will be conducting subsequently (for this reason, we are asking you to provide your WatID below if you decide to participate in the current study). *The amount received is taxable. It is your responsibility to report this amount for income tax purposes.*

<u>Are there benefits associated with this project?</u>

By participating in this project, you will contribute to a project to provide researchers with information to:

- Improve campus policies and programs that impact the health of post-secondary students; and

- Make recommendations for policies and programs to support health in Ontario and across Canada

Are there possible risks in taking part?

There are no known or anticipated risks associated with participation in this study. You may choose to skip any question that you are uncomfortable answering in this interview. If you feel uncomfortable or upset during this study, we encourage you to talk to Counselling Services on campus at 519-888-4567 ext. 32655.

How will my information be kept private?

With your permission, this interview will be audio-recorded and later transcribed for analysis. Notes and/or audio recordings collected during this study will be encrypted and stored on a secure server at UW for at least 7 years. Audio files and transcripts will be stored on password-protected computers in a locked research office at the School of Public Health and Health Systems.

Your identity will be kept confidential and any personal identifying information will not be shared publicly. The dataset without identifiers may be shared publicly. All information that could identify you will be removed from the data within **1 week** and stored separately. WatIDs will be used for eligibility purposes and stored separately from the data, as well as destroyed immediately after data collection. We will keep identifying information for a minimum of 2 years and our study records for a minimum of **7** years. Your consent form will be stored in a locked office at the School of Public Health and Health Systems. Only the research team will have access to study data. All records will be destroyed according to University of Waterloo policy.

Participation and withdrawal

Your participation is completely voluntary. You have the right to choose not to participate or to withdraw at any time without consequences. You can withdraw consent to participate and have your data destroyed by contacting us within the minimum 2 years that we will keep identifying information. It is not possible to withdraw your consent once papers and publications have been submitted to publishers, after which time, your data cannot be destroyed.

Project Results

If you are interested in receiving a summary of the results, please check the box at the bottom of the consent form. We anticipate that an overview of the results will be available in mid-2019.

Ethics clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31830). If you have questions, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

If you have any questions regarding the study, please contact the student investigator, Kirsten Lee, or the faculty supervisor, Dr. Sharon Kirkpatrick, using the information provided. Thank you for your consideration.

Contact Information

Kirsten Lee (project contact)
PhD Student, School of Public Health and Health Systems, University of Waterloo
200 University Ave West
Waterloo, ON N2L 3G1
Email: **kirsten.lee@uwaterloo.ca**

Dr. Sharon Kirkpatrick
Associate Professor, School of Public Health and Health Systems, University of Waterloo
200 University Ave West
Waterloo, ON N2L 3G1
Email: **sharon.kirkpatrick@uwaterloo.ca**

Consent

By providing your consent, you are not waiving your legal rights or releasing the investigators or involved institutions from their legal and professional responsibilities.

I confirm that I have read the above information about the study, titled "Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality". I had the opportunity to ask questions related to the study and have received satisfactory answers to my questions and any additional details.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I understand that participation is voluntary and I may withdraw this consent by informing the investigators.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

For all other questions, contact **Kirsten Lee** at **kirsten.lee@uwaterloo.ca.**

I agree of my own free will to participate in this study.

☐ YES ☐ NO

I agree to have my interview audio recorded.

☐ YES ☐ NO

Participant's name (please print): ____

Participant's signature: ____________________________ Date: _______________________

WatID: ____

Researcher's (witness) signature: ______________________ Date: ______________________

Please send me a summary of the research that this testing will support.

☐ YES ☐ NO

Email address:
____

We will only use your email address to send you a summary of the research.

Feedback letter for participants in the cognitive interviews

Study title: Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality

Study investigators: Kirsten Lee (**kirsten.lee@uwaterloo.ca**) and Sharon Kirkpatrick (**sharon.kirkpatrick@uwaterloo.ca**), School of Public Health and Health Systems, University of Waterloo

This study is being conducted as part of Kirsten Lee's PhD thesis.

Dear student,

Thank you for your participation in the pre-testing phase of our research study. The purpose of the primary study is to examine the impact of different menu labelling formats on food and beverage purchasing among post-secondary students.

The data collected during the interviews will help us improve the materials (i.e., labels/handouts OR surveys) that we will use in the study. The information provided today will contribute to materials that will help provide researchers with information to make recommendations for policies and programs that support health in Ontario and across Canada.

We want to remind your identity will be kept confidential and any personal identifying information will not be shared publicly. The dataset without identifiers may be shared publicly. All information that could identify you will be removed from the data within **1 week** and stored separately. WatIDs will be used for eligibility purposes and stored separately from the data, as well as destroyed immediately after data collection. We will keep identifying information for a minimum of 2 years and our study records for a minimum of **7** years. Your consent form will remain stored in a locked research office at the School of Public Health and Health Systems. Only the research team will have access to study data. All records will be destroyed according to University of Waterloo policy.

Your participation is completely voluntary. You have the right to choose not to participate and may withdraw at any time within the minimum 2 years that we will keep identifying information. To withdraw from the study, please contact **Kirsten Lee** using the information provided below. It is not possible to withdraw your consent once papers and publications have been submitted to publishers, after which time, your data cannot be destroyed. As a reminder, by participating in the pre-testing phase, you will not be eligible to take part in the primary study on menu labelling during Winter 2019.

While the feedback provided today will be used to improve our study materials, we plan on sharing our aggregated findings from the main study to the research community through conferences and journal articles. If you are interested in receiving more information regarding the results of this study, please provide your email address, and we will send you a summary of the results by Spring term 2019.

This study has received clearance by the University of Waterloo Research Ethics Committee (ORE #31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

For all other questions, please contact the student investigator, **Kirsten Lee**, or the faculty supervisor, Dr. Sharon Kirkpatrick, using the information provided below. Thank you again for your participation in this study.

<u>Contact Information</u>

Kirsten Lee (project contact)
PhD Student, School of Public Health and Health Systems, University of Waterloo
200 University Ave West
Waterloo, ON N2L 3G1
Email: **kirsten.lee@uwaterloo.ca**

Dr. Sharon Kirkpatrick
Assistant Professor, School of Public Health and Health Systems, University of Waterloo
200 University Ave West
Waterloo, ON N2L 3G1
Email: **sharon.kirkpatrick@uwaterloo.ca**

Appendix G. Recruitment poster displayed at cafeterias

Appendix H. Exit interviewer script and procedure

Research assistants used the following script to recruit participants at the study sites.

Step 1: Approaching students

Hello, we are conducting a study to learn more about how post-secondary students make decisions about food and beverage purchases at residence cafeterias. Would you be interested in learning more about our study?

If the student says yes, the research assistant tallies the response on the tracking sheet (see below) and provides them with an iPad.

If the student says no, the research assistant tallies the response on the tracking sheet.

Step 2: Eligibility screener

The research assistant provides the student with an iPad, which directs them to a page with the eligibility screener with the following questions:

1. Are you a student at the University of Waterloo?
2. To your knowledge, have you participated in this study this week?
3. Did you make a purchase or look at the menu options at ___*name of cafeteria*___ today?

If the student is eligible to participate, the survey will direct them to the information letter and consent form.

If the student is not eligible to participate, the survey will exit and the research assistant will thank the student for their time.

Step 3: Information letter and consent form (Appendix H-ii)

The survey directs the student to the information letter and consent form.

If the student consents to participating in the study, the survey will continue.

If the student does not consent to participating in the study, the survey will exit and the research assistant thanks the student for their time.

Number of students approached

Date/time: _______________ Location: _______________ Research assistant: _________________

This sheet must be returned to the study coordinator at the end of each day.
Mark 'Y' if the student consented and completed the survey; 'N' if they refused.
Use '*' if something unique happened (e.g., incomplete survey due to WiFi or survey errors).

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

Notes (if noting something specific to survey, please include time of submission):

Appendix I. Information letter and consent form

Study Title: Examining the factors that influence food and beverage purchasing among post-secondary students at campus eateries.

Study investigators: Kirsten Lee (**kirsten.lee@uwaterloo.ca**) and Sharon Kirkpatrick (**sharon.kirkpatrick@uwaterloo.ca**), School of Public Health and Health Systems, University of Waterloo

This study is being conducted as part of Kirsten Lee's PhD thesis.

Dear student,

Thank you for your interest in this study, funded by the Canadian Foundation for Dietetic Research. We are working in collaboration with Food Services to learn about the factors that influence food and beverage purchasing among post-secondary students at campus eateries.

Your participation in this study is voluntary. The information provided in this letter will help you make an informed decision regarding your participation.

<u>What will happen during this project?</u>

- Students who agree will be asked to complete a brief survey about them and their experience at this cafeteria.
    - The survey will take about 10 minutes and will be provided to you promptly after signing the informed consent form if you choose to participate.
    - You will be asked questions related to your most recent purchase at this cafeteria, as well as your eating habits and demographics (e.g., gender, program of study).

<u>Will I receive anything for participating in this study?</u>

- In appreciation of your time, you will receive $5 cash for completing the brief survey today.
- The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

<u>Are there benefits associated with this project?</u>

By participating in this project, you will contribute to findings that provide researchers with information to help:

- Improve campus policies and programs that impact the health of post-secondary students; and
- Make recommendations for policies and programs to support health in Ontario and across Canada

<u>Are there possible risks for taking part?</u>

Some students might feel uncomfortable answering personal questions about themselves or their eating habits. This information will help us understand participant characteristics and used to interpret responses to other items. You may choose to skip any question that you are uncomfortable answering. If you feel uncomfortable or upset during this study, we encourage you to talk to Counselling Services on campus at 519-888-4567 ext. 32655.

<u>How will my information be kept private?</u>

Your identity will be kept confidential and no personal identifying information will be shared publicly. The dataset without identifiers may be shared publicly. Your data will be stored with a numeric code and kept separate from any identifying information. The researchers will keep a file linking identifying information (e.g., email address) with participant ID numbers for a minimum of 2 years. Individual results will not be shared and your personal identifiers will not be included in any project materials, such as presentations or papers. All data and forms will be stored on secure UW servers and only accessed from password-protected computers by the research team. Consent forms will be stored in a locked research office at the School of Public Health and Health Systems for at least 7 years. All records will be destroyed according to University of Waterloo policy.

Participation and withdrawal

Your participation is completely voluntary. You have the right to choose not to participate or to exit the survey at any time without consequence. If you decide to exit the survey, you will still receive the honoraria. You can withdraw consent to participate and have your data destroyed by contacting us within the minimum 2 years that we will keep identifying information. To withdraw from the study, please contact **Kirsten Lee** using the information provided below. It is not possible to withdraw your consent once papers and publications have been submitted to publishers, after which time, your data cannot be destroyed.

Participation in other studies

At the end of the survey, you will be asked permission to be re-contacted later to participate in a separate study. If you agree to be contacted, your email address will be shared with other researchers who are leading this study.

Project Results

If you are interested in receiving a summary of the results of this research, please provide your email address at the end of the survey. We anticipate that an overview of the results will be available in mid-2019.

Ethics clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

If you have any questions regarding the study, please contact the student investigator, Kirsten Lee, or the faculty supervisor, Dr. Sharon Kirkpatrick, using the information provided. Thank you for your consideration.

Contact Information

Kirsten Lee (project contact)
PhD Student, School of Public Health and Health Systems, University of Waterloo
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Email: **kirsten.lee@uwaterloo.ca**

Dr. Sharon Kirkpatrick
Associate Professor, School of Public Health and Health Systems, University of Waterloo
200 University Ave West
Waterloo, ON N2L 3G1
Email: **sharon.kirkpatrick@uwaterloo.ca**

Consent

By providing your consent, you are not waiving your legal rights or releasing the investigators or involved institutions from their legal and professional responsibilities.

I confirm that I have read the above information about the study titled, “Examining the factors that influence food and beverage purchasing among post-secondary students at campus eateries”. I have had the opportunity to ask questions related to the study and have received satisfactory answers to my questions and any additional details.

I understand that participation is voluntary and I can withdraw this consent by informing the researcher.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

For all other questions, contact **Kirsten Lee** at **kirsten.lee@uwaterloo.ca.**

I agree of my own free will to participate in this study. ☐ YES ☐ NO

Appendix J. Thank you/debriefing email for participants

Study title: Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality

Study investigators: Kirsten Lee (**kirsten.lee@uwaterloo.ca**) and Sharon Kirkpatrick (**sharon.kirkpatrick@uwaterloo.ca**), School of Public Health and Health Systems, University of Waterloo

This study is being conducted as part of Kirsten Lee's PhD thesis.

Dear student,

Thank you for your participation in our research study, "Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality".

In the information letter, we described the project as an opportunity to learn more about post-secondary students' food and beverage purchasing. Students completed an in-person survey following their purchase at a residence cafeteria. Students who chose to participate in the second phase of the study were prompted to complete an online survey asking to recall their meals consumed the day of the initial survey.

However, the primary goal of this study was to understand the impact of different menu labelling formats on food and beverage purchasing among post-secondary students. This study included participation of three residence cafeterias on campus, in which two cafeterias received different calorie labels (i.e., either traffic lights or numbers to indicate calorie information) and one cafeteria did not receive any labelling. We used sales data, survey responses, and dietary intake from the online food and nutrition tool to assess how the labels may have influenced your food and beverage purchasing and decisions.

We did not reveal details regarding the specific purpose of the study because we did not want to influence your responses or actions. If the labels worked well to help make healthier food and beverage choices, we can use this information to provide recommendations on policies related to menu labelling or other labelling-related initiatives aimed at keeping Canadians healthy. The use of partial disclosure will not affect stipulations for receiving honoraria.

Now that the research project has been fully explained, we want to remind your identity will be kept confidential and any personal identifying information will not be shared publicly. The dataset without identifiers may be shared publicly. All information that could identify you will be removed from the data within **1 week** and stored separately. We will keep identifying information for a minimum of 2 years and our study records for a minimum of **7** years. Your consent form will remain stored in a locked research office at the School of Public Health and Health Systems. Only the research team will have access to study data. All records will be destroyed according to University of Waterloo policy.

Your participation is completely voluntary. You have the right to choose not to participate and may withdraw within the minimum 2 years that we will keep identifying information. To withdraw from the study, please contact **Kirsten Lee** using the information provided below. It is not possible to withdraw your consent once papers and publications have been submitted to publishers, after which time, your data cannot be destroyed.

This study, including the use of partial disclosure, has received clearance by the University of Waterloo Research Ethics Committee (ORE # 31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

Please do not hesitate to email us if you have any additional questions. Thank you again for your participation in this study.

Contact Information

Kirsten Lee (project contact)
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Debriefing note/poster for cafeterias

Study title: Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality

Study investigators: Kirsten Lee (**kirsten.lee@uwaterloo.ca**) and Sharon Kirkpatrick (**sharon.kirkpatrick@uwaterloo.ca**), School of Public Health and Health Systems, University of Waterloo

This study is being conducted as part of Kirsten Lee's PhD thesis.

Dear student,

This cafeteria took part in a research study in collaboration with Food Services, titled "Examining the impact of numeric versus traffic light calorie labelling at point-of-purchase on young adults' food and beverage purchases and diet quality".

The primary goal of this study was to understand the impact of different menu labelling formats on food and beverage purchasing among post-secondary students. This study included participation of three residence cafeterias on campus, with two cafeterias receiving calorie labels in different formats (i.e., traffic lights or numbers to indicate calorie information) and one cafeteria not receiving any labelling. We used sales data and responses from the survey to assess how the labels may have influenced students' food and beverage purchasing and decisions. This notice is to make you aware of the use of calorie labels in the past month and that we will be utilizing sales data to understand the influence of the labels on purchasing. Sales data do not contain any identifying information and will be used only to understand trends in total sales and items purchased.

If the labels worked well to help make healthier food and beverage choices, we can use this information to provide recommendations on policies related to menu labelling or other labelling-related initiatives aimed at keeping Canadians healthy. Thank you to the participants who volunteered their time to participate in the survey phases of the study.

This study has received clearance by the University of Waterloo Research Ethics Committee (ORE # 31830). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or **ore-ceo@uwaterloo.ca**.

Please do not hesitate to email us if you have any additional questions. Thank you again for your participation in this study.

Contact Information

Kirsten Lee (project contact)
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Appendix K. Exit survey

Questions have been adapted from the Canada Food Study by Hammond and colleagues, as well as a traffic light labelling study by Olstad and colleagues.

Cluster 0: Eligibility screener, consent, unique identifiers

Thank you for your interest in participating in this study. We will first ask you some questions to determine if you are eligible to participate.

1. Are you a student at the University of Waterloo?

2. To your knowledge, have you participated in this study this week?

3. Did you make a purchase or consume food at the present cafeteria today?

If the student is eligible to participate, the survey will continue to the information letter and consent form. If the student is not eligible to participate, the survey will exit.

*Information letter and consent form (see **Appendix H**)*

4. *(The survey will ask for consent from the participant using the checkbox and statement below)*
    - ☐ I agree of my own free will to participate in the study.

If the student consents to participate, the survey will continue. If the student does not consent to participate, the survey will exit.

Thank you for choosing to participate in our survey! We will first ask some questions about you.

5. What is your day of birth? (1-31)

6. What are your mother's initials? If you don't know your mother's initials, please enter YY. (A-Z) (A-Z)

7. What are your father's initials? If you don't know your father's initials, please enter ZZ. (A-Z) (A-Z)

8. In what city were you born? (XYZ)

Cluster 1: Intervention exposure and most recent purchase

Next, we will ask you questions about the purchase you just made at this cafeteria.

1. At which residence cafeteria did you most recently make a purchase?
    a. Ron Eydt Village (REV)
    b. Village 1 (V1)
    c. UW Place (UWP)/Claudette Millar Hall (CMH)
    d. Don't know
    e. Prefer not to answer

Please consult the research assistant if you are unsure of the name of this residence cafeteria.

2. Which cafeteria would you consider to be your main source for meals on campus?
a. Ron Eydt Village (REV)
b. Village 1 (V1)
c. UW Place (UWP)/Claudette Millar Hall (CMH)

3. How many times have you purchased food or drinks at the following cafeterias in the past week? Please tap and drag the slider circle until you see a number that corresponds with your response for each residence cafeteria.

Each time you paid at the cash register counts as one purchase. If you did not purchase a food or drink at a residence cafeteria, please tap on the slider circle so that you enter '0'.

a. Ron Eydt Village (REV) [Enter number]
b. Village 1 (V1) [Enter number]
c. UW Place (UWP)/Claudette Millar Hall (CMH) [Enter number]

4. How many times have you purchased food or drinks at the following cafeterias in the **past 24 hours?**

Each time you paid at the cash register counts as one purchase.

a. Ron Eydt Village (REV) [Enter number]
b. Village 1 (V1) [Enter number]
c. UW Place (UWP)/Claudette Millar Hall (CMH) [Enter number]

Now we are going to ask you questions about your most recent purchase at {piped text Q1}.

5. Did you purchase an entree? (e.g., hot menu items, sandwiches)
    a. Yes → *move to question 8*
    b. No → *skip to question 9*

6. Please select the phrase/image that best represents your entree (select all that apply).

- ☐ I purchased one of the daily hot meal specials.
- ☐ I purchased a sandwich from the sandwich bar.
- ☐ I purchased a noodle bowl, curry, or pasta from a customizable station.
- ☐ I purchased a pizza, bruschetta, or quesadilla from a customizable station.
- ☐ I purchased a salad as a meal from the salad bar.
- ☐ I purchased a burger from the grill station
- ☐ I purchased one of the 'on-the-go' items from the fridge stations (e.g., boxed sandwiches, sushi sets).
- ☐ Other (please specify): ____

Based on the options selected in question 6, a subset of questions will be asked:

a) (if selecting 'daily hot meal special') Which of the following daily hot meal specials best represents your entrée?
Meal: (dropdown of all meals)
Sides: (dropdown of all sides)
Sides: (dropdown of all sides)

b) (if selecting a 'sandwich from the sandwich bar') Please select all the items you included on your sandwich.
Checkboxes: list of breads, deli meats, vegetables, sauces, cheeses, and add-ons

c) (if selecting a 'noodle bowl, curry, or pasta from a customizable station') Please select all the items you included in your bowl.
Checkboxes: grain, vegetables, meats, sauces, add-ons

d) (if selecting a 'pizza, bruschetta, or quesadilla from a customizable station') Please select all the items you included on your entrée.
Checkboxes: Pizza, bruschetta, or quesadillas
Checkboxes: breading, sauce, cheese, vegetables, meats, add-ons

e) (if selecting 'salad as a meal from the salad bar') Please select all the salads you purchased.
Multi-select list: salad bar options
Please enter the approximate number of scoops for your salad: __

f) (if selecting a 'burger from the grill station') Please select all the items you included on your burger.
Checkboxes: buns, burger meat, vegetables, cheese, sauces, add-ons

g) (if selecting 'on-the-go' items) Please select the items you purchased.
Drilldown question: Sushi, salad, sandwich, yogurt
Drilldown question: type based on above selection
Drilldown question: size (if needed)

h) (using piped text) Please provide approximate serving sizes (e.g., scoops) for each of your entrees.

How much of the [item] did you consume?

a. I ate the entire item.
b. I ate about three-quarters of the item.
c. I ate about half of the item.
d. I ate about one-quarter of the item.
e. I did not eat the item.
f. Don't know
g. Prefer not to answer

Please estimate the number of calories for your meal if you were to consume the entire [item].

a. Enter amount _____
b. Don't know
c. Prefer not to answer

7. Did you purchase a beverage?
    a. Yes → *move to question 10*
    b. No → *skip to question 11*

8. Please select the phrase/image that <u>best represents</u> your beverage (select all that apply).
    - ☐ Water
    - ☐ Juice
    - ☐ Pop
    - ☐ Milk
    - ☐ Sports drink
    - ☐ Other (please specify): ____

Based on the options selected in question 8, a subset of questions will be asked:

a) (for each option) Please respond to the following list of dropdown questions.
Drilldown questions: brands, type of drink, size

How much of the [item] did you consume?

a. I ate the entire item.
b. I ate about three-quarters of the item.
c. I ate about half of the item.
d. I ate about one-quarter of the item.
e. I did not eat the item.
f. Don't know
g. Prefer not to answer

Please estimate the number of calories for your meal if you were to consume the entire [item].

a. Enter amount _____
b. Don't know

c. Prefer not to answer

9. Did you purchase a snack?
    a. Yes → *move to question 12*
    b. No → *skip to question 13*

10. Please select the phrase/image that best represents your snack (select all that apply).
    - ☐ Chips
    - ☐ Bakery items (e.g., cookies, squares, muffins, croissants)
    - ☐ Fruit (fresh)
    - ☐ Vegetable cup (fresh)
    - ☐ Chocolate and/or candy/gum
    - ☐ Yogurt
    - ☐ Ice cream
    - ☐ Crackers and dip
    - ☐ Nuts and/or trail mix
    - ☐ Other (please specify): ___

Based on the options selected in question 8, a subset of questions will be asked:

a) (for each option) Please respond to the following list of dropdown questions.
Drilldown questions: brands, type of drink, size

How much of the [item] did you consume?
    a. I ate the entire item.
    b. I ate about three-quarters of the item.
    c. I ate about half of the item.
    d. I ate about one-quarter of the item.
    e. I did not eat the item.
    f. Don't know
    g. Prefer not to answer

Please estimate the number of calories for your meal if you were to consume the entire [item].
    a. Enter amount _____
    b. Don't know
    c. Prefer not to answer

11. Did you purchase anything else that you did not already report?
    a. Yes (please specify): ___
    b. No
    (if yes) Please provide approximate serving sizes (e.g., scoops) for each of this item.

12. Estimate the number of calories for all the food and drinks you just purchased: ___
    a. Don't know
    b. Prefer not to answer

13. How much did you pay for your purchase?

a. Enter amount ___
b. Don’t know
c. Prefer not to answer

Cluster 2: Intervention-related questions (noticing/influence use)
The next questions are about the ***purchase you just told us about*** *and your experience making this purchase at {insert piped text from Q1}.*

14. Did you notice any nutrition information posted in this residence cafeteria when you made your purchase?
    a. Yes → **move to question 15**
    b. No → **skip to cluster 4**
    c. Don’t know
    d. Prefer not to answer

15. When did you first notice this nutrition information?
    a. Today was my first time noticing the nutrition information
    b. In the last 7 days
    c. In the last 2 weeks
    d. In the last 3 weeks
    e. In the last month
    f. More than a month ago
    g. Don’t know
    h. Prefer not to answer

16. Where was the nutrition information located? (select all that apply)
    a. On the menu board or a poster/sign
    b. Next to an item or on an item card/label
    c. Other (please specify): ______
    d. Don’t know
    e. Prefer not to answer

[PROGRAMMING NOTE: Using display logic/blocks in Qualtrics, a variation of cluster 3 will appear based on the option selected in question 16. This helps us to know how the use/influence/perceptions questions are linked to the labels that they saw. If participant chooses all the above, the survey will ask them to specify what the nutrition information looked like and what it conveyed (i.e., q17 and q18) for each location and then they will be asked to select an option. The remainder of the questions will be asked for their chosen option. Most likely, they will say that the format was the same for both, and there will only be a slight loss of data in the scenario that they see different formats for both locations.]

Cluster 3: Intervention-related questions (influence/use/perceptions)
[PROGRAMMING NOTE: Sample text for options based on selection for Q17]

You indicated that you noticed nutrition information [response to Q16]. Please answer the following questions based on the nutrition information that you saw [response to Q16].

17. What did the nutrition information include? (choose the best response)
    a. Symbols and numbers (e.g., colours using red, amber, and green)
    b. Numbers
    c. Other (please specify): _____
    d. Don't know
    e. Prefer not to answer

18. For your response above, what did the *{piped text Q17}* convey? (please select all that apply)
    - ☐ Amount of calories
    - ☐ Amount of fat
    - ☐ Amount of carbohydrates
    - ☐ Amount of sugar
    - ☐ Amount of sodium
    - ☐ Other (please specify): ______
    - ☐ Don't know
    - ☐ Prefer not to answer

Please answer the following for the {piped text Q17} that you noticed on the [response to Q16].

19. Did you use the nutrition information to help you make your purchase today?
    a. Not at all → **skip to question 21**
    b. A little → **display question 20**
    c. A lot → **display question 20**
    d. Don't know
    e. Prefer not to answer

20. **[PROGRAMMING NOTE: Only displayed if answered b or c to Q19]** How did you use the nutrition information to help make your purchase today?
    - ☐ I used the *{piped text Q16}* to help me identify foods that were healthy versus unhealthy.
    - ☐ I used the *{piped text Q16}* to help me identify foods that had less calories versus more calories.
    - ☐ Other (please specify): __
    - ☐ Don't know
    - ☐ Prefer not to answer

21. **<u>In the past week,</u>** how often did the nutrition information influence your food and beverage purchases?
    a. For all of my purchases
    b. For most of my purchases
    c. For some of my purchases
    d. For none of my purchases
    e. Don't know
    f. Prefer not to answer

Please answer the following questions for the {piped text Q17} that you noticed on the [answer from question 16].

22. How easy or hard was it to **understand** the nutrition information?
    a. Agree
    b. Neither agree nor disagree
    c. Disagree
    d. Strongly disagree
    e. Don't know
    f. Prefer not to answer

23. How easy or hard was it to **use** the nutrition information?
    a. Agree
    b. Neither agree nor disagree
    c. Disagree
    d. Strongly disagree
    e. Don't know
    f. Prefer not to answer

24. Overall, did the nutrition information make you feel …
    a. Less in control of making healthy eating decisions
    b. Neither less nor more in control
    c. More in control of making healthy eating decisions
    d. Don't know
    e. Prefer not to answer

25. For your most recent purchase, have you done any of the following due to the nutrition information [*answer from question 16*]? (Select all that apply)
    a. Ordered something different
    b. Ate less of the food ordered
    c. Chose to eat somewhere else
    d. Ate at that location less often
    e. Other (please specify): _____
    f. None of the above
    g. Don't know
    h. Prefer not to answer

Cluster 4: Understanding/general perceptions/general purchasing

*The following questions are related to **ANY** food or beverage purchases that you make in settings away from home, such as restaurants, cafeterias, and fast-food chains.*

26. Please rank the factors below from the **highest to lowest influence on your** food and beverage choices. You may drag the options.
    a. Price

b. Taste
c. Nutrition information
d. Convenience
e. Dietary restrictions
f. Other (please specify): ___
g. Don't know
h. Prefer not to answer

[PROGRAMMING NOTE: Movable options]

27. In the past week, how often does **<u>nutrition information on menus (e.g., calorie labels)</u>** influence the food or beverages you choose to eat in a cafeteria, restaurant or fast food chain setting?
    a. All the time
    b. Most of the time
    c. Some of the time
    d. Never
    e. Don't know
    f. Prefer not to answer

28. When you eat in a cafeteria, restaurant or fast food chain setting, what nutrition information would you most like to see on a menu? (select all that apply)
    - ☐ No nutrition information
    - ☐ The number of calories for each menu item
    - ☐ A symbol to summarize nutrition information for each menu item
    - ☐ The number of calories for each menu item **AND** a symbol to summarize nutrition information for each menu item
    - ☐ Other (please specify): ____
    - ☐ Don't know
    - ☐ Prefer not to answer

Cluster 5: Indicators (health literacy, body esteem and disordered eating behaviours)

[PROGRAMMING NOTE: The following are indicators of health literacy from the Newest Vital Sign: The participant will be shown a Nutrition Facts Table from a pint of ice cream and be prompted to answer the following questions.]

Next, we are going to show you the back of a container of a pint of ice cream. Please use the image to help answer the next set of questions.

29. If you eat the entire container, how many calories will you eat? (enter number of calories) ______

30. If you are allowed to eat 60 grams of carbohydrates as a snack, how much ice cream could you have? (enter number of cups) _____

31. 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 consuming each day? (enter number of grams) ____

32. Pretend that you are allergic to the following substances: penicillin, peanuts, latex gloves, bee stings. Is it safe for you to eat this ice cream? (yes/no) – follow up with why

33. 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? (enter value) _____

Almost done! We have a few questions about your perceptions of your body and eating habits. Please answer the questions to the best of your ability.

34. Which of these statements best describes you currently?
    a. I am trying to limit my calorie intake
    b. I am trying to maintain my calorie intake
    c. I am trying to increase my calorie intake
    d. I am not interested in changing my calorie intake
    e. Other (please specify): __
    f. Don't know
    g. Prefer not to answer

35. During the past 12 months, have you tried to…. (Select all that apply)
    a. Lose weight
    b. Gain weight
    c. Stay the same weight
    d. I have not tried to do anything about my weight
    e. Don't know
    f. Prefer not to answer

[**PROGRAMMING NOTE: The following are questions from SCOFF]**

36. Would you say that food dominates your life?
    a. Yes
    b. No
    c. Don't know
    d. Prefer not to answer

37. Do you worry that you have lost control over how much you eat?
    a. Yes
    b. No
    c. Don't know
    d. Prefer not to answer

38. Do you make yourself sick (vomit) because you feel uncomfortably full?
    a. Yes
    b. No
    c. Don't know
    d. Prefer not to answer

39. Have you recently lost more than 15 pounds (6.8 kg) in a 3-month period?
    a. Yes
    b. No
    c. Don't know
    d. Prefer not to answer

40. Do you believe yourself to be fat when others say you are thin?
    a. Yes
    b. No
    c. Don't know
    d. Prefer not to answer

Cluster 6: Demographics

To finish, the following questions are about you.

41. What is your year of birth? (starting from 2003 – 16 years of age min)

42. What sex were you assigned at birth, meaning on your original birth certificate?
    a. Female
    b. Male

43. What is your current gender identity?
    a. Woman
    b. Man
    c. Trans male/trans man
    d. Trans female/trans woman
    e. Gender queer/gender non-conforming
    f. Different identity (please specify): ______
    g. Don't know
    h. Prefer not to answer

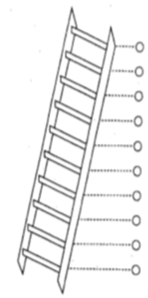
44. People living in Canada come from many different cultural and racial backgrounds. Are you...
    a. White
    b. Chinese
    c. South Asian (e.g., East Indian, Pakistani, Sri Lankan)
    d. Black
    e. Filipino
    f. Latin American

g. Southeast Asian (e.g., Cambodian, Indonesian, Laotian,
h. Vietnamese)
i. Arab
j. West Asian (e.g., Afghan, Iranian)
k. Japanese
l. Korean
m. Other (please specify): __
n. Don't know
o. Refuse to answer

45. What is your program of study?
    a. Applied Health Sciences
    b. Arts and Business
    c. Environment
    d. Engineering
    e. Math and Computing Sciences
    f. Science
    g. Other
    h. Prefer not to answer
46. What is your year of study?
    a. First year (1A/1B terms)
    b. Second year (2A/2B terms)
    c. Third year (3A/3B terms)
    d. Fourth year (4A/4B terms)
    e. Beyond fourth year (Beyond 4B term)
    f. Don't know
    g. Prefer not to answer

47. This next question is about your parents. By parents ("mother", or "father"), we mean whome ver you consider to be your parents/guardians. This can be your birth parents, adoptive parents, step-parents, foster parents, or legal guardians. Using this definition, please indicate the highest level of education that was completed amongst your mother and/or father?
    a. No post-secondary degree, certificate or diploma
    b. Trade certificate or diploma from a vocational school or apprenticeship training
    c. Non-university certificate or diploma from a community college, Collège d'enseignement général et professionnel (CEGEP), school of nursing, etc.
    d. University certificate below bachelor's level
    e. Bachelor's degree
    f. University degree or certificate above bachelor's degree
    g. Don't know
    h. Prefer not to answer

48. Think of this scale as representing where people stand in society.



- At the top of the ladder are the people who are best off – who have the most money, the most education and the best jobs.
- At the bottom of the ladder are people who are worst off – who have the least money, least education and the worst jobs or no job.

The higher up you are on this ladder, the closer you are to people at the very top and the lower you are, the closer you are to the bottom.

Where would you put yourself on the ladder?

a. *Scale from 1-10*
b. Don't know
c. Prefer not to answer

Cluster 7: Participation

We would like to email you tomorrow to participate in the second phase of this study.

49. Please enter your email address. We will use this email address to communicate with you after the study is complete. ____
50. Are you interested in being contacted to participate in similar studies?
    ☐ Yes, I am interested in being contacted to participate in similar studies.
    ☐ No, I am not interested in being contacted to participate in similar studies.

Thank you! Your response has been submitted.

Appendix L. Foods and beverages by category

<table>
<tr><th>Category</th><th>Description of food at cafeterias</th></tr>
<tr><td>Meal</td><td>Hot meal station (all cafeterias)
Daily rotating entrée, cafeterias were offset each week.
Sides at all cafeterias included rice, potatoes, and mixed vegetables.
Customizable sandwich station (all cafeterias)
Included add-ons for: bread, vegetables, protein, cheese, sauces.
Customizable bowl station (all cafeterias)
Included add-ons for: ‘grain’ of choice (e.g., pasta, rice, whole grain options available), vegetables, protein, cheese, sauces.
Customizable pizza station (all cafeterias)
Included add-ons for: type of breading, protein, cheese, vegetables, sauces/spices.
Grill (all cafeterias)
Included options for burgers, chicken fingers, pulled pork, hot dogs, French fries.
Burgers had add-ons, including: breading, protein, cheese, vegetables, sauces.
Salad bar (all cafeterias)
Options for were pre-made salads, customizable salads or soup.
Add-ons for salad included: vegetables, protein, sauces.
Grab-and-go station (all cafeterias)
Standard set of pre-packaged sandwiches, sushi trays, and salad containers.
Dressings were counted as an add-on for pre-packaged salads.</td></tr>
<tr><td>Beverage</td><td>Included all juices/iced teas, sodas, milks, and water bottles sold in fridges.
Drinks from self-serve stations for juices and pops were included.
Hot coffee/tea were also included as a beverage, with add-ons for sugar and milk available.
All beverages were standardized in offerings and sizes across all cafeterias.</td></tr>
<tr><td>Snacks</td><td>All pre-packaged snacks were standardized across cafeterias, including, chips, candy, chocolate bars granola bars and snack-sized cereal cups.
Pre-packaged yogurt and yogurt parfaits were included. Customizable yogurt salad bowls from the salad bar were coded as snacks for consistency.</td></tr>
</table>

	• Pre-packaged snacks served in the grab-and-go fridges were included (e.g., fruit cups). • Bakery items (e.g., cookies/cakes) made by the on-campus food services team was also standardized across sites, though some daily variation is possible. • Whole pieces of fruit and vegetables (e.g., from salad bar) were included as snacks for consistency with fruits cups. • The snacks described above were standardized in offerings and sizes across all cafeterias. • Smoothies were categorized as a snack given the multiple components used to comprise a smoothie. The traffic light labelling site had a branded smoothie outlet.

Appendix M. Supplementary data for Chapter 6

Table M-1. Model output for site, phase, and their interaction for outcomes related to noticing and use of nutrition information (N=1799 respondents; pre=854, post=945)

	Estimate	Standard error	95% CI	p-value
Noticing of nutrition information				
Phase				
Post-test vs. pre-test	-0.17	0.22	-0.59-0.26	0.44
Site				
Numeric vs. control	0.26	0.22	-0.17-0.68	0.24
Traffic light vs. control	0.55	0.21	0.14-0.96	0.01
Phase*site				
Post-test*numeric	1.14	0.28	0.59-1.70	<0.001*
Post-test*traffic light	1.64	0.28	1.08-2.19	<0.001*
Noticing calorie information				
Phase				
Post-test vs. pre-test	-0.06	0.26	-0.58-0.45	0.81
Site				
Numeric vs. control	0.31	0.25	-0.19-0.80	0.23
Traffic light vs. control	0.78	0.24	0.32-1.26	<0.001*
Phase*site				
Post-test*numeric	1.11	0.33	0.46-1.76	<0.001*
Post-test*traffic light	1.28	0.32	0.65-1.91	<0.001*
Strategies for use: Select items with fewer calories				
Phase				
Post-test vs. pre-test	0.23	0.54	-0.81-1.28	0.66
Site				
Numeric vs. control	0.65	0.51	-0.35-1.64	0.20
Traffic light vs. control	1.01	0.48	0.06-1.97	0.04*
Phase*site				
Post-test*numeric	0.91	0.63	-0.32-2.14	0.15
Post-test*traffic light	1.09	0.61	-0.09-2.28	0.07*
Strategies for use: Select items healthier items				
Phase				
Post-test vs. pre-test	-0.31	0.35	-0.99-0.36	0.37
Site				
Numeric vs. control	0.11	0.31	-0.50-0.72	0.72
Traffic light vs. control	-0.04	0.32	-0.67-1.40	0.91
Phase*site				
Post-test*numeric	0.55	0.44	-0.31-1.40	0.21
Post-test*traffic light	1.71	0.43	0.86-2.55	<0.001*

Behavioural response: Ordered something different				
Phase				
Post-test vs. pre-test	-0.22	0.35	-0.91-0.47	0.54
Site				
Numeric vs. control	0.03	0.34	-0.64-0.69	0.94
Traffic light vs. control	0.24	0.33	-0.41-0.88	0.47
Phase*site				
Post-test*numeric	0.81	0.46	-0.09-1.70	0.08
Post-test*traffic light	1.41	0.43	0.57-2.50	0.001*
Strategies for use: Ate less food				
Phase				
Post-test vs. pre-test	-0.49	0.50	-1.48-0.49	0.33
Site				
Numeric vs. control	0.25	0.42	-0.57-1.08	0.55
Traffic light vs. control	0.08	0.45	-0.81-0.97	0.86
Phase*site				
Post-test*numeric	1.50	0.60	0.33-2.67	0.01*
Post-test*traffic light	2.06	0.61	0.87-3.26	0.05

[1]Significance level of p<0.05 reported and significant p-values are indicated using an asterisk (*).
[2]All models were adjusted for a standard set of covariates. Model output for covariates was not included for ease of interpretability.
[3]Output for noticing and use was derived using generalized estimating equation models.

Table M-2. Model output for site, phase, and their interaction for outcomes related to calories purchased (N=1698 respondents; pre=828, post=870)

	Estimate	Standard error	95% CI	p-value
Calories purchased overall				
Phase				
Post-test vs. pre-test	-183.0	59.7	-299.9	0.002*
Site				
Numeric vs. control	-103.0	63.9	-228.4-22.3	0.11
Traffic light vs. control	-98.4	60.7	-217.5-20.7	0.11
Phase*site				
Post-test*numeric	60.8	80.1	-96.2-217.8	0.45
Post-test*traffic light	186.6	77.9	33.8-339.5	0.02*
Calories purchased by entrées				
Phase				
Post-test vs. pre-test	-144.2	67.7	-276.9-11.5	0.03*
Site				
Numeric vs. control	-135.7	68.7	-270.5-1.00	0.05
Traffic light vs. control	-154.8	65.8	-283- -25.8	0.02*
Phase*site				
Post-test*numeric	91.7	90.6	-95.8-269.2	0.31
Post-test*traffic light	186.8	88.1	14.2-359.4	0.03*
Calories purchased by beverages				
Phase				
Post-test vs. pre-test	-28.7	9.81	-47.9- -9.43	0.003*
Site				
Numeric vs. control	6.82	11.6	-15.8-29.5	0.56
Traffic light vs. control	-8.04	13.9	-35.4-19.3	0.56
Phase*site				
Post-test*numeric	22.3	15.5	-35.4-19.3	0.56
Post-test*traffic light	26.9	17.1	-6.58-60.4	0.12
Calories purchased by snacks				
Phase				
Post-test vs. pre-test	-45.8	24.5	-93.7-2.20	0.06
Site				
Numeric vs. control	6.72	28.4	-48.8-62.3	0.81
Traffic light vs. control	56.2	27.1	3.08-109.4	0.04*
Phase*site				
Post-test*numeric	-19.1	34.2	-86.2-48.0	0.58
Post-test*traffic light	45.9	36.5	-25.8-117.3	0.21

[1]Significance level of $p<0.05$ reported and significant p-values are indicated using an asterisk (*).
[2]All models were adjusted for a standard set of covariates. Model output for covariates was not included for ease of interpretability.
[3]Output for calories purchased was derived using generalized estimating equation models.

Table M-3. Number and proportion of participants noticing and using nutrition information by subgroups for gender, health literacy, subjective social status, and disordered eating risk (N=590 respondents; pre=195, post=358)

	Control		**Numeric**		**Traffic light**	
	Pre-test (n=47)	**Post-test (n=49)**	**Pre-test (n=67)**	**Post-test (n=135)**	**Pre-test (n=81)**	**Post-test (n=170)**
Noticing of nutrition information						
Gender n(%)						
Man	28 (59.6)	27 (56.3)	33 (50.0)	68 (50.8)	45 (55.5)	87 (51.2)
Woman	19 (40.4)	21 (43.8)	33 (50.0)	66 (49.3)	36 (44.4)	83 (48.8)
Health literacy (NVS)[1] n(%)						
High likelihood of limited literacy (0-1)	14 (29.8)	15 (30.6)	18 (26.9)	37 (27.4)	25 (30.9)	38 (21.8)
Low likelihood of limited literacy (2-3)	11 (23.4)	14 (28.6)	22 (32.8)	34 (25.2)	20 (24.7)	46 (26.4)
Adequate (4-6)	22 (46.8)	20 (40.8)	27 (40.3)	64 (47.4)	37 (44.4)	90 (51.7)
Subjective social status[2] M (SD)	4.32 (1.55)	4.45 (1.56)	4.47 (1.76)	4.49 (1.68)	4.75 (1.78)	4.75 (1.67)
Disordered eating risk (SCOFF)[3] n(%)						
Unlikely disordered eating (0-1)	31 (65.8)	33 67.4)	43 (64.2)	96 (71.1)	59 (72.8)	131 (69.5)
Likely disordered eating (2-5)	16 (34.0)	16 (32.7)	24 (35.8)	39 (28.9)	22 (27.2)	53 (30.5)
Using nutrition information						
Gender n(%)						
Man	11 (47.8)	12 (50.0)	19 (57.6)	32 (48.5)	20 (55.6)	54 (49.9)
Woman	12 (52.2)	12 (50.0)	14 (42.4)	34 (51.5)	16 (44.4)	56 (50.9)
Health literacy (NVS)[1] n(%)						
High likelihood of limited literacy (0-1)	6 (26.1)	6 (25.0)	7 (20.6)	17 (25.8)	12 (33.3)	26 (23.2)
Low likelihood of limited literacy (2-3)	6 (26.1)	9 (37.5)	14 (41.2)	17 (25.8)	6 (16.7)	26 (23.2)
Adequate (4-6)	11 (47.8)	9 (37.5)	13 (38.3)	23 (48.5)	18 (50.0)	60 (53.6)
Subjective social status[2] M (SD)	4.30 (1.72)	4.46 (1.61)	4.43 (1.74)	4.39 (1.74)	4.66 (1.71)	4.77 (1.75)
Disordered eating risk[3] **(SCOFF)** n(%)						
Unlikely disordered eating (0-1)	13 (56.5)	16 (66.7)	20 (58.8)	45 (68.2)	25 (69.4)	75 (67.9)
Likely disordered eating (2-5)	10 (43.5)	8 (33.3)	14 (41.2)	21 (31.8)	11 (30.6)	37 (33.0)

[1]Health literacy was assessed using the Newest Vital Sign (4-6=adequate; 2-3=low likelihood of limited literacy; 0-1=high likelihood of limited literacy).
[2]Subjective social status was used as an indicator for socioeconomic status. Participants rank their perceived social status on a 10-point scale (1=high; 10=low).
[3]Disordered eating risk was assessed using SCOFF, a 5-item questionnaire for eating disorder symptomology among non-clinical populations. (0-1=unlikely; 2+=likely at risk).

Appendix N. Supplementary data for Chapter 7

Table N-1. Model output for site, phase, and their interaction for food and beverage purchasing by TLL categories (N=1698 respondents; pre=828, post=871)

	Estimate	Standard error	95% CI	p-value
Green-labelled foods and beverages purchased				
Phase				
Post-test vs. pre-test	-0.2	0.14	-0.48-0.07	0.14
Site				
Numeric vs. control	-0.03	0.14	-0.31-0.25	0.86
Traffic light vs. control	-0.022	0.14	-0.29-0.25	0.87
Phase*site				
Post-test*numeric	-0.18	0.18	-0.54-0.18	0.34
Post-test*traffic light	-0.04	0.19	-0.41-0.33	0.34
Amber-labelled foods and beverages purchased				
Phase				
Post-test vs. pre-test	-0.20	0.07	-0.33- -0.07	0.003*
Site				
Numeric vs. control	-0.16	0.07	-0.30- -0.03	0.02*
Traffic light vs. control	-0.27	-0.07	-0.40	<0.001*
Phase*site				
Post-test*numeric	0.21	0.09	0.03-0.4	0.02*
Post-test*traffic light	0.26	0.09	0.09-0.43	0.002*
Red-labelled foods and beverages purchased				
Phase				
Post-test vs. pre-test	-0.11	0.05	-0.21- -0.01	0.04*
Site				
Numeric vs. control	-0.10	0.05	-0.21-0.00	0.05
Traffic light vs. control	0.00	0.05	-0.11-0.23	0.25
Phase*site				
Post-test*numeric	0.09	0.08	-0.06-0.23	0.25
Post-test*traffic light	0.11	0.08	-0.04-0.26	0.14

[1]Significance level of $p<0.05$ reported and significant p-values are indicated using an asterisk (*).
[2]All models were adjusted for a standard set of covariates. Model output for covariates was not included for ease of interpretability.
[3]Output for foods and beverages purchased by TLL categories was derived using generalized estimating equation models.
[4]Scores of green-, amber-, and red-labelled items were calculated using a proportional weighting and scoring system. Weights were calculated based on the proportion of green-, amber-, and red-labelled add-ons relative to the total number of add-ons in the full entrée. For example, a customizable sandwich with 5 green-labelled add-ons, 3 amber-labelled add-ons, and 2 red-labelled add-ons would receive a score of 0.5 for green, 0.3 for amber, and 0.2 for red. Similarly, a lasagna with 1 amber indicator would receive a score of 1 for the amber category and 0 for green and red categories.

Table N-2. Model output for site, phase, and their interaction for food and beverage purchasing by food groups and nutrients (N=1698 respondents; pre=828, post=871)

	Estimate	Standard error	95% CI	p-value
Fruits (cup equivalents)[5]				
Phase				
Post-test vs. pre-test	0.17	0.19	-0.20-0.54	0.37
Site				
Numeric vs. control	0.04	0.19	-0.32-0.41	0.82
Traffic light vs. control	-0.03	0.16	-0.34-0.29	0.87
Phase*site				
Post-test*numeric	-0.09	0.29	-0.66-0.48	0.76
Post-test*traffic light	-0.11	0.27	-0.63-0.42	0.69
Vegetables (cup equivalents)[5]				
Phase				
Post-test vs. pre-test	0.11	0.19	-0.26-0.47	0.56
Site				
Numeric vs. control	0.44	0.22	0.00-0.99	0.05
Traffic light vs. control	0.62	0.20	0.22-1.00	0.01*
Phase*site				
Post-test*numeric	-0.01	0.29	-0.58-0.56	0.96
Post-test*traffic light	-0.42	0,28	-0.96-0.12	0.13
Whole grains (oz equivalents)[5]				
Phase				
Post-test vs. pre-test	0.12	0.14	-0.14-0.39	0.37
Site				
Numeric vs. control	-0.19	0.10	-0.38-0.03	0.08
Traffic light vs. control	-0.27	0.10	-0.46- -0.08	<0.001*
Phase*site				
Post-test*numeric	-0.07	0.16	-0.39-0.24	0.65
Post-test*traffic light	0.12	0.16	0.20-0.44	0.47
Refined grains (oz equivalents)[5]				
Phase				
Post-test vs. pre-test	0.55	0.29	-0.01-1.11	0.06
Site				
Numeric vs. control	0.19	0.28	-0.35-0.74	0.49
Traffic light vs. control	0.39	0.28	-0.16-0.94	0.16
Phase*site				
Post-test*numeric	-0.75	0.05	-0.17-0.02	0.13
Post-test*traffic light	-1.07	0.39	-1.82- -0.31	<0.001*
Plant-based proteins (oz equivalents)[5]				
Phase				
Post-test vs. pre-test	0.05	0.12	-0.18-0.28	0.66
Site				
Numeric vs. control	-0.12	0.10	-0.32-0.07	0.21
Traffic light vs. control	0.06	0.11	-0.16-0.28	0.59
Phase*site				
Post-test*numeric	-0.11	0.13	-0.38-0.15	0.41

Post-test*traffic light	0.03	0.19	-0.32-0.37	0.88
Red meats (oz equivalents)[5]				
Phase				
Post-test vs. pre-test	-0.15	0.14	-0.45-0.14	0.31
Site				
Numeric vs. control	0.12	0.16	-0.19-0.44	0.45
Traffic light vs. control	0.14	0.16	-0.18-0.46	0.41
Phase*site				
Post-test*numeric	0.03	0.21	-0.37-0.43	0.88
Post-test*traffic light	0.42	0.25	-0.06-0.90	0.09
Saturated fat (g)[6]				
Phase				
Post-test vs. pre-test	0.58	0.86	-1.11-2.27	0.50
Site				
Numeric vs. control	1.31	1.26	-1.16-3.79	0.29
Traffic light vs. control	1.82	0.99	-0.12-3.76	0.07
Phase*site				
Post-test*numeric	0.04	1.64	-3.17-3.25	0.98
Post-test*traffic light	-2.10	1.28	-4.61-0.41	0.10
Sodium (g)[5]				
Phase				
Post-test vs. pre-test	-2.27	1.67	-4.56-0.02	0.05
Site				
Numeric vs. control	-2.78	1.31	-5.33-0.22	0.03*
Traffic light vs. control	-3.11	1.33	-5.71-0.50	0.02*
Phase*site				
Post-test*numeric	4.71	1.91	0.97-8.44	0.01*
Post-test*traffic light	2.70	1.76	-0.76-6.16	0.13
Added sugars (tsp equivalents)[6]				
Phase				
Post-test vs. pre-test	-2.27	1.17	-4.56-0.02	0.05
Site				
Numeric vs. control	-2.78	1.30	-5.33-0.22	0.03*
Traffic light vs. control	-3.10	1.32	-5.71- -0.50	0.02*
Phase*site				
Post-test*numeric	4.71	1.91	0.97-6.15	0.13
Post-test*traffic light	2.69	1.76	-0.76-0.15	0.13

[1]Significance level of $p<0.05$ reported and significant p-values are indicated using an asterisk (*).
[2]All models were adjusted for a standard set of covariates. Model output for covariates was not included for ease of interpretability.
[3]Output for foods and beverages purchased was derived using generalized estimating equation models.
[4]Nutrient density ratios were calculated by dividing the amount of food groups and nutrients for foods and beverages per individual by the total number of calories. All ratios were multiplied by 1000 kcal to aid interpretability.
[5]Amounts in cup, ounce, or teaspoon equivalents provided in the 2017-2018 Food Patterns Equivalents Database.
[6]Amounts in cup, ounce, or teaspoon equivalents provided in the 2017-2018 Food and Nutrient Database for Dietary Studies.