Smartphones for Smart Eating: Evaluating the Effectiveness of Smartphone Applications on Improving Adolescent Food Knowledge

Heather A. Jantzi, The University of Western Ontario

Supervisor: Gilliland, Jason A., The University of Western Ontario
A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Geography and Environment
© Heather A. Jantzi 2023

Follow this and additional works at: https://ir.lib.uwo.ca/etd

Part of the Human Geography Commons, and the Nutrition Commons

Recommended Citation
https://ir.lib.uwo.ca/etd/9683

This Dissertation/Thesis is brought to you for free and open access by Scholarship@Western. It has been accepted for inclusion in Electronic Thesis and Dissertation Repository by an authorized administrator of Scholarship@Western. For more information, please contact wlswadmin@uwo.ca.
Abstract

Many Canadian adolescents have unhealthy eating habits which are risk factors for developing chronic diseases later in life. Food literacy plays a role in healthy eating habits but teens in Ontario currently lack sufficient nutrition education learning opportunities in home and school environments. Across health research, smartphones have been utilized as a novel medium to promote learning and alter behaviour. This thesis seeks to understand the effectiveness of smartphone applications at improving food knowledge in adolescents through (i) a systematic review of published interventions, and (ii) by investigating the efficacy of a novel location-based smartphone application. Findings from this thesis may be helpful for policy makers and educators when addressing food literacy in youth, as well as for health researchers aiming to incorporate smartphone technology into behaviour change interventions.

Keywords

Adolescent, Engagement, Food Knowledge, Food Literacy, Geography, Smartphone Application
Summary for Lay Audience

Teens have patterns of unhealthy eating such as lower intakes of fruits and vegetables, higher intakes of high fat and salty snacks, and higher intakes of sugary beverages. Food knowledge refers to the information that individuals have about various aspects of foods, including nutritional information, sources of food, and food safety. Improving food knowledge is essential for teens to make informed food choices as they develop habits that will last into adulthood. Smartphones are popular among this population and are a promising platform to promote food knowledge learning. The goal of this research was to investigate the use of smartphone applications for improving food knowledge in adolescents.

In a review of similar studies, there were mixed findings for the effects of food knowledge on adolescent food knowledge improvements. Some studies reported no change in food knowledge while using a smartphone application, but other researchers found improvements in food knowledge when the application was paired with in-person instruction. Many studies lacked appropriate measurement tools to comprehensively assess food knowledge. The applications in these studies included a variety of theoretical foundations and features, but there was no pattern of features that predicted improved food knowledge. This research also investigated the effectiveness of a GPS-enabled smartphone application, called “SmartAPPetite”, on adolescent food knowledge in London, Ontario. There was no improvement in food knowledge between participants who used the application and those who did not, but an improvement in food knowledge over time was seen among those who engaged highly with the application. Engagement is a key predictor for food knowledge improvements using a smartphone application and future research should explore ways to increase user engagement. Findings from this thesis may be helpful for implementing nutrition education programming and can be used in future research that explores the use of smartphone devices for improving health behaviours.
Co-Authorship Statement

Each integrated article in this thesis will be submitted for publication in a peer-reviewed journal. In Chapter 2, Heather Jantzi performed the data search, data extraction, the data synthesis and is the primary author for this chapter. Holly Schaafsma assisted with data searching and extraction. Dr. Louise McEachern and Dr. Jason Gilliland provided edits for this work.

In Chapter 3, Heather Jantzi was the primary author with input and editing provided by Dr. Jason Gilliland and Dr. Louise McEachern. Data was extracted and organized with the support of Dr. Louise McEachern and Alexander Wray. Dr. Jamie Seabrook assisted with the statistical analysis in this chapter.
Acknowledgments

This thesis could not have been completed without the help of the team of the Human Environments Analysis Laboratory. I would like to thank Dr. Jason Gilliland for supervising this work and providing guidance through my graduate studies journey. You provided me with an opportunity during a pivotal change in my career path and for that I am grateful. Thank you to Dr. Louise McEachern for managing the large SmartAPPetite project; this work could not have been done without your help extracting data, reviewing my writing, and engaging in thoughtful discussions with me. A special acknowledgement goes to AJ Wray for retrieving and cleaning the app analytics data (that required computer competencies beyond my comprehension)! Thank you, Dr. Jamie Seabrook, for guiding me through analyzing this data.

To my colleagues on the SmartAPPetite team - Holly, Olivia, and Nick – thank you for providing peer mentorship through graduate studies and balancing SmartAPPetite work with much needed social boosts! Thank you to the other HEAL lab members who I built friendships with; you all made going back to school the fun part, even during COVID-19 restrictions.

A special thanks goes to my husband for supporting my goals and aspirations throughout my ‘second wind’. Thank you for endlessly reminding me: “You didn’t come this far, to only come this far.”
# Table of Contents

Abstract .................................................................................................................................................. ii

Keywords ............................................................................................................................................... ii

Summary for Lay Audience ................................................................................................................... iii

Co-Authorship Statement ....................................................................................................................... iv

Acknowledgments ................................................................................................................................. v

Table of Contents ................................................................................................................................. vi

List of Tables .......................................................................................................................................... x

List of Figures .......................................................................................................................................... xi

List of Appendices ................................................................................................................................... xii

Chapter 1 ............................................................................................................................................... 1

1 Introduction ........................................................................................................................................ 1

1.1 The SmartAPPetite for Youth Study ............................................................................................... 2

1.2 Research Questions and Objectives ............................................................................................... 3

1.3 Research Context ............................................................................................................................. 4

1.3.1 Canadian Adolescent Health and Food Knowledge ................................................................. 4

1.3.2 History of Adolescent Food Knowledge Education ................................................................. 6

1.3.3 Smartphones and Food Knowledge Education ........................................................................ 7

1.4 Theoretical Frameworks .................................................................................................................. 8

1.4.1 Social Ecological Model ........................................................................................................... 9

1.4.2 Behavioural Economics ........................................................................................................... 11

1.5 Study Rationale ............................................................................................................................... 13

1.6 Thesis Format and Organization .................................................................................................... 14

1.7 References ....................................................................................................................................... 15

Chapter 2 ............................................................................................................................................... 21
Exploring the Effectiveness of Smartphone Applications on Food Knowledge Among Adolescents: A Systematic Review

2.1 Abstract
2.2 Introduction
2.3 Methods
2.3.1 Search Strategy
2.3.2 Eligibility Criteria
2.3.3 Selection Process
2.3.4 Quality Review
2.3.5 Data Collection Process and Data Items
2.4 Results
2.4.1 Literature Search
2.4.2 Study Characteristics
2.4.3 Sample Characteristics
2.4.4 Study Measures
2.4.5 Quality Results
2.4.6 Smartphone Application Designs and Features
2.4.7 Smartphone Application Theoretical Frameworks
2.4.8 Intervention Effectiveness on Food Knowledge
2.4.9 Intervention Adherence
2.5 Discussion
2.5.1 Summary of Findings
2.5.2 Limitations
2.6 Conclusion
2.7 References
3 Effectiveness of Engagement with a Smartphone Application on Adolescent Food Knowledge: Randomized Controlled Trial

3.1 Abstract

3.2 Introduction

3.3 Methods

3.3.1 Theoretical Foundations and Intervention Design

3.3.2 Study Design

3.3.3 Data Collection

3.3.4 Measures

3.3.5 Statistical Analysis

3.4 Results

3.4.1 Participants

3.4.2 Intervention Effectiveness

3.4.3 Within-Group Effectiveness

3.4.4 SmartAPPetite Engagement

3.4.5 Characteristics of Engagers

3.4.6 Characteristics of Participants Who Dropped Out

3.5 Discussion

3.5.1 Effectiveness of Application Uptake on Food Knowledge Scores

3.5.2 Characteristics of High Engagers

3.5.3 Study Strengths

3.5.4 Study Limitations

3.6 Conclusion

3.7 References

Chapter 4

4 Synthesis and Conclusion
4.1 Summary of Studies ................................................................. 91
4.2 Research Contributions ............................................................. 93
4.3 Methodological Contributions ...................................................... 94
4.4 Limitations .................................................................................. 95
4.5 Implications for Policy and Practice .............................................. 97
4.6 Recommendations for Future Research ....................................... 98
4.7 Conclusion .................................................................................. 99
4.8 References .................................................................................. 101
Appendices ..................................................................................... 105
Curriculum Vitae ........................................................................... 149
List of Tables

Table 2-1: Framework of Search Terms Used for the Search Strategy ........................................ 24
Table 2-2: Summary of Study Characteristics ............................................................................ 30
Table 2-3: Results of Quality Assessment ................................................................................. 36
Table 2-4: Summary of Key Features in Smartphone Applications .......................................... 37
Table 3-1: Characteristics of the Intervention, Control, and Total Study Sample .................... 69
Table 3-2: Average T1 and T2 Scores by Group and Estimated Marginal Means for T2 Scores ........................................................................................................................ 70
Table 3-3: Analysis of Covariance for T2 Scores by Group with T1 Scores as a Covariant .... 70
Table 3-4: Change in Knowledge Scores Over Time Within Intervention and Control Groups .......................................................................................................................... 71
Table 3-5: Summary of Engagement Levels and Change in Food Knowledge Scores .......... 72
Table 3-6: Cross-tabulation Percentages of Characteristics Within Each Engagement Group .......................................................................................................................... 73
List of Figures

Figure 1-1: The Social Ecological Model for Health Behaviour ........................................... 10

Figure 2-1: PRISMA Flow Diagram of Search Strategy and Review Process ......................... 28

Figure 3-1: Screenshots of the SmartAPPetite User Interface .............................................. 61

Figure 3-2: Participant Enrollment and Survey Completion for the SmartAPPetite for Youth Study ........................................................................................................................................ 68
List of Appendices

Appendix A: Embase Search Strategy ................................................................................. 105

Appendix B: Letters of Information and Consent Forms .................................................. 106

Appendix C: SmartAPPetite for Youth Survey .................................................................. 134

Appendix D: Ethics Approval for the SmartAPPetite for Youth Study ......................... 148
Chapter 1

1 Introduction

There is a growing concern about the eating behaviours of adolescents in Canada. According to Health Canada, many Canadian adolescents have low intakes of the key nutrients needed for optimal growth and development including calcium, phosphorous, vitamin A, iron, and dietary fibre (Health Canada, 2022). The majority of youth in Canada report lower than recommended levels of fruit and vegetable consumption and higher intakes of fast food and “other” foods - those not belonging to a particular food group such as mostly sugar foods (e.g., candy), high salt and fat snacks (e.g., potato chips), and sugar sweetened beverages (Jessri et al., 2016; Slater et al., 2022; Storey et al., 2009). Together, these poor dietary habits have been found to co-occur and these habits have been found to carry on into adulthood (Hardy et al., 2012). It is important to intervene as early as possible, as these dietary risk factors contribute to chronic diseases later in life such as heart disease, diabetes, and certain cancers (Afshin et al., 2019).

One strategy to encourage healthier dietary choices among teens is to promote nutrition education initiatives. Food literacy has been found to be a significant predictor of diet quality (Grosso et al., 2013; Taylor et al., 2019) and research has shown that food literacy interventions can be effective at promoting positive diet-related behaviour changes in adolescents (Vaitkeviciute et al., 2015). As current adolescents are growing up in a digital world, they often turn to the internet for information or questions about their health (Skopelja et al., 2008), and health information from the web is becoming increasingly accessible by the uptake in smartphones. The prominent use of smartphones suggests that these platforms could be effective for health interventions, inclusive of food literacy (Rohde et al., 2019).

This chapter will outline a current smartphone intervention for youth, review the objectives for this thesis, provide context for nutrition educational learning environments, and provide theoretical foundations for this research. This thesis will investigate the
effectiveness of smartphone applications on improving adolescent food knowledge through a systematic review of the literature and a randomized controlled trial.

1.1 The SmartAPPetite for Youth Study

The SmartAPPetite for Youth Study is a research study based at the Human Environments Laboratory at Western University. The study took place between 2017 and 2020 (The Human Environment Analysis Laboratory, 2017), although data collection continued until 2023. This 10-week randomized controlled trial evaluates the effectiveness of a smartphone application called “SmartAPPetite” (Gilliland et al., 2015) for 1) improving knowledge about healthy eating, 2) encouraging healthier food purchasing, and 3) improving diet quality for youth living in Southwestern Ontario (Gilliland et al., 2015).

The development of SmartAPPetite was theoretically informed by both the social ecological model and behavioural economics. The SmartAPPetite application sends evidence-based food knowledge and local food retailer information to users in the form of short messages. Within the messaging, users are also provided with external webpage links to learn more information about the topic and a list of recipes relevant to the message. Messages are sent to users both temporally and spatially. Temporal messages are sent on a scheduled frequency (three times per day), and share knowledge tips on nutritional information, health benefits of foods, food preparation tips, and safe storage of foods. Spatial messages are sent to users when they are within 300 metres of fast-food restaurants to attempt to divert them away from unhealthy options and inform them of healthier choices.

This thesis examines the data collected from the SmartAPPetite for Youth study and focuses on the food knowledge objectives of this study utilizing data collected from 2017-2019. Further detail on the methodology of this project can be found in Chapter 3. This research will contribute towards synthesized findings of the SmartAPPetite for Youth Study inclusive of food purchasing behaviours and diet quality after the study concludes in 2023.
1.2 Research Questions and Objectives

The overarching goal of this thesis is to understand the effectiveness of utilizing smartphone applications to improve food knowledge in adolescents. To achieve this goal, a systematic review of the literature was conducted, and a randomized control trial was completed to measure the effectiveness of a smartphone application, SmartAPPetite for Youth, on food knowledge scores on teens living in London, Ontario CMA. This thesis is guided by the following research questions:

1. (a) What are the features and theoretical underpinnings of existing smartphone applications designed to improve adolescent food knowledge? (b) What is the effectiveness of these applications?

2. What is the effectiveness in uptake of a smartphone application (SmartAPPetite) on the improvement of food knowledge scores for adolescents in London, Ontario?

3. What are the characteristics of adolescents who highly engage with the SmartAPPetite smartphone application? What characteristics of the population do not engage with the smartphone application?

The first set of research questions (1a & 1b) were addressed through the systematic review of current smartphone application interventions that aim to improve food knowledge for adolescents (Chapter 2). This systematic review explored applications used globally to capture a range of features and theoretical foundations. This review aims to determine the effectiveness of previous interventions to understand gaps and act on recommendations for future intervention research.

The second and third research questions are addressed through the randomized controlled trial presented in Chapter 3. The first objective was to understand the effectiveness of a smartphone application on food knowledge for adolescents who received the intervention versus adolescents who did not. The second objective was to determine how the level of engagement with the application influenced food knowledge scores for participants in the intervention group while also understanding the characteristics of top users.
1.3 Research Context

To understand the background of adolescent food knowledge in Canada, the following sections will highlight the key definitions of food knowledge, the history of nutritional education environments for teens, and the application of smartphones for improving food knowledge.

1.3.1 Canadian Adolescent Health and Food Knowledge

Proficiency in food literacy is complex due to the diverse and interconnected knowledge areas and skills that fall under its definition. These multiple factors are captured in the Dietitians of Canada proposed definition of food literacy, which is as follows:

Food literacy is the ability of an individual to understand food in a way that they develop a positive relationship with it, including food skills and practices across the lifespan in order to navigate, engage, and participate within a complex food system. It’s the ability to make decisions to support the achievement of personal health and a sustainable food system considering environmental, social, economic, cultural, and political component (Cullen et al., 2015).

The Locally Driven Collaborative Project (LDCP) Healthy Eating Team, consisting of representatives from 16 public health units across Ontario published “Food Literacy: A Framework for Healthy Eating” to categorize and define the numerous components of this definition (LDCP Healthy Eating Team, 2018). The categories of food literacy are broken down into food and nutrition knowledge, food skills, self-efficacy and confidence, ecological factors, and food decisions (LDCP Healthy Eating Team, 2018).

Furthermore, Slater and colleagues published “The Food Literacy Competencies for Young Adults”, a framework which specifically focuses on adolescent food literacy considerations that are divided into functional, relational, and system competencies (Slater et al., 2018). Functional competencies highlight the knowledge of food and nutrition, food safety, budgeting, and preparation; relational competencies address joy
and meaning through food which include emotional and cultural competencies and emphasizing positive relationships with food; and system competencies focus on engagement and understanding factors that impact food systems including social justice, the environment, and corporate interests (Slater et al., 2018).

It has been suggested that “literacy” not only marks an achievement of understanding, but enables us to make informed choices (Smith, 2009). However, to gain confidence in making informed decisions, the integral competency of food knowledge outlined in each framework needs to be addressed. Food knowledge refers to both the understanding of food and how to seek out information on food: this includes both the critical knowledge of food (acquiring knowledge about food) and functional knowledge (applying knowledge into practice) (Truman et al., 2017).

In the context of this thesis, food knowledge encompasses the following attributes:

- **Food knowledge** – “To understand the variety of foods within all food groups. To know where food comes from and what is in it” (LDCP Healthy Eating Team, 2018; Slater et al., 2018).
- **Nutrition knowledge** – “To understand the nutrients in food and how these can affect health and wellbeing” (LDCP Healthy Eating Team, 2018; Slater et al., 2018).
- **Food and nutrition language** – “To understand commonly used words to describe characteristics of food and preparation of food” (LDCP Healthy Eating Team, 2018).
- **Food safety and hygiene knowledge** – “Understanding food safety risks associated with food storage and preparation and understanding hygienic food handling practices” (Slater et al., 2018).
- **Have knowledge of where food comes from** – “Understanding food origins, the seasonality of food, where to access food, and the impact of food systems on the environment and local economy” (Slater et al., 2018).
1.3.2 History of Adolescent Food Knowledge Education

Historically, young people, typically women, learned about food and recipes through traditional means such as learning how to cook at home from family members. The beliefs around food and what constituted “health” was passed along traditionally based on family beliefs and values around food (O'Sullivan et al., 2008). Teens today still report that the home is still a source of where they learn about food practices and healthy food “rules” (Wang & Fielding-Singh, 2018). However, the opportunity for teens to engage in family cooking and mealtimes has reduced over time (Hunt et al., 2011). Women are still reported to be the main providers of food and meals within households (Horne et al., 2018) and mothers’ full-time employment has been found to have an inverse relationship with family mealtimes (Neumark-Sztainer et al., 2003). Time and scheduling have been identified as a main barrier to cooking and the increasing ease of access to convenience foods exacerbate the priority for at-home cooking (Lavelle et al., 2016; Monsivais et al., 2014). So, while teens still recognize home as a place to learn about food, cultural and societal influences have limited the opportunities to fully engage in this learning environment.

Whether home environments were conducive to food educational opportunities or not, Ontario schools previously provided lessons in home economics to students. In the early 1900s, home economics was introduced to Ontario high schools with the intent to provide young women a foundation in home activities (such as cooking, hygiene, household emergencies, and sewing) alongside other academic subjects (Mlynaryk, 2018). Over the decades, home economics was integrated into the Ontario school curriculum for all students; however, by the late 1900s and early 2000s, school boards removed the previously mandatory home economics classes from middle school curriculum (grades 6-8) (Waldron, 2022). Students today still have the option to take food and nutrition courses if they are offered by the Ontario secondary school they attend, but these classes are no longer mandatory. These courses are also offered to upper year high school students, but they may be of lower priority for students choosing electives based on post-secondary program requirements. This absence of requirement for students to engage with home economic courses, and the limit to what these courses can provide for in-depth
comprehension and skill building, have contributed to the reduction in food literacy skills (Chenhall, 2010; Colatruglio & Slater, 2016). To address the need for food literacy improvements for both elementary (Colley et al., 2022) and high school students (Brown et al., 2021) in Ontario, the Ontario Home Economics Association has a call to action for Ontario legislature to add food education to grade K-12 curriculum to the Ontario Education Act (Ontario Home Economics Association, 2023). Some progress has been made with the integration of food literacy within science and technology curriculum for grades 1-8 (The Government of Ontario, 2023).

1.3.3 Smartphones and Food Knowledge Education

Over the last decade, technological advancements have provided a novel medium for food knowledge learning opportunities that cater to the current generation of tech savvy adolescents. Teens now often turn to the internet for health information (Skopelja et al., 2008) and nutrition has been found to be one of the top health topics researched by teens online (Wartella et al., 2016). In Canada, over 88% of adolescents over the age of 15 own a smartphone (Government of Canada, 2021), so food literacy interventions have utilized this technology with internet-based platforms (Wickham & Carbone, 2018), text-messaging (Hingle et al., 2013; Wickham et al., 2019), and smartphone applications (Dute et al., 2016; Villasana et al., 2020).

Smartphone applications have been notable in providing nutrition-based apps to users with abundant search results when looking up “nutrition” or “healthy eating” in the iTunes or Google Play store (Schoeppe et al., 2017). Measuring the amount of nutrition messaging content in social media streaming applications (e.g., YouTube, Instagram, and TikTok) would be a futile attempt due to boundless account creations and continuous content uploads. Smartphone applications provide active engagement for messaging and can reach a wide audience, especially with influential content creators (i.e., influencers). Recent research found that teens exposed to healthy eating ads or messaging from influencers had higher food literacy scores (Qutteina et al., 2022). However, because of the public nature of these platforms, they can also have negative effects on well-being depending on the biases and credibility of the messaging as it falls out of the hands of nutrition professionals and policy makers (Steils & Obaidalahe, 2020). Awareness of
healthy eating does not translate to a healthy behaviour if the information is flawed (Grunert et al., 2012) and people can only respond to healthy eating messaging based on their foundational understanding (Spiteri Cornish & Moraes, 2015), so it is important to consider the differing levels of baseline food knowledge and the accuracy of the message. While social media applications fall under the definition of a smartphone application, it is difficult to assess credentials of content creators and monitor the mass uploads for food knowledge initiatives. A reputable smartphone application that is downloaded from an app store or other reputable organization, on the other hand, will typically have the author listed and will have a website associated with the application to provide more details about the application’s purpose. For example, the Childhood Obesity Foundation, along with other pediatric health researchers, utilize an application called “Aim2Be” to educate, set goals, and counsel youth and families toward healthier lifestyles (Tugault-Lafleur et al., 2023). Their app is available publicly to download but also has a website to explain the aim of the Aim2Be initiative, sponsors, and their research projects (Childhood Obesity Foundation, 2022).

Therefore, in the context of this thesis, smartphone applications that are within the scope of this research are:

- Applications that are available publicly or privately for download on a smartphone or tablet device; and
- Applications that utilize gamification for nutrition knowledge.

Smartphone applications that are not included in the scope of this research are:

- Social media or streaming service applications (e.g., TikTok, YouTube, Instagram)
- Smartphone applications that are designed for instant messaging (e.g., WhatsApp or Facebook Messenger)

1.4 Theoretical Frameworks

Understanding the contexts in which behaviours occur can help build a strong foundation for behaviour change health interventions (Glanz et al., 2008). Interventions that have been developed with a defined theoretical foundation are more successful than those that
lack a framework for understanding behaviours (Glanz et al., 2008). To help understand the varying influences on food knowledge and healthy eating, two frameworks – the social ecological model and behaviour economics – were applied in the SmartAPPetite intervention study examined in this thesis.

1.4.1 Social Ecological Model

The social ecological model is based on several different fields of research. The term ecology has been extended from studying the relationship between humans and their physical environments to now encompassing social environments inclusive of the institutional and cultural context of human relationships; this broadening of ecology understanding can better inform the cumulative impact of the environment on population health (Stokols, 1996). This model emphasizes that behaviours shape and are shaped by the environment with multiple spheres of influence (Glanz & Bishop, 2010) suggesting that behaviour change strategies linked to environmental supports can improve both individual and collective well-being (Stokols, 1996). As this model integrates the role of persons, organizations, and the environment in shaping practices and policies, it can play a strong focus in health promotion by enhancing the well-being of a geographical area (Stokols, 1996).

Figure 1-1 outlines the spheres of influence within the ecological model informed by McLeroy et al. (1988), adapted from Urie Bronfenbrenner’s ecological model (Bronfenbrenner, 1979).

The intrapersonal level covers the individual characteristics of a person and interventions at this level look at changing individual behaviour, knowledge, attitude, or skills (McLeroy et al., 1988). The interpersonal level looks at social networks and social support systems including family and friends; interventions focusing on this level may look at changing individuals through social influences (McLeroy et al., 1988). The organizational level captures social institutions and rules and regulations for operating these spaces (McLeroy et al., 1988). Many people spend most of their day in an organizational setting (such as school or the workplace). Organizations reinforce social norms and values through their own cultures while also providing economic and social
resources, therefore they are vital to include in an ecological approach intervention as they can support long term behaviour changes in individuals (McLeroy et al., 1988). The community sphere looks at relationships between organizations and institutions as well as informal networks within a defined boundary (such as families, friendship networks, or neighbourhoods (McLeroy et al., 1988). Community also captures a group under a power structure so it can be a key sphere to build an understanding of facilitators or barriers to health interventions (McLeroy et al., 1988). The most distal sphere is the societal (or public policy) sphere which accounts for local, provincial, and national laws and policies and has the largest effect on the health of a population as interventions or changes implemented at this level would affect entire populations of a geographic region (McLeroy et al., 1988).

**Figure 1-1:** The Social Ecological Model for Health Behaviour
(McLeroy et al., 1988; Bronfenbrenner, 1979)

The social ecological model suggests that these spheres of influence can affect people’s behaviour even if they are highly motivated (Glanz & Bishop, 2010). Interventions focusing on multiple levels should be more effective at behaviour changes (Sallis et al., 2008), while also accounting that there is a dynamic interaction between spheres that
need to be accounted for in program planning (Stokols, 1996). For example, implementing a breakfast program within the organizational structure of an elementary school would also need to consider the funding for the program (societal/policy level) neighbourhood demographics with proximity and feasibility for earlier arrival times (community level), receiving buy in from parents/guardians to send their children to a breakfast program (interpersonal level) while also considering culturally and nutritionally acceptable food for children attending the program (intrapersonal level). Therefore, the goal for interventions following this model is to have individuals motivated and educated enough to engage in the behaviour change, social supports for these behaviours are strong, and the environment and policies are built to support the behaviour change (Sallis et al., 2008).

1.4.2 Behavioural Economics

Neoclassical economics suggests that people will always consider the rational or optimal choice if they have the information and tools available to do so (Mullainathan & Thaler, 2000). Rationality suggests that the preferences between two options should not reverse with changes of a frame (Tversky & Kahneman, 1981). Psychological studies suggest that humans are not rational decision makers; psychological principles have shown that decisions do change based on framing of a problem (Tversky & Kahneman, 1981). When problems involve gains, decisions are often risk averse but when they are framed as involving a loss, decisions are more likely to be risk taking; that is, individuals choose to avoid losses more than achieve a corresponding gain (Tversky & Kahneman, 1981). Therefore, behavioural economics combines psychology and economics to investigate the factors which influence human decision making (Mullainathan & Thaler, 2000). There is little evidence to suggest that humans make decisions that are in their best interest 100% of the time; this could be a result of not having complete information, cognitive abilities, or willpower (Thaler & Sunstein, 2020). A common example of this is healthy eating: although most Canadians are educated through school and public health initiatives that unhealthy diets are a significant risk factor for developing chronic conditions, 73% of individuals over the age of 65 report having at least one common chronic condition and
of this population, over 77% report low fruit and vegetable intakes (Government of Canada, 2020).

Present-bias decision making, the behaviour of accepting a lesser present reward over a greater delayed reward but reversing this decision if the delay for the rewards were equal, has shown to play a large role in understanding behavioural economics (O’Donoghue & Rabin, 2003). It has been found that behaviours are often predictable based on these patterns (Just, 2006) and that it is more prevalent in adolescents and young adults than with older adults (Wong et al., 2021). Another bias that plays a role in behavioural economics is the availability heuristic, which suggests that people make decisions based on how easily or available relevant cases or events come to mind, which often is not representative of the true probability of an outcome (Tversky & Kahneman, 1973).

There are some important things to consider when integrating behavioural economic theories into health interventions. While the goal is for an intervention to reach as much of a target population as possible, the implementation may seem paternalistic in nature as it can reduce one’s ability to make free choices (Thaler & Sunstein, 2020). Libertarian paternalism is a philosophy that can balance the two extremes of personal choice and health policy mandates (Thaler & Sunstein, 2020). Libertarian paternalism aims to shift behaviours as a means of self-interest without impeding freedom of choice (Downs et al., 2009). Rather than veer participation away from health efforts by taking away individual choice, behavioural tools can be implemented to make initiatives seem less patronizing (Just, 2006).

Choice architecture is a libertarian paternalism method used to predict how people make choices and re-organize the context to “nudge” individuals towards a particular behaviour (Thaler & Sunstein, 2021). A nudge is used to steer individual behaviour towards making decisions that promote their welfare (Downs et al., 2009) but does not change any economic incentives (Thaler & Sunstein, 2021). An example of nudging in choice architecture is stocking healthy snacks at vending machines in high schools; while students have a choice to leave school and purchase foods they want to eat, the most convenient ones available to them are healthier options. In addition to the present-bias
and availability bias, the status quo bias, the bias that people will choose the default option provided to them even if better options are available, is also considered in choice architecture (Samuelson & Zeckhauser, 1988). In choice architecture, setting the default option as the desired option is a method of deciding on behalf of an individual by assuming they will not change the default, but does not remove their free choice of selecting other options. A common example of this in Ontario universities is automatically enrolling students into a dental insurance plan in which they must apply to opt-out to receive the refund from their student fees. Choice architecture attempts to consider the biases in decision making to promote individuals to facilitate their own choices that provide greater long-term benefits (Lindstrom et al., 2023).

1.5 Study Rationale

With society’s substantial use and reliance on smartphones, a systematic review of the literature for this topic is valuable as mobile health interventions have been heavily explored across public health research. The outcomes of the systematic review guided the rationale for the objectives in the randomized control trial. Firstly, while there are many protocol papers and feasibility/usability studies in this subject area, there are few studies that take a controlled trial approach to study effectiveness of smartphone applications on adolescent food knowledge. Secondly, there was a gap in the literature that 1) required the exploration of the relationship between dosage and outcomes (i.e., level of engagement with an application on food knowledge improvements), and 2) identified potential differences in the characteristics of application users. Each of these are vital when researching a novel intervention medium as they build on future recommendations for research and practice; these objectives go beyond understanding whether the intervention is simply effective or ineffective but help guide exposure effects and target populations who would benefit and become involved with this type of food knowledge initiative. This research is also important and timely due to the decrease in opportunities for teens to gain food knowledge skills in home and school environments. This reduction in food knowledge skills can contribute to the development of poor eating habits that carry on into adulthood, increasing the risk for diet-related chronic conditions. As current adolescents have been shown to demonstrate unhealthy eating habits in the
emerging absence of food educational spaces, finding a way to make food knowledge accessible and attractive to teens is crucial for their healthy development.

1.6 Thesis Format and Organization

This thesis is written in an integrated article format composed of one systematic review and one original research study. The following chapter (Chapter 2) is the systematic review which synthesizes the interventions in this field of research. This systematic review explores peer-reviewed studies that utilize smartphone applications to improve adolescent food knowledge and summarizes effectiveness, application features, and theoretical foundations of application design and implementation. Chapter 3 is a randomized controlled study that investigates the effectiveness of a smartphone application (SmartAPPetite) on food knowledge for teens living in London, Ontario. This research also explores the influence of engagement on food knowledge scores and characteristics of high engagers of the application. Chapter 4 provides a synthesis of the two manuscripts. This final chapter discusses research contributions and implications, research limitations, and recommendations for future research in this field.
1.7 References


https://doi.org/10.1155/2015/841368

https://doi.org/10.1146/annurev.publhealth.012809.103604


https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2210011501


https://doi.org/10.1017/S1368980012003965


https://doi.org/10.1016/j.jadohealth.2011.12.017


https://doi.org/10.1016/j.jneb.2012.05.001


Chapter 2

2 Exploring the Effectiveness of Smartphone Applications on Food Knowledge Among Adolescents: A Systematic Review

2.1 Abstract

Dietary risk factors are prevalent among teens in developed countries. Improvements in adolescent food knowledge have been shown to improve dietary behaviours later in life. As smartphones are increasingly popular among adolescents, nutrition knowledge-based smartphone applications are a promising medium for improving an educational reach among this population. The objectives of this review are to (1) describe the features and theoretical foundations of smartphone application interventions that aim to improve food knowledge in adolescents and (2) explore the effectiveness of smartphone application interventions at increasing food knowledge in adolescents. Seven databases were searched for peer-reviewed articles published between January 2008 and April 2022. Studies were eligible for inclusion if (1) participants were 10-19 years old, (2) the intervention used a nutrition smartphone application, (3) they used pre-post or randomized control trial designs, and (4) measured at least one food knowledge competency. The search yielded 2837 studies, of which eight were eligible for inclusion. A total of 17 features were identified across the applications and summarized as nine key features. Six studies reported using a theoretical framework to inform their smartphone intervention. Significant improvements in food knowledge competencies were identified in four studies. The number and combination of features differed across applications, and each used varying theoretical frameworks used to inform application design. While four out of the 8 included studies reported significant positive changes in food knowledge outcomes, only one study reported using a validated measurement tool. Engagement with smartphone applications may be a factor influencing nutrition knowledge. Future studies should utilize a valid and reliable nutrition knowledge measurement tool and to consider barriers and facilitators to application engagement.
2.2 Introduction

Adolescence is a stage of emerging adulthood that involves significant biological and social changes (Sawyer et al., 2018). Through these changes, risk factors that lead to future morbidities such as diabetes, cardiovascular disease, and metabolic syndrome become prevalent among this age group; specifically, a co-occurrence of dietary risk factors such as decreased fruit and vegetable consumption, increased sugary drink intake, and fast-food consumption (Hardy et al., 2012). There is a high prevalence globally of disease related to dietary risk factors (Afshin et al., 2019), and because youth eating patterns have been found to carry into adulthood, it is important to address these risk factors early (Mikkilä et al., 2005; Movassagh et al., 2017).

One way to improve eating patterns among adolescents is to increase their food literacy. Food literacy is “an individual’s ability to have the knowledge and skills to make decisions within a complex food system across the lifespan to support personal health and a sustainable food system” (Cullen et al., 2015). According to the food literacy competency model for young adults proposed by Slater et al., much of the existing literature exploring nutrition education focuses on functional competencies, as it is these competencies that are central to making food choices with the goal of disease prevention (2018). These competencies encompass understanding knowledge about food, nutrition, and food safety while also emphasizing food planning, preparation, and budgeting skills (Slater et al., 2018). Nutrition functional competencies can be defined synonymously with food knowledge which focuses on the educational component of food and the ability to understand and seek out information about food (Truman et al., 2017). Research exploring dietary intake in adolescents has found that food knowledge improvements can effectively promote positive diet-related behaviour changes (Vaitkeviciute et al., 2015), and that food skills and behaviours adopted in the late adolescent years can be continued on into adulthood (Laska et al., 2012).

As adolescents are growing up in a digital world, they often turn to the internet for information or questions about their health (Skopelja et al., 2008), and health information from the web is becoming increasingly accessible due to the widespread uptake in smartphones. A previous systematic review reported that internet-based platforms using
computers with games and active learning aimed at improving adolescent nutrition literacy can have positive dietary outcomes (Wickham & Carbone, 2018). However, with the increasing ownership of smartphones globally (Poushter, 2016), utilizing smartphone applications, rather than computer-based interventions, could reach a wide audience for nutrition education initiatives.

Most systematic reviews that have assessed the effectiveness of smartphone applications for adolescents have focused on changes in diet intake (Schoeppe et al., 2016) or weight-management outcomes (Langarizadeh et al., 2021; Reddy et al., 2021). Previous reviews assessing nutrition knowledge explored application features, but do not measure their overall effectiveness at increasing food knowledge (Dute et al., 2016; Villasana et al., 2020b). One review reported behavioural theory within smartphone application interventions (Dute et al., 2016), however it did not also capture food knowledge outcomes. Numerous reviews have focused on publicly available applications for youth from the iTunes or the Google Play Store, with the aim of describing the features of the smartphone applications (Schoeppe et al., 2017; Schoffman et al., 2013; Villasana et al., 2019) or classifying the behaviour change techniques of the features (Brannon & Cushing, 2015; Burrows et al., 2015; Schoeppe et al., 2017). Although well-marketed and attractive to teens, these applications have been found to score low for information quality (Burrows et al., 2015; Schoeppe et al., 2017; Schoffman et al., 2013). Therefore, a review has yet to address the effectiveness of evidence-based smartphone application interventions at increasing food knowledge.

To address the gap in the literature, this systematic review seeks to 1) describe the features and theoretical foundations of smartphone applications that aim to improve food knowledge in adolescents and 2) explore the effectiveness of smartphone applications at increasing food knowledge in adolescents.

2.3 Methods

This systematic review follows The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Page et al., 2021).
2.3.1 Search Strategy

A search was conducted using OVID (MEDLINE, Embase, and PsychInfo databases), EBSOhost (CINAHL database), ProQuest (ERIC), Scopus, and Cochrane Library. Search terms were developed using a framework including population descriptors, independent variables, and outcome variables. Table 2-1 outlines the key terms used for the search based on this model. Search terms were developed by two researchers (HJ and HS) and reviewed by a third reviewer (JG) before a final consultation with a research librarian. An example of a database search strategy can be found in Appendix A. The most updated search was carried out in October 2022 and results were limited to peer-reviewed studies available in English. Only studies published after 2008 were included, as this is the year the first contemporary smartphone-application store was available. Reference lists of studies included in the review, as well as reference lists of systematic reviews with a similar topic, were scanned for eligible studies.

Table 2-1: Framework of Search Terms Used for the Search Strategy

<table>
<thead>
<tr>
<th>Population</th>
<th>AND (Independent Variable)</th>
<th>AND (Outcomes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child OR Youth OR Teen OR High School OR Secondary School</td>
<td>Smartphone OR Mobile Health OR App OR mHealth OR Mobile App OR Mobile Phone OR Cell Phone</td>
<td>Diet OR Dietary OR Nutrition or Eating OR Food Knowledge OR Nutrition Knowledge OR Food Literacy OR Healthy Eating OR Snack OR Food</td>
</tr>
</tbody>
</table>

2.3.2 Eligibility Criteria

The PICO (Population, Intervention, Comparator, and Outcome) framework was used to develop the eligibility criteria for the review process. All geographic locations were included.
Population: Studies with participants who had a mean age between 10 to 19 years, inclusive of all health statuses, were eligible for inclusion. Ten to 19 years of age is defined as adolescence by the World Health Organization (World Health Organization, 2022). Studies in which the mean age of participants was younger than 10 years or older than 19 years were excluded.

Intervention: Studies were eligible for inclusion if the intervention participants engaged with a smartphone application, either commercially or publicly available, that is designed to provide food knowledge. Applications could aim to improve other health behaviour outcomes along with food knowledge. Interventions could use an application as the sole exposure or pair an application with another method (e.g., counselling or classroom sessions). Interventions that were smartphone-based but did not use an application (e.g., tele-counselling, text message education, websites) were not included. Phone applications that did not have nutrition themes in the content or design were not included (e.g., meditation applications).

Comparator: Studies that compared the intervention group to a control group, or studies that compared use of the application in a pre/post assessment were eligible for inclusion. Feasibility papers were only eligible if there was a pilot intervention in the study design.

Outcomes: Eligible studies measured at least one food knowledge item according to the Functional Competency list from Slater et al.’s Food Literacy Competencies for Young Adults (Slater et al., 2018). Studies were included if they reported outcome measures related to food knowledge.

2.3.3 Selection Process

Reports from each database were uploaded to Covidence Software, where duplicates were automatically removed. All titles and abstracts were screened by two researchers (HJ and HS) independently while following the eligibility criteria. Studies where eligibility requirements were unclear were included to assess in the full-text review process. A full-text review of included studies from the title and abstract screen were
completed independently by two researchers (HJ and HS). A third reviewer (JG) adjudicated where conflicts arose to discuss consensus for eligibility requirements.

2.3.4 Quality Review

The Joanna Briggs Institute (JBI) checklist for Randomized Control Trials was used to assess the quality of the included studies (JBI, n.d.). All studies, regardless of quality score, were intended to be included in the review to capture all smartphone application design elements published in the literature. All studies were independently assessed by two researchers (HJ and HS) and conflicts were assessed by a third reviewer (JG) for consensus. This checklist was used for all studies, regardless of the study design despite randomized controlled trials being accepted in research as being the most reliable for evaluating the effectiveness of an intervention (Evans, 2003). Comparing all study designs to randomized control trials better reflects the degree to which the study methodology is susceptible to bias, justifying lower quality scores. This approach is consistent among similar systematic reviews (Maher et al., 2014; Schoeppe et al., 2016; Villinger et al., 2019).

2.3.5 Data Collection Process and Data Items

Data from studies were extracted and recorded in Table 2-2. Study characteristics (author, year, location, study design), sample characteristics (number of participants, age, number of participants in the control and intervention group, recruitment methods), study characteristics (e.g., description of the intervention and control group, duration of intervention, and frequency of exposure to intervention), measurement tool (e.g., type, measurement frequency, and outcome measured), theoretical framework, smartphone application features, and results were collected for analysis. Due to the heterogeneous nature of the included studies’ outcomes, results were presented as a narrative review. Positive outcomes were constituted as study results that had a statistically significant $p$-value of $p \leq 0.05$. 
2.4 Results

2.4.1 Literature Search

The search strategy resulted in 3087 records after the removal of duplicates; Figure 2-1 outlines the PRISMA flow for included reports. A total of 2654 studies were excluded at the title and abstract screening phase. After full-text review of the remaining 432 studies, 8 were deemed eligible for inclusion in the review. Articles were primarily removed as they were an ineligible study design (n=142), were protocol papers (n=58) or abstracts only (n=56), the intervention was delivered via an ineligible route of administration (e.g., text messaging or web-based platforms) (n=52), or the study did not measure a food knowledge correct outcome (n=35).
2.4.2 Study Characteristics

Table 2-2 outlines a summary of study characteristics. The 8 studies were dispersed globally with interventions in Europe (n=5) (De Cock et al., 2018; García-Muñoz et al., 2022; Heikkilä et al., 2019; Ragelienė et al., 2022; Villasana et al., 2020a), North America (n=1) (Byrne et al., 2012), Asia (n=1) (Kato-Lin et al., 2020), and Australia (n=1) (Baghaei et al., 2016). Three of the studies followed a randomized control trial
study design (Byrne et al., 2012; Heikkilä et al., 2019; Kato-Lin et al., 2020), three studies followed a non-randomized control trial design (De Cock et al., 2018; García-Muñoz et al., 2022; Ragelienė et al., 2022), and two studies followed a single-arm trial design (Baghaei et al., 2016; Villasana et al., 2020a). All interventions ranged in duration from 1 week to 5 weeks, apart from one study, which lasted 12 weeks (Ragelienė et al., 2022). One study had a 3-month follow-up period (Heikkilä et al., 2019), whereas no other studies reported follow-up assessments. Frequency of exposure to the smartphone application within the interventions included participants autonomously engaging with the application through the duration of the study (Baghaei et al., 2016; Byrne et al., 2012; De Cock et al., 2018; Heikkilä et al., 2019; Ragelienė et al., 2022; Villasana et al., 2020a) or engaging with the application during allocated scheduled times (García-Muñoz et al., 2022; Kato-Lin et al., 2020)
Table 2-2: Summary of Study Characteristics

<table>
<thead>
<tr>
<th>Author, Year, Location</th>
<th>Study Design</th>
<th>Sample Characteristics</th>
<th>Intervention</th>
<th>Measurement, Frequency, NE Outcome</th>
<th>Theoretical Framework or Models</th>
<th>Application Features</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heikkilä M et al., 2019, Finland</td>
<td>Randomized controlled trial</td>
<td>N= 62, Age 16-20 (M=18.0) endurance athletes, Intervention N=42, Control N= 37, Recruited from sports academies</td>
<td>Intervention group: Participate in weekly nutrition education sessions and engage with phone application Control group: Participate in nutrition education sessions only 5 weeks Autonomous use of application in between education sessions</td>
<td>Nutrition knowledge questionnaire (78-item), Pre, post, and 12-week follow up measurement Nutrition knowledge</td>
<td><strong>Self-determination theory</strong> focusing on increase intrinsic motivation, competence, and autonomy.</td>
<td>Food recording Goal Setting Feedback</td>
<td>Significant difference in nutrition score improvement for both the intervention and control group ($p&lt;0.001$) Healthy knowledge scores within intervention group increased in users vs. non-users ($p&lt;0.001$)</td>
</tr>
<tr>
<td>Kato-Lin YC et al., 2020, India</td>
<td>Randomized controlled trial</td>
<td>N= 58, Age 10-11, Intervention N=52, Control N=52, Recruited within schools</td>
<td>Intervention group: Engaged with smartphone application Control group: Engaged in a non-food related game 2 weeks 20-minute session scheduled once per week (2 sessions total)</td>
<td>Healthy food survey question (1-item), Pre and post measurement Healthy Food knowledge</td>
<td><strong>Intrinsic motivation</strong> theory in application design to encourage implicit learning.</td>
<td>Positive Reinforcement, Gamification Nutrition messaging</td>
<td>Increase in healthy foods identified by intervention group compared to control group ($p=0.048$)</td>
</tr>
</tbody>
</table>
| Byrne S et al., 2012, USA | Multi-arm randomized controlled trial | N=39  
Age 12-14 (M= 13.1),  
Intervention arm 1 N=12, intervention arm 2 N=13, control N= 14,  
Recruited within school | Intervention condition 1: Participants engage with application and receive positive and negative feedback  
Intervention condition 2: Participants engage with application and receive positive or neutral feedback  
Control: No engagement with smartphone application  
9 days  
Autonomous use of application at breakfast time | 5 Point Scale question (1-item), Pre and post measurement  
Perceptions on the importance of healthy eating | Social cognitive theory using positive or negative feedback to motivate behaviour change | Food recording  
Positive reinforcement | Increase in the perception on the importance of healthy eating in Intervention condition 1 (positive and negative feedback) ($p <0.01$) and the control group ($p <0.05$) compared to Intervention condition 2 (positive or neutral feedback) |
|---|---|---|---|---|---|---|---|
| De Cock N et al., 2018, Belgium | Non-randomized controlled trial | N=988  
Age 14-16 (M=14.9),  
Intervention N=416, control N=572  
Recruited within schools | Intervention group: Engaged with mobile application  
Control group: No engagement with application  
4 weeks  
Autonomous use of application during trial duration | Scoring test of healthiness of different foods (28-items), Pre and post measurement  
Knowledge about healthiness of snacks | Dual process model focusing on implicit and explicit pathways to target behaviour change | Food recording  
Positive reinforcement  
Goal setting  
Feedback  
Peer challenges | Increase in food knowledge scores in the control group compared to the intervention group ($p=0.04$)  
Larger decrease in food knowledge scores in low-users ($p<0.05$) and non-users ($p<0.05$) than in control group |
<table>
<thead>
<tr>
<th>Study Authors</th>
<th>Study Type</th>
<th>Sample size</th>
<th>Age</th>
<th>Intervention</th>
<th>Control</th>
<th>Recruitment</th>
<th>Duration</th>
<th>Outcomes</th>
<th>Measurements</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baghaei N et al., 2016</td>
<td>Single-arm pre-post trial</td>
<td>N=12</td>
<td>Age 9-13 (M=10.3)</td>
<td>Pilot trial. All participants engaged with phone application</td>
<td></td>
<td></td>
<td>1 week</td>
<td>Health knowledge questionnaire (21-item),</td>
<td>Theory of game “flow” to achieve involvement in gamification and positive reinforcement</td>
<td>Average scores on healthy food choices increased from</td>
</tr>
<tr>
<td>Ragelienė T et al., 2022</td>
<td>Non-randomized controlled trial</td>
<td>N=118, Age 9-13 (M=10.9)</td>
<td></td>
<td>Intervention: Engaged with smartphone application</td>
<td>Control: No engagement with smartphone application</td>
<td>Recruited within schools</td>
<td>12 weeks</td>
<td>Food knowledge questionnaire (5-items), Social cognitive theory using social interaction features to model peers' behaviours</td>
<td>Food recording Positive reinforcement Gamification Nutrition messaging Peer interaction Improvement in 1 out of 5 questionnaire items on the importance of balanced meals ($p = 0.006$)</td>
<td></td>
</tr>
<tr>
<td>García-Muñoz S et al., 2022, Poland &amp; Spain</td>
<td>Non-randomized controlled trial</td>
<td>N=339, Age 9-14 (M=10.7)</td>
<td></td>
<td>Intervention (Poland): Received weekly nutrition education sessions and engaged with smartphone application</td>
<td>Control (Poland): Engaged with phone application only 4 weeks</td>
<td>Recruited within schools</td>
<td></td>
<td>Classification of food items on healthiness (12-items), Pre and post measurement Healthiness perception of different foods</td>
<td>None described</td>
<td>Food recording Feedback No change in the healthiness perception of foods between the intervention and control group</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Recruited through community and schools</td>
<td>Autonomous use of application during trial duration</td>
<td>Pre and post measurement of Knowledge of healthy diet and lifestyle</td>
<td>Achieve active learning environment.</td>
<td>Pretest (66%) to post-test (77%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Villasana MV et al., 2020, Portugal</td>
<td>Single-arm pre-post trial</td>
<td>N= 7, Age 13-18, Recruited within schools</td>
<td>All participants engaged with phone application 5 weeks</td>
<td>Nutrition knowledge questionnaire (4 items x 4 unique questionnaires), Weekly measurements Nutrition knowledge</td>
<td>None described</td>
<td>Food recording, Goal setting, Nutrition messaging</td>
<td>Highest scores achieved in week 3 questionnaire. Testing of change in scores not reported</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.4.3 Sample Characteristics

The total number of participants within each study ranged from 7 to 998 adolescents, with three studies including more than 100 participants (De Cock et al., 2018; García-Muñoz et al., 2022; Ragelienė et al., 2022). All studies included did not have a criterion for health status except for one study that recruited endurance athletes only (Heikkilä et al., 2019). Six of the 8 studies recruited participants from schools only (Byrne et al., 2012; De Cock et al., 2018; García-Muñoz et al., 2022; Kato-Lin et al., 2020; Ragelienė et al., 2022; Villasana et al., 2020a), one study recruited from schools and community advertisements (Baghaei et al., 2016), and one study recruited from sports academies (Heikkilä et al., 2019).

2.4.4 Study Measures

Within the included studies, variables that were considered a measure of food knowledge included nutrition or healthy diet knowledge (Baghaei et al., 2016; De Cock et al., 2018; Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienė et al., 2022; Villasana et al., 2020a), healthiness perception of foods (García-Muñoz et al., 2022), or the perception of the importance of healthy foods (Byrne et al., 2012). All studies used a questionnaire to measure their food knowledge variable, but frequency of testing differed between studies. Six studies measured their food knowledge variable using a questionnaire at pre and post intervention (Baghaei et al., 2016; De Cock et al., 2018; García-Muñoz et al., 2022; Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienė et al., 2022) and follow up where applicable (Heikkilä et al., 2019), one study administered a questionnaire at various study intervals (Villasana et al., 2020a), and one study used a questionnaire at post intervention and compared results across intervention conditions (Byrne et al., 2012). Three studies reported reliability testing of the questionnaires used (Byrne et al., 2012; Heikkilä et al., 2019; Kato-Lin et al., 2020) and one study reported use of a validated survey (Heikkilä et al., 2019). All studies evaluated other outcomes in addition to food knowledge. Outcomes include dietary intake changes (Byrne et al., 2012; De Cock et al., 2018; García-Muñoz et al., 2022; Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienė et al., 2022; Villasana et al., 2020a), feasibility/acceptability of the application (Baghaei et al.,
2016; Byrne et al., 2012; De Cock et al., 2018; Villasana et al., 2020a), self-efficacy (De Cock et al., 2018; Ragelienė et al., 2022), food preference/likeability (García-Muñoz et al., 2022; Ragelienė et al., 2022), and physical activity measures (Villasana et al., 2020a).

2.4.5 Quality Results

The assessment for report quality can be found in Table 2-3. Studies that did not fulfill the checklist criteria for quality were driven by not having a randomized study design or study procedures were unclear due to lack of specific study details. Notably, studies that did not have blinding in place for group allocation, participant blinding to treatment group, and researcher blinding to participant assignment scored lower on the checklist. Studies may have described the reason for loss to follow up in their results, but if they did not discuss the impact the loss to follow up had on the results they did not score for this item on the checklist. Numerous studies were marked as having unreliable methods as they did not provide a reliability measure, describe inter-rater reliability, or describe rater training specifically for nutrition knowledge measures. Studies that did not have sample size power or very low participant enrolment did not score for having appropriate statistical analysis. Checklist items were marked with an “Unclear” rating if not enough detail was provided to satisfy the item criteria. “Not Applicable” was used for studies that followed a single-arm trial design. All studies were included regardless of checklist scoring to capture all smartphone application design features.
Table 2-3: Results of Quality Assessment

<p>| JBI Checklist for Randomized Control Trials |
|-----------------|---|---|---|---|---|---|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Article Author</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
<th>Q11</th>
<th>Q12</th>
<th>Q13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kato-Lin et al.</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Heikkilä et al.</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>U</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Byrne et al.</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>U</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>De Cock et al.</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>García-Muñoz et al.</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Rageliene et al.</td>
<td>N</td>
<td>N</td>
<td>U</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baghaei et al.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>U</td>
<td>NA</td>
<td>NA</td>
<td>U</td>
<td>U</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Villasana et al.</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>N</td>
<td>NA</td>
<td>NA</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>

Legend: Green = Yes, Red = No, Yellow = Unclear, Grey = Not Applicable

Q1) Was true randomization used for assignment of participants to treatment groups? Q2) Was allocation to treatment groups concealed? Q3) Were treatment groups similar at baseline? Q4) Were participants blind to treatment assignment? Q5) Were those delivering treatment blind to treatment assignment? Q6) Were outcomes assessors blind to treatment assignments? Q7) Were treatment groups treated identically other than the intervention of interest? Q8) Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? Q9) Were participants analyzed in the groups to which they were randomized? Q10) Were outcomes measured in the same way for treatment groups? Q11) Were outcomes measured in a reliable way? Q12) Was appropriate statistical analysis used? Q13) Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

2.4.6 Smartphone Application Designs and Features

Specific features of the interventions’ smartphone applications are highlighted in Table 2-4. Key features of the applications included: food recording, positive reinforcement, feedback, gamification, goal setting, nutrition messaging, collaborative challenges, peer interaction, and reflection. The key features of each intervention are summarized in Table 2-2.
### Table 2-4: Summary of Key Features in Smartphone Applications

<table>
<thead>
<tr>
<th>Key Application Feature</th>
<th>Details of Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food Recording n=6</strong></td>
<td>• Manual Entry (De Cock et al., 2018; Ragelienė et al., 2022; Villasana et al., 2020a)</td>
</tr>
<tr>
<td></td>
<td>• Photo Entry (Byrne et al., 2012; Heikkilä et al., 2019)</td>
</tr>
<tr>
<td></td>
<td>• Food Frequency Questionnaire (García-Muñoz et al., 2022)</td>
</tr>
<tr>
<td><strong>Positive Reinforcement n=6</strong></td>
<td>• Points/Score (De Cock et al., 2018; Kato-Lin et al., 2020; Ragelienė et al., 2022; Villasana et al., 2020a)</td>
</tr>
<tr>
<td></td>
<td>• Storyline/Game Level Progression (Baghaei et al., 2016; De Cock et al., 2018; Kato-Lin et al., 2020)</td>
</tr>
<tr>
<td></td>
<td>• Virtual Pet Response (Byrne et al., 2012)</td>
</tr>
<tr>
<td><strong>Feedback n=4</strong></td>
<td>• Feedback on Food Records (De Cock et al., 2018; García-Muñoz et al., 2022; Heikkilä et al., 2019; Ragelienė et al., 2022)</td>
</tr>
<tr>
<td><strong>Gamification n=4</strong></td>
<td>• Virtual Simulation (De Cock et al., 2018)</td>
</tr>
<tr>
<td></td>
<td>• Active Platform (Baghaei et al., 2016; Kato-Lin et al., 2020)</td>
</tr>
<tr>
<td></td>
<td>• Puzzle Style (Ragelienė et al., 2022)</td>
</tr>
<tr>
<td><strong>Goal Setting n=3</strong></td>
<td>• Personal Goals/Challenges (Villasana et al., 2020a)</td>
</tr>
<tr>
<td></td>
<td>• Weekly Focused Goals (De Cock et al., 2018; Heikkilä et al., 2019)</td>
</tr>
<tr>
<td><strong>Nutrition Messaging n=3</strong></td>
<td>• Healthy Eating Messages (Villasana et al., 2020a)</td>
</tr>
<tr>
<td></td>
<td>• Nutrition Facts Messaging (Kato-Lin et al., 2020; Ragelienė et al., 2022)</td>
</tr>
<tr>
<td><strong>Collaborative Challenges n=1</strong></td>
<td>• Weekly Team Point Challenges (De Cock et al., 2018)</td>
</tr>
<tr>
<td><strong>Peer Interaction n=1</strong></td>
<td>• Share and React to Recipes (Ragelienė et al., 2022)</td>
</tr>
</tbody>
</table>

The two most common features found within the applications were food recording (n=6) and positive reinforcement (n=6). Three applications required participants to manually
enter their food diary into the application (De Cock et al., 2018; Ragelienë et al., 2022; Villasana et al., 2020a), two applications allowed participants to take photos of their food as a recording tool (Byrne et al., 2012; Heikkilä et al., 2019), and one application administered a food frequency questionnaire to users (García-Muñoz et al., 2022). Positive reinforcement was delivered in applications in a variety of formats such as accumulating points or a score, progressing through a game or virtual storyline, and emotional response from a virtual pet. The “Snack Track School” application by de Cock et al. rewarded points to participants based on the healthiness of the snacks that were entered into their food records and when personal or group goals were achieved; this positive reinforcement was continued by progressing through the virtual high school environment storyline based on the accumulation of points (De Cock et al., 2018). Ragelienë et al. gave positive feedback through the form of a score on a healthy eating game (Ragelienë et al., 2022), whereas Kato-Lin et al. and Baghaei et al. provided positive feedback through game-level progression (Baghaei et al., 2016; Kato-Lin et al., 2020). Villasana et al. displayed a score to participants based on weekly healthy eating questionnaire results (2020a), and Byrne et al. utilized a virtual pet to show an emotional status in response to the healthiness of the breakfast that participants recorded for that day (Byrne et al., 2012).

Nutritional feedback (n=4) was found specifically among the applications as a response to a participant’s food record entries. Two applications provided individualized feedback on food records (De Cock et al., 2018; Heikkilä et al., 2019), one application provided general eating recommendations after participants completed a food frequency questionnaire (García-Muñoz et al., 2022), and one application provided nutritional information for participants fruit and vegetable diary (Ragelienë et al., 2022).

Gamification elements (n=4) across applications included story line progression, puzzle style, or active platform. As mentioned, the “Snack Track School” guided participants through a virtual high school story line progression driven through a points system (De Cock et al., 2018). “Food Boss,” the smartphone application used by Ragelienë et al., featured a puzzle-style game where users had to click on healthy foods during repeated exposures (2022). The two interventions that focused primarily on gamification were
designed as active platform games (Baghaei et al., 2016; Kato-Lin et al., 2020). The “Fooya” application, used by Kato-Lin et al., took participants through an 80-level action game where the goal was to collect healthy foods to keep an avatar at a healthy body weight and maintain enough energy to fight enemies to unlock the next level of the game (2020). Similarly, Baghaei et al. modeled their game application “Diabetic Mario” from a popular active platform game (Mario Brothers) (2016). The goal of the game was to control the main character’s energy intake, exercise, and insulin levels in order to progress through the levels of the game (Baghaei et al., 2016).

Goal setting (n=3) appeared in applications in the format of personalized goals or of weekly challenges that are assigned to each user. In the application “Covi Health,” participants could create objectives as well as accept challenges in response to content they learned about (Villasana et al., 2020a) In “Snack Track School”, users had the opportunity to complete assigned weekly goals (De Cock et al., 2018). Similarly, participants in the Heikkila et al. intervention focused on an assigned weekly nutrition topic and uploaded photos using the application “MealLogger Pro” to track goal progression (2019).

Nutrition messaging (n=3) were within smartphone applications as specific messages about healthy eating or were shown as nutrition facts information. “Covihealth” was the only application that delivered healthy eating messaging to users in what researchers called “nutrition tips and curiosities” (Villasana et al., 2020a). “Fooya” displayed nutrition facts of the foods collected by the avatar during gameplay (Kato-Lin et al., 2020). “Food Boss” had a feature in the application where users could create their own recipes and get instant nutrition facts on the recipe that they created (Ragelienė et al., 2022).

Collaborative challenges were a feature found in only one application; participants in the “Snack Track School” intervention had the opportunity to complete weekly challenges with peers to gain points (De Cock et al., 2018). Similarly, peer interaction was only present in the “Food Boss” application where users could share the recipes they created with their friends and view and like friends’ recipes (Ragelienė et al., 2022).
2.4.7 Smartphone Application Theoretical Frameworks

There were two studies that did not report using a theoretical framework for the smartphone intervention design (García-Muñoz et al., 2022; Villasana et al., 2020a). The remaining six studies reported varying theories of the intervention to promote behaviour change (Byrne et al., 2012; De Cock et al., 2018; Heikkilä et al., 2019; Ragelienë et al., 2022), or described a theory to promote engagement in the design process of the application (Baghaei et al., 2016; Kato-Lin et al., 2020).

Two studies utilized Social Cognitive Theory to frame the smartphone application in the intervention design (Byrne et al., 2012; Ragelienë et al., 2022). Byrne et al. focused on the promotion of modelling behaviour by providing positive or negative feedback to serve as motivation for learning and behaviour change (2012). Similarly, Ragelienë et al. used this theory to inform the social interaction components of their smartphone application; liking, reacting, commenting, and viewing peers’ application content was reported as developing competence and control through modelling peers’ behaviours (2022).

The study completed by Heikkila et al. involved both education sessions and the use of a smartphone application in the intervention (Heikkilä et al., 2019). These researchers used the meaningful learning process which focused on increasing motivation based off the Self-Determination theory (Heikkilä et al., 2019). The education sessions and interaction with the application aimed to increase feelings of autonomy, competence, and relatedness to achieve intrinsic motivation to lead to behaviour change (Heikkilä et al., 2019).

De Cock et al. used the dual process model as a theoretical framework as it includes both explicit and implicit pathways to describe the theory of changing behaviours (2018). They focused primarily on rewards and positive reinforcement behaviour change techniques for eating habits (implicit processes) and goal setting, exposure, monitoring, feedback, and active learning for eating intentions (explicit processes) (De Cock et al., 2018).
Two studies used theoretical underpinnings within the design of their smartphone application to promote engagement (Baghaei et al., 2016; Kato-Lin et al., 2020). Kato-Lin et al. focused on the theory of intrinsic motivation (2020). With the goal of participants engaging with the smartphone application because they found it satisfying, the intervention aimed to target implicit learning processes by increasing knowledge necessary to change behaviours (Kato-Lin et al., 2020). Baghaei et al. used the theory of “flow”, defined as being in the state of intensive involvement, when designing the gamification component of their application (2016). Intensive involvement in the game is achieved by structuring game difficulty to be adjusted to match knowledge, feedback about performance is delivered during engagement, and the application has varying challenges that increase in complexity (Baghaei et al., 2016). The combination of these features in the application design ultimately contributes to an active learning environment (Baghaei et al., 2016).

2.4.8 Intervention Effectiveness on Food Knowledge

Four of the eight studies included in this review reported significant food knowledge outcome measures (Byrne et al., 2012; Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienè et al., 2022). Heikkila et al. found a significant increase in nutrition education scores across time both the control group (participants receiving nutrition education sessions) and the intervention group (participants receiving nutrition education sessions and phone application) \( p < 0.001 \) (Heikkilä et al., 2019). There was no difference in education scores between the two groups and there were no significant differences in education scores between groups across time of the study (Heikkilä et al., 2019).

Researchers found that there was a significant increase in scores across time in the topics of nutrition recommendations for endurance athletes, dietary supplements, fluid balance and hydration, and energy intake and recovery \( p < 0.001 \), but there was no significant increase in score for the topic on association between food choices and body image (Heikkilä et al., 2019). Using one survey question on identifying healthy foods out of a list, Kato-Lin et al. found that there was a significant increase in the number of healthy foods identified by the treatment group post-intervention compared to the control group \( p = 0.048 \) (2020). Ragelienè et al. assessed five healthy diet items on fruit and vegetable
consumption and healthy diet guidelines and found that there was one significant improvement found in the intervention group on the item relating to the importance of balanced meals for a healthy diet \( (p = 0.006) \) (2022). Byrne et al. assessed the importance of healthy eating across multiple intervention arms receiving different treatment conditions; one group was assigned to receiving both positive and negative feedback from the application, one group received neutral and positive feedback, and one group was in the control condition with no application interaction (Byrne et al., 2012). It was found that those in the positive feedback only condition reported caring less about healthy eating than those in the combined positive and negative condition \( (p < 0.01) \) and the control group \( (p < 0.05) \) (Byrne et al., 2012).

Alternatively, De Cock et al. found an adverse effect in the intervention outcome (2018). By scoring the healthiness of 28 food items to determine participants’ knowledge about the healthiness of snacks, they found that there was a decrease in knowledge about healthiness of snacks in the intervention group \( (p = 0.04) \) in comparison to the control group, where food knowledge increased (De Cock et al., 2018).

Two studies used descriptive statistics to analyze outcome findings (Baghaei et al., 2016; Villasana et al., 2020a). Nutrition knowledge was assessed in the form of a questionnaire with four questions regarding the previous week’s lessons in the application intervention implemented by Villasana et al. (2020a) Using four unique questionnaires (one unique questionnaire per week), Villasana et al. reported that the highest score was achieved in the week three questionnaire, the lowest scores were in the second week, and the scores remained the same in the first and fourth week (2020a) Testing for change in scores over time was not measured. Baghaei et al. used a 21-item questionnaire on health-related knowledge (diet, physical activity, and diabetes) and reported using descriptive statistics that there was an increase in average scores for questions related to healthy food choices between pretest (66%) and post-test (77%) assessment (2016).

One study, completed García-Muñoz et al., reported no significant findings in the healthiness perception of 12 different foods on individual, country, and group between pre-intervention and post-intervention (2022).
2.4.9 Intervention Adherence

Two studies measured the impact of engagement with the outcome measures (De Cock et al., 2018; Heikkilä et al., 2019). Heikkila et al. reported that participants within the intervention group who engaged with the application over the five-week study period obtained higher knowledge scores than the participants that did not engage with the application \((p < 0.001)\), and that there was a significant group by time and effect of time \((p < 0.001)\) for participants who participated in all education lectures (2019). De Cock et al. assessed outcome measures between high users, low users, and participants who did not engage with the application; over the 28-day intervention period, non-users were those who did not log into the application over the study duration, low-users logged in less than four days and high-users logged in more than four days (2018). Results showed that non-users and the low app users had a higher decrease in knowledge about the healthiness of snacks compared to the control group \((p <0.05\) non-users, \(p <0.05\) low users) (De Cock et al., 2018).

2.5 Discussion

2.5.1 Summary of Findings

This systematic review identified and assessed eight studies that investigated the use of smartphone applications to improve food knowledge in the adolescent population. This review is unique to other reviews as it focuses solely on food knowledge outcomes using evidence-based smartphone applications among adolescents, irrespective of their health statuses. The features, theoretical frameworks, and effectiveness of these applications were explored to determine their potential for food literacy initiatives that utilize smartphone technology.

The eight unique applications in this review had a varying number and combination of features. Food recording was the feature found in most of the applications followed by positive reinforcement, feedback, and gamification. Recording diet or other self-assessment tools as the main feature in applications is consistent across other reviews that assess smartphone applications for adolescents (Dute et al., 2016; Villasana et al., 2020b). The features least found in the included studies were collaborative challenges,
peer interaction, and reflection. This is a surprising finding as research has found that modeling and social support are highly important considerations for apps focusing on youth health behaviour changes (Brannon & Cushing, 2015). These are important components to include in future nutrition interventions for this age group.

Theoretical frameworks used to inform the design of the interventions included social cognitive theory, dual-process model, and self-determination theory; intrinsic motivation theory and the theory of game flow were used as theories to promote engagement with the applications. All interventions with positive outcomes were informed by a theoretical model; both studies that used social cognitive theory, one study that used self-determination theory, and one study using intrinsic motivation theory found effectiveness in food knowledge outcomes. These findings align with other systematic reviews that found theory-informed technology-based and internet-based nutrition interventions to generally more effective than those without a theoretical underpinning at (do Amaral e Melo et al., 2017) promoting healthy behaviour changes (Kohl et al., 2013; Webb et al., 2010).

Positive outcomes were found in half of the included studies. Three out of the eight studies reported significant increases in at least one area of food knowledge (Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienė et al., 2022). Specifically, improvements were found in overall food knowledge scores (Heikkilä et al., 2019), identifying healthy foods (Kato-Lin et al., 2020), and knowledge on the importance of balanced meals (Ragelienė et al., 2022). Furthermore, one study found a significant increase in the perception of the importance of eating healthily (Byrne et al., 2012). Each of these interventions had a variety of application features; however, there is a pattern of features that are commonly found between them. Between the four studies there was an overlap in features including food recording (75%), positive reinforcement (75%), nutrition messaging (50%), feedback (50%), and gamification (50%). Although most studies did not go into detail about the theoretical basis for each specific feature, each of them could be categorized as a behaviour change technique (BCT) according to the taxonomy proposed by Michie et al. (2013). Food recording in this framework is classified as self-monitoring of behaviour. While self-monitoring in applications has shown to be effective at changing
diet behaviours, the personalized feedback of self-monitoring BCT has shown to be an effective way to improve nutrition knowledge (Chung & Fong, 2018). Feedback has also been found to increase the adherence of self-monitoring (Turk et al., 2013), indicating that the combination of these two features may also work in a causal loop to promote application exposure. It is, however, important to note that emerging research suggests tracking food for teens and young adults can have unintended consequences such as poor relationships with foods, body image dissatisfaction, and restrictive eating patterns (Eikey, 2021; Honary et al., 2019; Levinson et al., 2017).

Gamification in the applications were all combined with positive reinforcement features which could be classified as the BCT of social reward (i.e., the game would respond with positive messaging and/or progress to the next level). It is unclear the number and combination of BCTs used in game design within the included studies due to the general detail given about these games in the reporting; however, strategically designing games with these techniques in mind may show promise, as research suggests that game-based approaches can have a positive influence on youth’s attitudes and knowledge towards healthy eating (Chow et al., 2020). Nutrition messaging worked in combination with gamification or as a solo feature in the applications. The messaging within the included studies are a combination of shaping knowledge BCTs as well as comparing outcomes using credible sources. Promisingly, this is beginning to address the call from other reviews for more evidence informed applications to be available to teens (Schoeppe et al., 2016, 2017). However, given that this review of eight studies included only three studies with nutrition messaging, there is a gap of this BCT among dietary or health behaviour apps and there is still work needed to be done to have evidence-based apps well-marketed in a public domain accessible to teens.

Like other systematic reviews (Villasana et al., 2020b), there was a differing number of features between the applications with positive outcomes. Literature suggests that the number of components within an application may not increase effectiveness due to the often static nature of these features (Villinger et al., 2019). For instance, including multiple components to an application without a dynamic response from the app (such as personalized feedback, progress updates, or well-timed notifications) may not be as
effective, regardless of how many features are present (Villinger et al., 2019). Too much content may also overload the user during a learning experience (van Genugten et al., 2016). However, researchers found that apps that scored higher quality using a mobile application rating score (Stoyanov et al., 2015) incorporated more behaviour change techniques (Schoeppe et al., 2017). This suggests that features should be strategically integrated into an app, where those features are effective at interacting with users without being overly complex, in order to have effective outcomes.

This review reveals that engagement may be a key factor in influencing food knowledge improvements. Of the two studies that measured smartphone application adherence, both found significant differences in food knowledge between users and low-users or non-users (De Cock et al., 2018; Heikkilä et al., 2019). In the two studies that used theoretical frameworks in the application design to promote engagement with the application, one had a statistically positive finding for identifying healthy foods (Kato-Lin et al., 2020), while the other had an improvement in food knowledge score averages (Baghaei et al., 2016). These findings align with a similar study that found higher engagement with a smartphone application improved fruit, vegetable, and breakfast intake among adolescents (Caon et al., 2022). This highlights the importance of designing smartphone applications with theoretically informed features that encourage participation with the application. Unfortunately, only two studies in this review measured engagement. This is consistent with other reviews on web-based health interventions (Davies et al., 2012; Schoeppe et al., 2016; Villinger et al., 2019). As increased engagement means increased exposure to the intervention, future studies should strive to understand how engagement influences their interventions. While facilitators and barriers for application use may overlap (for example, notifications may be a barrier to some users but a facilitator for others), developers can address barriers through application design by considering the user’s needs, the interaction between user and the application, and the social environment (König et al., 2021).

It is important to note that these findings should be interpreted with caution when looking solely at food knowledge outcomes, as improvement in food knowledge was the primary objective for only one (Heikkilä et al., 2019) of the effective interventions. Two of the
interventions with significant findings only utilized a 1-item question on healthy food knowledge or the importance of healthy eating, and one study found significance for only 1-item out of a 5-item questionnaire on healthy eating knowledge. With the complexity and breadth of nutrition literacy, this low number of testing items may not truly assess nutrition knowledge comprehension that would lead to long-term behaviour changes. The fourth study that found significant changes in nutrition knowledge utilized nutrition education sessions for both the intervention and control group, indicating that multi-component interventions may show promise for nutrition education, but that sole use of applications may not result in knowledge improvements (Heikkilä et al., 2019). A balance needs to be considered as research shows that apps may be more effective when they are included as part of an already existing structure (Kohl et al., 2013) or in combination with other intervention strategies (Schoeppe et al., 2016).

2.5.2 Limitations

Limitations within the included studies should be noted for future food knowledge interventions. Many studies noted that personalization, either in the interaction or feedback of the application, was a limitation in shaping unique experiences for each participant. Small sample size and study duration was a limitation for many studies, and follow-up was seldom measured. Only three studies reported using reliability testing with their measures (Byrne et al., 2012; Heikkilä et al., 2019; Kato-Lin et al., 2020) and one study reported that food knowledge testing was completed using a validated questionnaire (Heikkilä et al., 2019). Each of these are important considerations as there is no standardized nutrition knowledge assessment tool to date that researchers can utilize, (Carroll et al., 2022) emphasizing the importance of identifying and using reliable and validated tools when assessing food knowledge outcomes.

This review also has limitations in its design. The search strategy was limited to those articles only available in English and did not include reports that were not peer-reviewed. Thus, features and effectiveness of other well-researched nutrition applications may have been missed. Nutrition literacy involves complex competencies for many concepts around food and eating. This review only included search terms for functional competencies such as food and nutrition knowledge. Relational and food system
competencies are emerging themes within nutrition literacy frameworks and should be included in search terms for future reviews on nutrition literacy as they become more readily used in research. Another limitation to this review is that feasibility measures were not included in this review, even if they were reported by the study. Acceptability and feasibility of the smartphone applications are an important indicator for engagement and consideration of these factors can better inform application improvements or development for future initiatives.

2.6 Conclusion

Smartphone applications have the potential to be a useful tool to improve food knowledge and ultimately influence eating behaviours among adolescents. Each smartphone application in this review was unique with the number and variety of features used, as well as the theoretical framework used to inform the application design. There is no conclusive combination of these characteristics that resulted in positive outcomes, indicating that there is not a “one size fits all” approach to designing nutrition education applications. Some applications show positive results in improving food knowledge, but most lacked the use of comprehensive validated tools to measure food knowledge outcomes. This review also indicated that engagement is a factor that could influence food knowledge improvements. Future studies should consider barriers and facilitators to engagement in addition to tailoring application features strategically with behaviour change techniques that consider the population, setting, and intended outcomes for nutrition literacy competencies.
2.7 References


Honary, M., Bell, B. T., Clinch, S., Wild, S. E., & McNaney, R. (2019). Understanding the role of healthy eating and fitness mobile apps in the formation of maladaptive
eating and exercise behaviors in young people. JMIR MHealth and UHealth, 7(6). https://doi.org/10.2196/14239


Villinger, K., Wahl, D. R., Boeing, H., Schupp, H. T., & Renner, B. (2019). The effectiveness of app-based mobile interventions on nutrition behaviours and


Chapter 3

3 Effectiveness of Engagement with a Smartphone Application on Adolescent Food Knowledge: Randomized Controlled Trial

3.1 Abstract

There is a growing need for improved food knowledge skills among adolescents to promote healthier eating habits into adulthood. Smartphone applications provide a novel way to teach food knowledge due to their popularity among this population. This study aimed to evaluate the effectiveness of a smartphone application, “SmartAPPetite”, on adolescent food knowledge. This study also explored the influence engagement has on knowledge scores and identified characteristics of high engagers. Adolescents in London, Ontario (n=571) participated in a randomized controlled trial where the intervention group (n=356) engaged with SmartAPPetite for 10-weeks and the control group (n=215) did not use the smartphone application. All participants completed a food knowledge questionnaire pre and post study. There were no significant findings between food knowledge scores between the intervention and control group (p=0.199). Within the intervention group, there was no difference in food knowledge scores between the non-engagers (n=83) and low engagers (n=149) (p=0.880), and there was no difference in scores between the non-engagers and high engagers (n=123) (p=0.166). Within the high engager group, there was a significant difference in food knowledge scores over time (p=0.010). Among the high engager group, there were no statistically significant characteristics that differentiated them from the low-engager group, but there was a higher ratio of female, White/Caucasian, and older aged participants that engaged highly with the app as well as users who followed a special diet or had a health condition that affects eating patterns. Engagement was the key determinant that influenced improved food knowledge scores. This smartphone application-based intervention could potentially serve as a tool for improving food knowledge improvements in adolescents; future research should consider engagement improvement strategies for this population.
3.2 Introduction

Globally, there is a high prevalence of chronic non-communicable diseases such as heart disease, diabetes, and certain cancers that are causally related to dietary risk factors (Afshin et al., 2019). To reduce the occurrence of these diseases, it is important to mitigate their risk factors. Poor dietary habits that develop in adolescence have been found to carry on into adulthood (Mikkilä et al., 2005; Movassagh et al., 2017), making this an important life stage for preventative interventions. Adolescence is a stage of increasing autonomy and individual decision-making (Lamb et al., 2001), and teens begin making independent food choices and consume food outside of the home more often (Woodruff & Hanning, 2008). Among Canadian teens, increasing independence with respect to food choices has been associated with decreased fruit and vegetable consumption, increased sugary drink intake, and increased fast-food consumption, which have been found to co-occur as dietary risk factors (Hardy et al., 2012).

Nutrition education initiatives are a strategy to promote healthy food choices to teens as they gain independence. Increasing knowledge about food and how nutrition impacts health is a key influence at the individual level as adolescents begin to explore and develop personally meaningful values and attitudes (Bogaerts et al., 2019). Furthermore, the environment plays a significant role in adolescent food choice such as in social environments (Drolet & Arcand, 2013; Neufeld et al., 2022), physical environments (He et al., 2012; Ziegler et al., 2021), and online environments (Neufeld et al., 2022; Scully et al., 2012). Nutrition literacy aims to increase self-efficacy when making food choices among these influences (Azevedo Perry et al., 2017). Dietitians of Canada define food literacy as an “individual’s ability to have the knowledge and skills to make decisions within a complex food system across the lifespan to support personal health and a sustainable food system” (Cullen et al., 2015). Research exploring dietary intake in adolescents has shown that food literacy interventions can be effective at promoting positive diet-related behaviour changes (Vaitkeviciute et al., 2015). Food knowledge is a component of food literacy. Food knowledge focuses on the ability to understand and seek out information about food, inclusive of functional knowledge such as food skills and choices and critical information about food and food issues (Truman et al., 2017).
Adolescents often turn to the internet to seek out health information (Skopelja et al., 2008) which is becoming increasingly accessible by the near ubiquitous uptake of smartphones among this population. In Canada, over 88% of adolescents over the age of 15 have a smartphone (Government of Canada, 2021). The prominent use of smartphones in this population demonstrates that these platforms could be effective for health interventions that include food knowledge improvements (Rohde et al., 2019). Research on the use of smartphone applications for adolescent food knowledge has become more prominent in the literature (Schaafsma et al., 2023), with most interventions including other outcomes such as dietary intake changes (Byrne et al., 2012; De Cock et al., 2018; García-Muñoz et al., 2022; Heikkilä et al., 2019; Kato-Lin et al., 2020; Ragelienė et al., 2022; Villasana et al., 2020), feasibility of the application (Baghaei et al., 2016; Byrne et al., 2012; De Cock et al., 2018; Villasana et al., 2020), self-efficacy (De Cock et al., 2018; Ragelienė et al., 2022), food preference (García-Muñoz et al., 2022; Ragelienė et al., 2022), and physical activity (Villasana et al., 2020). There have been mixed findings on food knowledge improvements in current smartphone applications targeted towards teens. Some studies have reported no statistically significant findings in food knowledge outcomes (Baghaei et al., 2016; De Cock et al., 2018; García-Muñoz et al., 2022; Villasana et al., 2020) and those that did observe positive findings have used additional in-person education sessions (Heikkilä et al., 2019) or measured a limited scope of food knowledge outcomes (Byrne et al., 2012; Kato-Lin et al., 2020; Ragelienė et al., 2022).

It is important to consider that smartphone applications being used as an intervention medium are unlikely to provide a human-facing delivery method as seen in other nutrition education initiatives for adolescents, such as classroom-based research (Medeiros et al., 2022). Adherence to an intervention can be more feasibly measured with in-person delivery interventions and is a key determinant in assessing accurate interpretation of study results, but measures of adherence (i.e., engagement) are not consistently reported among digital health intervention studies (Beinttner et al., 2019). Some form of engagement is assumed to be important for smartphone application effectiveness as it is not possible for change to occur if participants are not using the application (Donkin et al., 2011). Therefore, digital health researchers have
recommended measuring engagement in interventions using a digital platform such as a smartphone application (Beintner et al., 2019; Perski et al., 2017; Yardley et al., 2016).

Interventions that utilize a publicly available, standalone smartphone application on food knowledge outcomes for adolescents has not yet been reported in the literature. There also does not seem to be any nutrition education smartphone application for teens that considers the influential role that the environment plays on food choices. While engagement has been assessed in some food knowledge smartphone application interventions (De Cock et al., 2018; Heikkilä et al., 2019), this factor has not been considered consistently across this field of research.

In an attempt to fill this gap in the literature, the main objectives of this study are to 1) determine if the use of a smartphone-based intervention improves nutrition knowledge for adolescents, 2) understand if the level of engagement with the app influences a change in nutrition knowledge and 3) identify characteristics of adolescents who engage with food knowledge applications to identify the intervention reach.

### 3.3 Methods

#### 3.3.1 Theoretical Foundations and Intervention Design

SmartAPPetite is a healthy eating smartphone application that aims to improve user food knowledge, food purchasing behaviours, dietary behaviours, and ultimately user wellbeing. The application was informed by the Social Ecological Model (SEM) as a guiding framework and uses behavioural economics in the intervention design. The SEM emphasizes that behaviours shape and are shaped by the environment with multiple spheres of influence (Glanz & Bishop, 2010) suggesting that behaviour change strategies linked to environmental supports can improve both individual and collective well-being (Stokols, 1996). This model has been used in research for understanding how adolescent food choice can be impacted by factors at different levels (Neufeld et al., 2022; Woods et al., 2023). SmartAPPetite aims to improve knowledge and food choices at the individual level while also considering the influence of the built environment at the organizational and community level on individual behaviours. This is accomplished through messaging prompts that are delivered both temporally and spatially based on a user’s interests and
geographical location. These notifications are a form of choice architecture intended to ‘nudge’ an individual towards a particular behaviour change. Nudging stems from the behavioural economics theory of libertarian paternalism (Thaler & Sunstein, 2020). Libertarian paternalism aims to shift behaviours as a means of self-interest without impeding freedom of choice (Downs et al., 2009).

SmartAPPetite sends food knowledge and local food retailer information to users in the form of short messages. Brief tips are sent to the user’s phone as notifications and display a short description about the food topic. This ‘nudging’ prompts the user to click on the notification. For example, the notification might say, “Is fat bad for you? Click here to learn about the different types of fat your body needs!” When the user clicks the notification, the SmartAPPetite app is launched and displays the full message about the food knowledge topic. Within the full message, users are also provided with selected external sources to learn more valid information about the topic and a list of recipes that are relevant to the message. Figure 3-1 outlines screenshots of the features within SmartAPPetite.

SmartAPPetite messages are written by trained health researchers using information from reliable academic sources and credible Canadian dietetic and public health websites and are carefully reviewed and approved by Registered Dietitians before being published in the application. When the user first downloads the application, they are prompted to rate their interest level for several nutrition topics (Figure 3-1a); the app then sends tailored messages to the user based on their interests from a coded database of over 1000 unique messages.

Messages are sent to users both temporally and spatially. Temporal messages are sent on a scheduled frequency. Default settings in the application enable three messages to be sent to users each day at breakfast, lunch, and dinner times. Users can change the timing and number of messages they receive in the application settings. The content of temporal messages includes nutritional information, health benefits of foods, food preparation tips, and safe storage of foods. Spatial messages are notifications sent to users when they are within 300 metres of food retailers. In the SmartAPPetite for Youth study, these location-
based notifications appeared when users were near a fast-food restaurant to divert them away from unhealthy choices by informing them of healthier options. For example, if a user is within 300 metres of a fast-food restaurant, they may receive a notification that says, “Water is always a healthy choice! Click here to learn more about healthy alternatives when eating out.”

Users have the option of liking or disliking a message after they review it which further tailors the types of incoming messages they receive in the future. Users can also ‘favourite’ a message which will pin the message to the home screen of the application to make it available for viewing again in the future (Figure 3-1d).
Figure 3.1: Screenshots of the SmartAPPetite User Interface

a. Users rank interest of food knowledge topics when they download the application to receive tailored messaging.

b. An example of a food knowledge message format.

c. An example of a recipe linked to a food knowledge topic.

d. A list of messages “favourited” by the user that they can view again in the future.

3.3.2 Study Design

The SmartAPPetite for Youth intervention, led by the Human Environments Analytics Laboratory (The HEAL) at Western University, is a longitudinal, cluster randomized controlled trial that took place between 2017 and 2023 (The Human Environment Analysis Laboratory, 2017).

This intervention targets high school students between the ages of 13-19 years as this is an age where new food habits and purchasing behaviours are formed and can be carried into adulthood (Laska et al., 2012). The Census Metropolitan Area (CMA) of London, Ontario, with a population of 494,069 (Government of Canada, 2017), was identified as the ideal location for the intervention as it contains a range of built environments (urban, suburban, and rural) and the HEAL team had existing relationships with the regional
school boards that are supportive of the SmartAPPetite project, allowing for a feasible recruitment plan. This region has also been fully mapped with data on all food retailers (The Human Environment Analysis Laboratory, 2021). By conducting the intervention in locations where retailers have been mapped and programmed into the application, participants can gain a full experience of the application’s geographically prompted messaging in areas with fast-food vendors.

Participating high schools were randomly assigned as intervention schools or control schools. Participants from the intervention schools were asked to download and engage with the SmartAPPetite phone application, whereas the control group were not given access to the app. Participants in the intervention group engaged with the application for 10 weeks, an ideal time frame to identify significant changes in dietary behaviour intervention studies (Plotnikoff et al., 2015). Participants engaged with the application during their own time.

The COVID-19 pandemic disrupted data collection for the intervention, as schools were closed intermittently from March 2020 – September 2021. Therefore, the research presented in this paper is restricted to an analysis of data from participants recruited in schools before COVID-19 between 2017 and 2019.

3.3.3 Data Collection

3.3.3.1 Participant Recruitment and Consent

Applications to conduct research within schools were sent to the two English-speaking school boards in London, Ontario. Emails outlining the study details were sent to the principals of each school within the approving school boards. For individual schools that accepted the study, posters were hung within the school and invitations to participate in the study were distributed to students within class. Students took home letters of information and consent forms for the study (Appendix B). Students that were under the age of 18 had to return a signed consent from a parent or guardian to participate. Participants were required to have English comprehension as this was the only language currently available for the SmartAPPetite intervention and the survey instruments.
3.3.3.2 Youth Survey

Participants in both the intervention and control group completed a youth survey using Qualtrics software before the intervention began (T1) and completed the same survey at the end of the 10-week study period (T2). If the student did not have their device at school to independently complete the survey on, a tablet was lent to them to complete the electronic survey. Students were excused from class to complete the surveys in a separate space (e.g., library, cafeteria, or large classroom) with the research team present to support with any questions the participants might have. Students were given 45 minutes to complete each survey.

The survey included questions on demographic information such as gender identity, age, and ethnicity; questions about physical health, mental health, the use of health apps or wearable technology, and dietary restrictions and/or practices; questions on eating habits such as frequency of meals and snacking as well as food purchasing behaviours; and questions on food knowledge.

A total of 52 food knowledge questions were adapted from a previously validated study by Registered Dietitians on the research team (Anderson et al., 2002). The food knowledge questionnaire covered knowledge areas on recommended food intakes, nutrient content of food groups, making healthy food choices, and effects of nutrition on health (Appendix C).

3.3.3.3 Parent Survey

Parents of participants were invited to complete one optional household demographic survey at the start of the intervention using Qualtrics software. Demographic questions included ethnicity, household size, household arrangement, household income, parental education, employment status, and postal code.

3.3.3.4 App Analytics

All data collected in the SmartAppetite phone application was retrieved using App Analytics Software. This data includes the number of messages sent, number of messages opened, and the unique number of days each user engaged with the application.
3.3.3.5 Incentives

Each participant received a $10 gift card for completing the first baseline survey. Participants were granted a $15 gift card for the completion of the second survey. Parents received a $10 gift card for completing the household demographic survey.

3.3.3.6 Ethics

Ethics for this study were approved by Western University’s Non-Medical Research Ethics Board (#107034) and by the research committees of the participating school boards (Appendix D).

3.3.4 Measures

3.3.4.1 Food Knowledge

Food knowledge was measured from the total score of the 52 multiple-choice format food knowledge questions of the study survey. There was only one correct answer per question. Correct responses were given a score of 1 and were summated to calculate a total score out of 52 points. Surveys had to be at least 50% completed to be included in the analysis. Participants that completed T2 but not T1 were excluded from analysis.

3.3.4.2 User Engagement

Engagement was calculated using the App Analytics software. The engagement frequency was calculated by dividing the total number of messages opened by the user from the total number of messages sent to the user and converted to a percentage.

\[
\text{Engagement frequency} = \frac{\text{Number of messages opened}}{\text{Number of messages sent}} \times 100
\]

As SmartAppetite is publicly available and study participants could continue using the application after the intervention period, a filter was applied to App Analytics to only retrieve messaging data between the start data of the intervention (survey 1 completion
date) to the last day of the intervention (survey 2 completion date) to include only the messages sent and opened during the study period, and halt data collection thereafter.

Participants were categorized into four engagement level profiles dependent on their engagement frequency. “Non-engagers” were participants who did not download the application or downloaded the application but did not open any messages; “low engagers” had an engagement frequency between 1.0-15.9% (i.e., between 1 – 15% of messages were opened); and “high engagers” had an engagement frequency greater than 16.0%. As the average number of messages sent to participants was three per day, the engagement levels were created on the rational of how many days the participant could have engaged with the application. Low engagers could have opened one message less than every other day (<15.9%), and high engagers could have opened at least one message every other day (>16.0%). Sensitivity testing of these thresholds was performed by analyzing study outcomes using cut-off engagement frequencies ranging from 10% to 30% between the low and high engagement groups (Thabane et al., 2013).

### 3.3.4.3 Characteristics of Engagers

To describe the characteristics of the engagers in the intervention, the non-engagers and low engagers were combined into a “non/low engager” group and compared to the high engager group. Demographic characteristics such as gender, ethnicity, age, parental education, and household income were used to compare top engagers and non/low engagers. Other variables used to describe engagers were self-reported health statuses, use of other health-related smartphone applications, health conditions, and special diets.

### 3.3.5 Statistical Analysis

Data were combined, organized, and analyzed using SPSS software (v. 28.0.1.1). Statistical analysis was completed using a 95% confidence interval.

Descriptive statistics were used to determine distribution patterns of the baseline and final knowledge scores. As each histogram illustrated a normal distribution, an analysis of covariance test (ANCOVA) was used to determine the change in improvement scores between the intervention and control group. As the intervention was randomly
controlled, the baseline knowledge scores were used as the covariate in the ANCOVA model to control for the confounding effect the baseline knowledge scores could have on the differences for the final knowledge score (de Boer et al., 2015). Levene’s test of equality of error variances was performed to meet the assumptions of the ANCOVA analysis with unequal group sizes. ANCOVA testing was also used to test within group knowledge differences between gender, ethnicity, age, parental education, and household income.

Paired t-testing was used to evaluate the change in food knowledge scores within each engagement level group over time. Independent t-testing was used to compare the average difference in knowledge scores (T2-T1) using the non-engager group as a reference point and comparing this reference group to both the low engager and high engager delta knowledge scores.

Cross tabulation analysis was used to compare characteristic variables between non/low engagers and top engagers by assessing the percentages and adjusted residual values of each characteristic within the engagement group (Beasley & Schumacker, 1995). Chi-squared testing was used to determine if there were significant differences in characteristics between the non/low engager group and high engager group. Chi-squared testing was also used to determine if there was a significant difference in characteristics between participants who dropped out of the study. As testing multiple hypothesis in Chi-squared testing can increase the chance of a type 1 error (Armstrong, 2014), post-hoc analysis was conducted when there was a significant Chi-squared result. For significant results, adjusted residual values (z-scores) of each characteristic were squared and computed to p-values. The Bonferroni correction was applied to the significance level by dividing the level of significance (p=0.05) by the number of hypothesis tests being analyzed in the post-hoc analysis. The computed p-values were then compared to the Bonferroni corrected p-value to determine significant characteristics.
3.4 Results

3.4.1 Participants

Of the 1376 participants that enrolled in the study, all were eligible to participate. There were 927 students allocated from five intervention schools and 449 students from three control schools. A total of 175 and 64 students did not complete the first survey (T1) from the intervention group and control group respectively, and there was a loss to follow up of 390 participants in the intervention group and 164 students in the control group for the second survey (T2). The final sample size was 571 with 356 participants from intervention schools and 215 participants from control schools. Six participants from each group were excluded as they did not complete more than 50% of the T2 survey. An overview of the eligibility process flow is outlined in the CONSORT flow chart (Figure 3-2).
Participant ages ranged from 13-19 years, with the average participant aged 15.5 years. There were more females enrolled in the study than males (62.2%) and more than half of the participants (56%) identified as White/Caucasian. A summary of participant characteristics and the breakdown of other identified ethnicities is outlined in Table 3-1.

More than half of the parent surveys (58.8%) reported at least one parent in the household with a post-secondary education at diploma level or higher. Most households fell into the middle cut off for the average median household income by dissemination area (57.5%), followed by the high income cut off (34.9%), and low income cut off (7.6%). There were significant differences between the intervention and control group for both parent post-secondary education and neighbourhood-level household income.
Table 3-1: Characteristics of the Intervention, Control, and Total Study Sample

<table>
<thead>
<tr>
<th></th>
<th>Intervention (n356)</th>
<th>Control (n215)</th>
<th>Total (n571)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Mean SD</td>
<td>% Mean SD</td>
<td>% Mean SD</td>
</tr>
<tr>
<td><strong>Youth Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (%Female)</td>
<td>64.0 59.1</td>
<td>62.2</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (%Caucasian)</td>
<td>59.0 51.2</td>
<td>56.0</td>
<td></td>
</tr>
<tr>
<td>Age b</td>
<td>15.4 1.2</td>
<td>15.5 1.2</td>
<td>15.5 1.2</td>
</tr>
<tr>
<td><strong>Parent Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent Education (%Post-Secondary) c</td>
<td>55.1 50.5</td>
<td>58.8</td>
<td></td>
</tr>
<tr>
<td><strong>Household Income ($)</strong> d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income</td>
<td>4.3 13</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>Middle Income</td>
<td>55.1 61.4</td>
<td>57.5</td>
<td></td>
</tr>
<tr>
<td>High Income</td>
<td>40.6 25.6</td>
<td>34.9</td>
<td></td>
</tr>
</tbody>
</table>

a. Percentages of other ethnicities include: South Asian (4.7%), East Asian (4.9%), Middle Eastern (8.1%), Latin American (7.4%), Black (7.7%), Southeast Asian (2.3%), Mixed (8.6%)
b. 8 participants did not disclose age
c. 74 participants did not disclose. Post-secondary education is inclusive at the diploma, bachelor's degree, or higher than bachelor's degree level
d. 6 participants did not disclose. Income cut-offs determined by median income of dissemination area where low income is <$50K, middle income is $50k-$100K, and high income is >$100k

3.4.2 Intervention Effectiveness

Table 3-2 outlines the average T1 and T2 scores for the intervention and control group. The intervention group had a higher average knowledge score than the control group for each T1 and T2. Levene’s test of equality of error variances was not significant (P=0.333), indicating that the error variance of T2 scores is equal across both groups.

Results showed that there was no significant difference in knowledge scores between the intervention group and control group when controlling for T1 scores [F(1,568)=1.652,
p=0.199] (Table 3-3). Comparing the estimated marginal means in Table 3-2 shows that the intervention group scores for T2 decreased to 31.47 and the control group increased to 30.81, decreasing the differences in score averages when controlling for T1 scores.

There was no statistically significant difference in T2 scores when controlling for gender, age, ethnicity, parental education, or household income.

Table 3-2: Average T1 and T2 Scores by Group and Estimated Marginal Means for T2 Scores

<table>
<thead>
<tr>
<th></th>
<th>T1 Scores</th>
<th>T2 Scores (Unadjusted)</th>
<th>T2 Scores (Adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Control</td>
<td>30.20</td>
<td>7.48</td>
<td>30.23*</td>
</tr>
<tr>
<td>Intervention</td>
<td>31.29</td>
<td>7.21</td>
<td>31.82*</td>
</tr>
</tbody>
</table>

SE: Standard Error
*Levene's test of equality of error variances p=0.333
** Covariates in the model are evaluated at the mean level of T1=30.88

Table 3-3: Analysis of Covariance for T2 Scores by Group with T1 Scores as a Covariant

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
<th>ηp²</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Score</td>
<td>22262.4</td>
<td>1</td>
<td>22262.4</td>
<td>643.479</td>
<td>&lt;.001</td>
<td>0.531</td>
</tr>
<tr>
<td>Intervention</td>
<td>57.2</td>
<td>1</td>
<td>57.2</td>
<td>1.652</td>
<td>0.199</td>
<td>0.003</td>
</tr>
<tr>
<td>Error</td>
<td>19651.1</td>
<td>568</td>
<td>34.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>598821.0</td>
<td>571</td>
<td>34.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>42250.2</td>
<td>570</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SS: Sum of Squares
MS: Mean Squares
3.4.3 Within-Group Effectiveness

Within each the intervention and control group, there was no significant difference in the change in knowledge scores over time between gender, age, ethnicity, or household income over time (Table 3-4). There was a significant difference in knowledge scores within the intervention group for participants who had at least one parent reporting post-secondary education (p=0.048).

Table 3-4: Change in Knowledge Scores Over Time Within Intervention and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>Intervention Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 (M)</td>
<td>T2 (M)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>31.72</td>
<td>32.33</td>
</tr>
<tr>
<td>Non-Female</td>
<td>30.78</td>
<td>31.26</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>32.29</td>
<td>32.91</td>
</tr>
<tr>
<td>Non-White</td>
<td>29.86</td>
<td>30.24</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>29.17</td>
<td>29.08</td>
</tr>
<tr>
<td>14</td>
<td>31.57</td>
<td>32.46</td>
</tr>
<tr>
<td>15</td>
<td>29.8</td>
<td>30.45</td>
</tr>
<tr>
<td>16</td>
<td>32.35</td>
<td>33.24</td>
</tr>
<tr>
<td>17</td>
<td>33.27</td>
<td>32.8</td>
</tr>
<tr>
<td>18</td>
<td>27.41</td>
<td>28.92</td>
</tr>
<tr>
<td>19</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Parental Education</strong> a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Secondary</td>
<td>32.78</td>
<td>33.15</td>
</tr>
<tr>
<td>Non Post-Secondary</td>
<td>30.03</td>
<td>29.8</td>
</tr>
<tr>
<td><strong>Household Income</strong> b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>32.07</td>
<td>33.73</td>
</tr>
<tr>
<td>Middle</td>
<td>30.7</td>
<td>31.15</td>
</tr>
<tr>
<td>High</td>
<td>31.96</td>
<td>32.51</td>
</tr>
</tbody>
</table>

a. ‘Post-secondary education’ includes diploma, bachelor's degree, or post-graduate levels
b. Income cut-offs determined by median income of dissemination area where low income is <$50K, middle income is $50k-$100K, and high income is >$100k
3.4.4 SmartAPPetite Engagement

A summary of descriptive statistics for SmartAPPetite engagement is outlined in Table 3-5. Most of the participants fell into the low engagers (n=149) category, followed by high engagers (n=123), and non-engagers (n=83). One participant is missing from the engagement analysis due to an error in the server to pull the historical app analytic data. There was a statistically significant linear relationship between engagement frequency level and the average unique days engaged with the application (r=0.966, p=<0.001). There was a significant difference in food knowledge scores over time with the high engager group (p=0.010). The average change in food knowledge scores increased with higher engagement, but this relationship was not found to be statistically significant between the engagement groups (p=0.314). Sensitivity testing of the engagement groups at thresholds ranging from 10%-30% engagement frequency yielded the same results.

Table 3-5: Summary of Engagement Levels and Change in Food Knowledge Scores

<table>
<thead>
<tr>
<th>Engagement Level</th>
<th>n (355)</th>
<th>%</th>
<th>Days Engaged</th>
<th>Δ Score</th>
<th>Within Group</th>
<th>Between Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Non-Engagers</td>
<td>83</td>
<td>23.4</td>
<td>0</td>
<td>0</td>
<td>0.14</td>
<td>6.63</td>
</tr>
<tr>
<td>Low Engagers</td>
<td>149</td>
<td>42.0</td>
<td>4.62</td>
<td>3.41</td>
<td>0.01</td>
<td>6.19</td>
</tr>
<tr>
<td>High Engagers</td>
<td>123</td>
<td>34.6</td>
<td>30.17</td>
<td>16.10</td>
<td>1.35</td>
<td>5.72</td>
</tr>
</tbody>
</table>

3.4.5 Characteristics of Engagers

Of the total intervention group, 123 participants fell into the top engager group (34.6%) and 65.4% of the participants were in the non/low engager group. Table 3-6 displays cross tabulation percentages of within group characteristics between non/low engagers and top engagers where the bold number represents the higher percentage of the characteristic within the engagement groups.
Table 3-6: Cross-tabulation Percentages of Characteristics Within Each Engagement Group

<table>
<thead>
<tr>
<th></th>
<th>Non/Low Engagers (n 232)</th>
<th>Top Engagers (n 123)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><strong>Gender</strong> a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>145</td>
<td>63.3</td>
<td>83</td>
</tr>
<tr>
<td>Non Female</td>
<td>84</td>
<td>36.7</td>
<td>40</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>136</td>
<td>58.4</td>
<td>74</td>
</tr>
<tr>
<td>Non-white</td>
<td>97</td>
<td>41.6</td>
<td>49</td>
</tr>
<tr>
<td><strong>Age</strong> b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>4.4</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>60</td>
<td>26.5</td>
<td>24</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>26.1</td>
<td>31</td>
</tr>
<tr>
<td>16</td>
<td>46</td>
<td>20.4</td>
<td>34</td>
</tr>
<tr>
<td>17</td>
<td>45</td>
<td>19.9</td>
<td>25</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>2.7</td>
<td>6</td>
</tr>
<tr>
<td><strong>Use Food, Nutrition, and Health Apps</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>67</td>
<td>28.9</td>
<td>41</td>
</tr>
<tr>
<td>No</td>
<td>165</td>
<td>71.1</td>
<td>82</td>
</tr>
<tr>
<td><strong>Self-Reported Physical Health</strong> c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>29</td>
<td>12.5</td>
<td>13</td>
</tr>
<tr>
<td>Very Good</td>
<td>64</td>
<td>27.6</td>
<td>41</td>
</tr>
<tr>
<td>Good</td>
<td>94</td>
<td>40.6</td>
<td>52</td>
</tr>
<tr>
<td>Fair</td>
<td>37</td>
<td>15.9</td>
<td>16</td>
</tr>
<tr>
<td>Poor</td>
<td>8</td>
<td>3.4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Self-Reported Mental Health</strong> d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>22</td>
<td>9.5</td>
<td>18</td>
</tr>
<tr>
<td>Very Good</td>
<td>76</td>
<td>32.8</td>
<td>40</td>
</tr>
<tr>
<td>Good</td>
<td>85</td>
<td>36.6</td>
<td>42</td>
</tr>
<tr>
<td>Fair</td>
<td>33</td>
<td>14.2</td>
<td>20</td>
</tr>
<tr>
<td>Poor</td>
<td>16</td>
<td>6.9</td>
<td>3</td>
</tr>
</tbody>
</table>

*Has health condition that affects eating e*
<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>10.9</th>
<th>16</th>
<th>13.6</th>
<th>0.472</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>89.1</td>
<td>118</td>
<td>86.4</td>
<td></td>
</tr>
<tr>
<td>Follows special diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>17.0</td>
<td>25</td>
<td>20.7</td>
<td>0.400</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>83.0</td>
<td>96</td>
<td>79.3</td>
<td></td>
</tr>
<tr>
<td>Parent Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Post-secondary)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>67.0</td>
<td>62</td>
<td>57.9</td>
<td>0.116</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>33.0</td>
<td>45</td>
<td>42.1</td>
<td></td>
</tr>
<tr>
<td>Household income h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>4.8</td>
<td>4</td>
<td>3.3</td>
<td>0.636</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>55.9</td>
<td>65</td>
<td>53.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>39.2</td>
<td>53</td>
<td>43.4</td>
<td></td>
</tr>
</tbody>
</table>

*Numbers listed in bold represent higher percentages of the characteristic within engagement groups

a. 3 participants did not disclose gender.
b. 8 participants did not disclose age.
c. 18 participants did not disclose health conditions. Health conditions that affect eating patterns include diabetes, Crohn's disease, celiac disease, food allergies.
d. 17 participants did not disclose diets. Special diet includes gluten-free, lactose-free, Kosher, Halal, vegetarian, and vegan.
e. 49 parents did not disclose education. ‘Post-secondary education’ includes diploma, bachelor's degree, or post-graduate levels.
f. 7 parents did not disclose postal codes for dissemination area identification

There were higher percentages of females and White/Caucasian participants (67.5% and 60.2%, respectively) in the top engager group, and higher percentages of non-females and non-White participants (36.7% and 41.6%, respectively) in the non/low engager group. There was a divide in ages between non/low engagers and top engagers; more (57.08%) of the non/low engagers were in the younger half of the participants (13-15 years old) whereas the older half of the participants (16-18 years old) made up a higher percentage (53.28%) of the top engager group. Participants that reported using other health related phone applications had a higher ratio in the top engager group (33.3% top engager group and 28.9% non/low engager group) compared to those who had reported no use of other health applications (71.1% non/low engager group and 66.7% top engager group). Those who self-reported their physical health as “good” or “very good” made up a higher percentage of top engagers (76.6%), and those who reported mental health as “good” or
“very good” made up a higher within-group percentage of non/low engagers (69.4%). Participants that have a health condition that affect their eating patterns had higher within-group percentages in the top engager group (13.6% top engager group and 10.9% non/low engager group), as well as those who reported following a special diet (20.7% top engager group and 17.0% non/low engager group). There was a higher percentage of students in the top engager group whose parents reported not having post-secondary education (42.1% top engager group and 33.0% non/low engager group). Participants whose households were in the highest median household income neighbourhoods (dissemination areas) made up a higher percentage of the top engager group compared to participants in the low or middle median household income neighbourhoods (43.4% top engager group and 39.2% non/low engager group). There were no statistically significant differences between the non/low engager group and the top engager group across each characteristic.

3.4.6 Characteristics of Participants Who Dropped Out

A total of 566 participants dropped out of the study after T1. There was a higher proportion of students that withdrew in the intervention group (53.1%) compared to the control group (44.2%). Within the intervention group, White/Caucasian participants had a significantly higher drop-out rate than non-White participants (p=0.002). Participants that were 16 years old had a higher drop-out rate than other age groups (p=0.030). Participants who self-reported “excellent” mental health had significantly higher drop-out rate than other self-reported mental health statuses (p=0.035).

3.5 Discussion

3.5.1 Effectiveness of Application Uptake on Food Knowledge Scores

This study aimed to explore the effectiveness of the smartphone application “SmartAPPetite” as an intervention for improving adolescent food knowledge scores in London, Ontario, while taking into consideration the role that engagement with the application plays in outcome effectiveness. The results of this study exemplify that there is a barrier to evaluating intervention effectiveness if the treatment is not received. There
was a high drop-out rate in the intervention group of this study (53.1%), which has been a consistent finding across other app-based health interventions (Meyerowitz-Katz et al., 2020). Of those that stayed in the study, 65.4% of participants were either non-engagers or low engagers of the application. There were no significant differences in food knowledge scores between the intervention and control group which could be explained by this low adherence to treatment. This finding is not unique to this study design; De Cock et al.’s research using a standalone smartphone application to improve teen snack habits and food knowledge also found that 65% of those allocated to the intervention were either non-users or low users of the app and those in the intervention group did not see an improvement in food knowledge scores (De Cock et al., 2018).

One of the reasons for low adherence in this type of intervention may be due to the challenging nature of engaging adolescents in health research initiatives (Steinbeck et al., 2009). As this is an age for increasing autonomy and independent decision making, it is also an age where peer pressure and belonging with social groups is a strong influence of behaviours (Lamb et al., 2001). If a program is not condoned by peer groups, it can be challenging to attract teens and maintain adherence. Health research with adolescents is also challenging as this age group may underestimate consequences of current behaviours in the long-term (Reyna & Farley, 2006). Sensitivity reward has been found to be highest in mid-adolescence and teens make decisions that lean towards instant benefit as opposed to a delayed benefit (Scott-Parker & Weston, 2017). Therefore, it can be less likely for teens to be attracted to health interventions unless it has an immediate impact on their lives. Furthermore, this immediate reward sensitivity is heightened in the presence of peers (Chein et al., 2011), adding to the powerful influence social groups have on the success of health interventions.

Although adherence was a challenge in this study, those that were high engagers with the application saw a statistically significant improvement in pre and post food knowledge scores. This finding is consistent with research completed by Heikkilä et al. who found that athletes using a food knowledge application had higher knowledge scores than those who were assigned to the treatment but did not use the application (Heikkilä et al., 2019). There was a high correlation between the frequency of messages opened and unique days
engaged with the application. This indicates that participants who opened more messages also engaged with the application for more days over the intervention period, prolonging their exposure to the treatment rather than opening all their messages within a short period of time. This sustained use may demonstrate the effectiveness of the nudge notifications in the application. Applying behavioural economic theories to adolescent health research has been less common than in adult studies as strategies used for adults may not be applicable to teens’ decision-making process (Wong et al., 2021). However, using reminders in adult digital behaviour change interventions have been found to positively influence engagement (Perski et al., 2017), and the success of the nudge notifications in the SmartAPPetite intervention may be useful to inform future approaches of paternalistic libertarianism in health interventions for the adolescent population.

3.5.2 Characteristics of High Engagers

As those who engaged with the application the most saw a higher change in food knowledge scores, it is important to understand the characteristics of these participants to understand who would utilize this type of intervention while also identifying gaps in the intervention reach. There were no characteristics that were statistically significant in separating the top engagers from the rest of the intervention group, however, descriptive statistics comparing proportions of characteristics within the top engager group can serve as a starting point to understand application users.

There was a higher proportion of female top engagers which is consistent across other health intervention applications for teens (Caon et al., 2022; Lin & Mâsse, 2021). Researchers have found female adolescents to be more interested in learning about food and nutrition knowledge than males (Ronto et al., 2016), as well as being more concerned with dietary health and body image (Naeeni et al., 2014). Research suggests that adolescent males are more interested in the practical preparation skills of food (Ronto et al., 2016), yet still lack involvement and overall proficiency in food and nutrition knowledge and skills (Simonds et al., 2021). Because home-economic classes were no longer within the school curriculum in Ontario high schools during the time of this study,
those who do not have food skills acquired from outside of school may not be able or interested in applying the messaging or recipes.

Those who identified as White/Caucasian were top engagers, but this group also had a higher drop-out rate than other ethnicities. So, while other ethnicities stayed in the intervention, these participants did not have high engagement with SmartAPPetite. One explanation for this can be due to the change in the Canada’s Food Guide which helped to inform content for the SmartAPPetite messaging. The new version of the food guide was released in 2019 and promotes, among other things, eating foods from your culture and trying new and diverse foods from other cultures (Health Canada, 2023), however, this messaging did not exist in the version of the food guide that was used to inform SmartAPPetite messaging (Health Canada, 2019). Research has found that immigrants have difficulty seeing their traditional meal practices within Western views of healthy eating (Tiedje et al., 2014) which may present as a barrier for teens who did not see their own culture within the SmartAPPetite messaging that was released during the time of this study. Since the release of the 2019 Canada’s Food Guide, SmartAPPetite has updated messages on food from diverse cultures.

Those who were in the older half of the sample (aged 16-18 years) made up a higher percentage of top engagers than the younger half (aged 13-15 years). Teens have recognized that nutrition literacy and skillling are needed in their future (Ronto et al., 2016), and this may be due to recognizing that they may be living independently after high school.

There was a higher percentage of participants in the top engager group who reported having a health condition that affects their eating patterns and/or follows a special diet. This finding suggests that SmartAPPetite could be appealing and helpful to those who need to be more conscientious about their eating behaviours due to health related or special diet reasons. Adult studies using digital interventions that targeted a specific health condition were found to be more effective than those focused on a general population (Schubart et al., 2011). Many research studies have utilized smartphone applications to address diet behaviours in response to health conditions such as diabetes.
(Baghaei et al., 2016) obesity, (Choi et al., 2021; Dzielska et al., 2020; Likhitweerawong et al., 2020), cancer (Fuemmeler et al., 2020), or overall healthy eating behaviours (Benavides et al., 2021; Benítez-Andrades et al., 2020; Sousa et al., 2020), yet most studies do not have food knowledge outcomes related to diet behaviour. Future SmartAPPetite use could focus on specific populations living with these conditions to address the educational gap currently present in the research.

### 3.5.3 Study Strengths

A strength of this study was the measurement and analysis of user engagement, as this has been a limitation among other technology-based interventions. If there is no way for researchers to measure engagement in an online/smartphone delivered intervention, participants could still complete trial assessments without ever having received treatment (Eysenbach, 2002). Therefore, it is difficult to assess how the intervention thoroughly influences study outcomes (Donkin et al., 2011). Numerous methods that have been synthesized for capturing engagement in digital-based interventions, however, a strong consideration in a digital-based intervention is to achieve effective engagement rather than prolonged engagement (Yardley et al., 2016). This can be achieved by assessing engagement directly against study outcomes. In the case of SmartAPPetite, the significant change in food knowledge scores for the highest engagement group indicate that engagement was effective, even though their average days of unique interaction with the app was 53% of the total intervention period.

Utilizing an application that considered the role that environment plays on food knowledge and food choice was another strength to this study. It is our understanding that SmartAPPetite is currently the only publicly available smartphone application that provides nutrition messaging both temporally and spatially. When applying the social ecological model in the context of adolescent food choices, looking at the influential roles the environment plays is vital for healthy behaviour change (Glanz & Bishop, 2010) as interventions that look beyond individual influences can be more effective for population level health initiatives (Glanz et al., 2008).
Another strength of this study is the use of a food knowledge questionnaire that has been adapted from a validated study. The use of comprehensive assessment tools is not consistent across literature assessing smartphone application use and nutrition knowledge in teens. Some studies have reported using surveys that incorporate one to five questions on food knowledge (Kato-Lin et al., 2020; Ragelienè et al., 2022; Villasana et al., 2020) while others have only assessed perceptions of healthy eating (Byrne et al., 2012; García-Muñoz et al., 2022). Food knowledge is a comprehensive topic where numerous competencies need to be considered to promote healthy behaviour changes (Cullen et al., 2015). SmartAPPetite strived to achieve this comprehension by asking 52 questions across numerous themes under the umbrella of food knowledge such as recommended food intakes, nutrient content of food groups, making healthy food choices, and effects of nutrition on health.

Lastly, an important strength in this research is the consideration of unintended consequences that have emerged from smartphone use with adolescents. While smartphone applications have been a promising way to deliver health interventions to a wide reach of participants, new research is emerging that explores the negative implications to health because of smartphone use. There is evidence to suggest that the phone applications (inclusive of social media applications) that teens utilize for health goals may lead to body image concerns, a poor relationship with food, or the adoption of health-averse habits because of over-monitoring food intake (Eikey, 2021; Honary et al., 2019; Levinson et al., 2017). A recent concern is the rise of social media influencers that deliver health advice who may not be credible sources (Marks et al., 2020). Furthermore, research on smartphone dependencies among teens after the COVID-19 pandemic recommends a reduction in screen time, as over-use of smartphones have been found to negatively affect physical and mental wellbeing (Daniyal et al., 2022). The SmartAPPetite intervention strives to mitigate these consequences. With three messages sent per day, it is unnecessary for users to repeatedly go back and check the application; furthermore, the messages delivered are concise (approximately 150 words) which limits the screen time users have with the application. Lastly, messages are written by nutrition researchers and Registered Dietitians based on current health recommendations from valid government and academic sources, providing credible food knowledge content to
users in a digital environment. It is vital for future health research using smartphone applications to consider the emerging evidence of smartphone use among teens to strategize an optimal way to provide positive health outcomes while mitigating the risks associated with smartphone use.

3.5.4 Study Limitations

While this study explored engagement with messaging features of the SmartAPPetite application, it did not investigate how usage patterns fluctuated over the course of the intervention period, so researchers did not know when participants engaged with the application the most. Multiple studies have shown that engagement levels decrease over time (Caon et al., 2022; Lin & Mâsse, 2021) and understanding when this drop-off rate occurs in SmartAPPetite could inform how to improve application design or future intervention methods. Furthermore, a valuable measure for smartphone application studies is to define and measure treatment “dosage” to truly evaluate usage behaviours (Beintner et al., 2019; Schubart et al., 2011). For example, this study evaluated engagement by number of messages opened, but effective engagement in this intervention could explore the length of time a user spent within each feature of the application to understand if the users were reading the messages.

Another limitation to this study was the completion of surveys during school hours without the involvement of school staff, which may have contributed to the high drop-out rate. The absence of students for the second survey could be explained by numerous reasons; students may have been absent that day, they were not excused from class, or the student prioritized their time elsewhere.

Another limitation in this study was that the COVID-19 pandemic disrupted the data collection and resulted in a higher number of intervention schools than control schools in the dataset. To avoid cross-contamination between teens in the intervention and control groups, all students in a particular participating school were assigned to the same group, either the intervention school group or control school group. During the 2019-20 academic school year, in response to the wishes of the participating school principals, student data were collected for the intervention schools during the first half of the school
year (Fall 2019), and data for the control schools were to be collected during the second half of the school year (Spring 2020). However, because Ontario schools closed due to COVID-19 in March 2020, the data for control schools scheduled to participate during that academic year could not be collected.

While a strength of this study was using a validated survey to inform the measurement tool, a current barrier to nutrition education research in Canada across all studies is the lack of a standardized assessment tool for nutrition literacy (LDCP Healthy Eating Team, 2008) and the limited validated testing instruments in the literature that questionnaires can be compared against. A standardized tool that is informed by nutrition literacy experts in Canada could provide a valid and reliable testing measurement for food knowledge across all nutrition education interventions. There is also a limitation in the delivery of SmartAPPetite messages against the survey instrument; because participants can receive tailored messages based on their interest from a bank of over 1000 messages, it could be possible that they do not receive messages that are directly related to the food knowledge survey questions and may miss an opportunity for comprehension across the numerous fields of food knowledge.

3.6 Conclusion

The use of the smartphone application, “SmartAPPetite”, showed an improvement in food knowledge scores in adolescents who highly engaged with the application. Although there were no significant differences in food knowledge scores between the control and intervention group, engagement was a key factor in improving scores. Therefore, future research should not only measure engagement, but also explore what makes teens engage or not engage with an application. While there were no statistical findings to identify key characteristics of high engagers, it was found that a higher proportion of high users were female, White/Caucasian, older adolescents, and live with a health condition that affects eating patterns or follows a special diet. Future research could not only tailor application design to these members of the adolescent population, but also investigate other intervention strategies to reach members who did not engage with SmartAPPetite.
3.7 References


Chapter 4

4 Synthesis and Conclusion

This thesis explored the use of smartphone applications and their effectiveness for improving food knowledge for adolescents. Chapter 2 presents a systematic review that explores existing interventions that use a smartphone application to improve adolescent food knowledge and investigated the features, effectiveness, and theoretical foundations of these interventions. Chapter 3 reports on a randomized controlled trial that evaluates the effectiveness of the smartphone application “SmartAPPetite” on adolescent food knowledge among teens in the greater London, Ontario region.

4.1 Summary of Studies

The systematic review identified eight studies that utilized smartphone applications to improve food knowledge among teens. Numerous features within each smartphone application informed these interventions, as well as a variety of theoretical foundations. Studies showed mixed results for effectiveness in food knowledge improvements and there was no pattern to features or theories that related to positive findings. All studies that were included in this review measured other outcome measures in addition to food knowledge, such as healthy eating changes, self-efficacy, and physical activity, and many did not focus on food knowledge as the primary objective of the intervention. These findings illustrate a need for more focused research on utilizing interventions solely for food knowledge as the features of these applications may have been designed to target other health outcomes. Furthermore, few studies used comprehensive measurement tools to evaluate food knowledge, making it challenging to draw accurate conclusions about the validity of the food knowledge outcomes. Although many studies also evaluated food choice or dietary improvements, a gap within this research was that they did not consider the role the environment plays on teen food choices (Azevedo Perry et al., 2017). Of those studies that used a theoretical model to inform their intervention, the social cognitive theory was the only one identified that included an environmental factor. Yet, the studies that utilized social cognitive theory focused on modeling and reinforcement rather than environmental influences (Byrne et al., 2012; Ragelienė et al., 2022).
A significant factor that some studies considered was the impact that engagement had on food knowledge outcomes; this is an important measure to consider as it is assumed change cannot occur if participants do not use the application (Donkin et al., 2011). Of the two studies that did measure engagement, it was found that users had a higher increase in scores than non-users (Heikkilä et al., 2019), and non-users scored lower than the control group (De Cock et al., 2018), indicating that uptake in the application, or lack thereof, could be influential in food knowledge improvements.

The findings from the systematic review helped to inform the objectives of the randomized controlled trial in Chapter 3. This trial investigated the effectiveness of using the smartphone application “SmartAPPetite” for improving food knowledge among adolescents in London, Ontario. The application focused on food knowledge as a primary outcome through healthy eating messages and considered the role of retail environments to send healthy reminders to teens when they are near fast-food restaurants. Identified as an important factor in the systematic review, engagement was explored as a measure to determine its influence on food knowledge outcomes within the intervention group. Although there were no statistically significant differences in food knowledge scores between the experimental and control groups, engagement was found to significantly influence the change in food knowledge scores for participants who were high users of the application. This highlights the importance of measuring adherence to mobile-based interventions; simply measuring the change in scores between a control and an intervention group without considering if the experimental group ever received the treatment is going to yield gaps in research findings (Eysenbach, 2002).

Another outcome explored in this trial was that of identifying characteristics of high engagers with the application, which was not measured within any of the systematic review studies. Of the characteristics measured, none were found to be significantly different between the high users and non/low users of the application. However, there was a pattern of high users being female, older in age, already using health apps, living with a health condition that affects eating, or following a special diet. As defining a population is vital when informing research interventions (Eldredge et al., 2014), this information is valuable to inform future health interventions that wish to utilize
smartphone applications for teens. Overall, the major research finding from this study was that engagement with SmartAPPetite appears to be the only factor that significantly influences positive changes in food knowledge scores.

### 4.2 Research Contributions

The exploration for effective and sustainable solutions to nutrition-related problems among humans is interdisciplinary in nature (Pelletier, 1997), and the work presented within this thesis is no exception. The research undertaken for this thesis broadly contributes to research in the disciplines of nutrition and public health, as well as the field of health geography.

Firstly, the findings in this thesis provide a foundation for addressing food literacy by using smartphone technology. As seen in the systematic review, this thesis presents the first intervention study to look specifically at a food knowledge smartphone application for food knowledge within Canada. The systematic review in this thesis also helps to synthesize features of smartphone applications and theoretical frameworks to consider when designing smartphone-based interventions for adolescents.

Secondly, this work contributes to the rapidly growing body of studies that use digital platforms to achieve public health outcomes. While the research in this field is abundant, literature that focuses on adolescents specifically, and especially those that are living in the absence of a disease, is not as common. This is likely because chronic conditions that result from dietary risk factors may not develop until later in life (Afshin et al., 2019). However, this research emphasizes the need for addressing habits that develop in adolescent years to proactively promote healthier food choices. The findings from Chapter 3 emphasize that smartphone applications can be effective at food knowledge improvements, but engagement is the main influence in positive outcomes. While other public health researchers may not specifically look at food knowledge, this research helps identify the importance of establishing appropriate exposure to a digital intervention as well as measuring effective engagement if this medium is utilized to promote healthy behaviour changes.
Thirdly, this work broadly contributes to the field of health geography. Health geography explores the spatial dimensions of health and well-being using geographical methods and looks at ways in which geographical factors impact health outcomes (Emch et al., 2017). It is of the researchers’ understanding that this is the first study that uses social ecological theory to theoretically inform a smartphone application of this nature. Also, it is the first intervention-based study to tangibly utilize the physical placement of participants in prompting healthy messaging in the goal of improving food knowledge and ultimately healthier food choices. Furthermore, the focus of food environments in this research contributes to the intersection between food and urban geography. Public health outcomes are impacted by the urban environment and the food systems within them (Neff et al., 2009). Of one concern is the built environment of urban areas with high densities of fast-food restaurants; this research seeks to shift behaviour changes within this built environment by considering location when prompting users towards healthier food options. This research may also contribute to strategies for promoting healthier food choices in urban areas with varying levels of access to nutritious food. Educational strategies can be partnered with urban planning and policy development to design healthier food environments.

4.3 Methodological Contributions

A significant methodological contribution of this work is the analysis of engagement effectiveness in Chapter 3. While numerous other studies have recommended that engagement should be measured in all digitally based interventions (Beintner et al., 2019; Perski et al., 2017; Yardley et al., 2016), the review in Chapter 2 illustrates that this is not yet common practice in research methodologies. A current challenge when measuring engagement is defining the “dosage” to categorize types of engagers. While studies may provide a rationale for engagement categories such as number of days an application was used (Caon et al., 2022; Ragelienè et al., 2022) or median use of application features (Lin & Mâsse, 2021), it is often unclear if the results would change if the distribution of the engagement categories changed. This research aimed to eliminate this uncertainty by conducting a sensitivity analysis on the engagement groups against the study outcomes. This process improves the robustness of the assessment and eliminates biases made in the
assumptions of the grouping rationale (Thabane et al., 2013). So, while there are no clear best practices yet to define engagement dosage in digitally based interventions, this research provides a first step in which similar methodologies can inform and more accurately determine the effects of engagement grouping on their final outcomes.

The SmartAPPetite for Youth project is also the first project in the literature to build and launch a GPS-enabled smartphone application for the goal of improving food knowledge, diet quality, and purchasing habits for users by using geofencing around food retailers to prompt messaging to a user’s device. This contribution to geographic information science is a significant bridge between geography and health studies; this application is a product that considers physical location in human decision making. Rather than focusing on structural changes to food environments such as building or removing food retailers from a location, SmartAPPetite focuses on behaviour change through awareness and education while still considering food environments in real-time (Gilliland et al., 2015). This is a significant development in choice architecture for promoting behaviour changes.

4.4 Limitations

There are limitations to consider within both manuscripts in this thesis, as well as limitations to this research as a whole.

The systematic review only included peer-reviewed literature of studies that provided a measurement of effectiveness using pre- and post-intervention testing. Unfortunately, this yielded very few results as smartphone applications used specifically for food knowledge among teens are not prevalent in the literature. As one of the objectives of the systematic review was to also identify features and theoretical foundations of these smartphone applications, considering protocol papers, feasibility studies, and gray literature could possibly have provided a more thorough representation of how applications are being designed and informed. This review also considered all studies regardless of quality score to capture application features; however, a limitation within many of the studies was the lack of comprehensive evaluations on food knowledge outcomes which ultimately affects the results of the systematic review. While the review
reported mixed results, those findings that were reported as positive may not yet be robust enough to provide concrete recommendations for future practice.

Within the randomized controlled trial, engagement was only considered based on the frequency of messages opened; to capture a more comprehensive analysis of engagement patterns, the number of days spent over time as well as time spent within the application could possibly further inform the correct dosage of the intervention (Beintner et al., 2019). Furthermore, due to the limited number of messages sent to users per day, and the large bank of potential messages that could be sent to participants, it may be possible that users did not receive all messages that relate to questions asked on the food knowledge survey which may impact the relevance of the food knowledge survey for testing changes in food knowledge due to the app intervention. This would also be impacted if participants opted to only receive messages based on their interests, rather than those related to questions on the food knowledge survey.

More broadly, there are limitations worth noting for this thesis. Firstly, the author of this research conducted analysis on a previously collected dataset and was not present for development of the app or data collection. This limited the author’s ability to capture certain engagement metrics that may not have been initially programmed to measure at the launch of the intervention such as number of clicks into each feature or time spent within each feature. This also posed a challenge in classifying reasons for participant drop-out. The scope of timing for the author’s contributions also limited the depth of research carried out. Because of the timing of this project, data collection was disrupted due to the global COVID-19 pandemic. Data collected after the COVID-19 pandemic would have provided a more even distribution to the control and experimental groups in Chapter 3; however, this data was not yet available to accommodate the timeline for completing the thesis (i.e., the dataset was not yet complete). Furthermore, it was out of scope for this work to analyze the types of messages that were sent to users. Understanding if users engaged with time-based messaging or location-based messaging could have provided a more context for the impact that retail spaces and the environment plays in food knowledge improvements.
Lastly, this research only considered the food knowledge components of food literacy which limits both the inclusion of studies in the systematic review and the measurement scope of food knowledge improvements in the randomized controlled trial. There are numerous other components to food literacy such as food skills, relational competencies, self-efficacy and confidence, and food systems competencies (LDCP Healthy Eating Team, 2018; Slater et al., 2018) that this research does not include. Some of these components, if measured, could theoretically also improve food knowledge. For example, using applications that aim to improve food skills can increase food knowledge skills through learning about food safety and sourcing of ingredients with a hands-on approach (Ellis et al., 2013). Food literacy is a dynamic set of competencies, and capturing more of these factors could better inform next steps for nutrition research and practice.

4.5 Implications for Policy and Practice

There are two generalized policy implications to consider from the findings of this research from each area of food literacy and adolescent smartphone usage.

Firstly, nutrition literary has been identified as an area of improvement for both elementary (Colley et al., 2022) and high school students (Brown et al., 2021) in Ontario. There have been numerous studies which have discussed the dietary risk factors in teen eating habits (Hardy et al., 2012; Health Canada, 2022; Jessri et al., 2016; Slater et al., 2022; Storey et al., 2009), yet much of the initiatives to improve food literacy are research-based and not readily accessible to teens in their home and school environments, particularly over a sustained period of time. This research demonstrates that there is some promise to smartphone applications to improve food knowledge, but the minimal collection of robust and comprehensive intervention studies makes it challenging to provide reassurance in solely relying on these applications, especially with the nature of voluntary uptake. As other researchers have suggested, the loss of home economics education in schools has contributed to diminished food literacy skills among youth (Chenhall, 2010; Colatruglio & Slater, 2016). Food literacy topics are beginning to be integrated into grades 1-8 curricula (The Government of Ontario), and this research aligns with the recommendation and practice to have a designated space for youth to
improve food literacy such as home-economics classes; however, this research suggests that technology can be a valuable tool for educators to utilize within the curriculum to complement in-class teaching. Research has shown food knowledge improvements for teens who participated in in-class sessions, but those who also utilized a phone application saw greater improvements (Heikkilä et al., 2019), indicating that catering to the technological skills and interests of teens is a worthwhile teaching strategy.

Secondly, although this research focused on smartphone applications that were created and administered by researchers, this research brought forward the popularity of the internet and social media sites for teens to get access to their health information. Accounts with a high number of followers (i.e., influencers) are often not credible in providing health recommendations to their audiences (Marks et al., 2020) and recent research has shown that applications teens use for health goals may lead to body image concerns, a poor relationship with food, or the adoption of health-averse habits because of over-monitoring food intake (Eikey, 2021; Honary et al., 2019; Levinson et al., 2017). This highlights the need for smartphone application users to have direction towards credible information as implemented by media regulations. A similar example of this would be when the social media conglomerate ‘Meta’ added links to accurate public health information sources on all posts that mentioned the COVID-19 pandemic in an effort to reduce the spread of misinformation (Clegg, 2020). Governments and health agencies should strategize regulations for media sites that deter food misinformation. This could include strategies that make it easier for the public to identify credible authors (e.g., a distinct verification symbol on the account) or program more exposure to credible health messaging within search and scrolling algorithms for Canadian social media users. Teens are highly active on social media applications, and lack of policy in these domains could eliminate the potential smartphone devices have to promote healthy messaging.

4.6 Recommendations for Future Research

To gain a better understanding of the effects of smartphone applications on adolescent food knowledge, there are areas to note where future research is needed. There is a limited number of controlled studies with a high-quality score in the literature; there is a need for more studies on this topic to inform recommendations on application
effectiveness and design strategies. However, future studies can consider improved approaches based on the findings from Chapter 2 and Chapter 3. Firstly, studies should have adequate sample sizes and intervention duration as well as appropriate statistical measures to identify the effects of the intervention. Secondly, a comprehensive and validated food knowledge questionnaire needs to be utilized to capture the vast range of food knowledge topics. Lastly, interventions should identify the dosage of the application exposure using sensitivity analysis and measure the impact engagement has on food knowledge.

A major finding from Chapter 3 indicates that regardless of participant characteristics, engagement was the driving influence behind food knowledge improvements. Therefore, qualitative research is needed to understand what drives adolescent engagement with an application. This information is highly beneficial to design future applications and maintain retention for the target population.

More information is needed on the impact of the environment on food knowledge improvements. While this thesis aimed to start the baseline understanding in this field by utilizing a geographically informed smartphone application, more detail behind the interaction with these geographical components is necessary to understand their influence on knowledge. Furthermore, socio-ecological theory has been described as beneficial for health behaviour, as it considers the highly influential role of the environment (Stokols, 1996), yet this is not considered in many nutrition literacy studies. More research is needed to consider the multiple environmental influences on food knowledge and food literacy to construct effective programs.

4.7 Conclusion

There is a need for improved food knowledge among adolescents to mitigate dietary risk factors that cause chronic diseases later in life. Because of their popularity in use among this population, smartphone applications offer a novel way to provide food knowledge education in the absence of nutrition education environments in the home and school. A systematic review of this area revealed mixed findings for the effectiveness of applications on food knowledge scores, however many studies focused on other primary
outcomes in their intervention design and lacked validated food knowledge measures. There were numerous features and theoretical underpinnings within the applications which indicated that there is not a universal approach to predict effectiveness. Smartphone application design was largely dependent on population, setting, and research objectives. A finding in the systematic review, when reported, indicated that engagement can play a role in effectiveness. The findings from a randomized controlled trial, utilizing the SmartAPPetite application indicated that food knowledge scores did not improve significantly in the intervention group compared to the control group, but those who engaged highly with the application saw a significant improvement in food knowledge scores than non/low engagers.

Overall, this research indicates that smartphone applications are promising for food knowledge improvements in adolescents, but only if teens receive adequate exposure to the application. Because applications are voluntary in uptake, future programming should utilize smartphone technology in conjunction with curriculum-based nutrition education. Future research should also continue to consider the influence of physical, social, organizational, and societal environments to implement impactful food literacy programs.
4.8 References


Denmark. *Health Promotion International, 37*(1), daab081. 
https://doi.org/10.1093/heapro/daab081

https://doi.org/10.1111/ijcs.12471


https://doi.org/10.4278/0890-1171-10.4.282


https://doi.org/10.1016/j.amepre.2016.06.015
Appendices

Appendix A: Embase Search Strategy

1 child*.tw. 2060424
2 youth.tw. 94387
3 adolescent/ or teen*.tw. 1784600
4 high school*.tw. 47791
5 second* school*.tw. 14971
6 adolescent*.tw.411671
7 smartphone/ or smartphone*.tw. 25389
8 smart phone*.tw. 2818
9 mobile health.tw. 5050
10 mobile application/ or app.tw. 52265
11 mhealth.tw. 4148
12 mobile app*.tw. 7801
13 mobile phone*.tw. or mobile phone/ 22916
14 cell phone*.tw. 3946
15 cell phone*.tw.698
16 diet.tw. or diet/ 598035
17 dietary.tw. 350056
18 adolescent nutrition/ or nutrition*.tw. or nutrition/ 461834
19 food knowledge.tw. 197
20 nutrition knowledge.tw. 1975
21 food literacy.tw. 145
22 healthy eating.tw. 11159
23 snack*.tw. 11986
24 food/ or food*.tw. 675528
25 eat*.tw. 149857
26 1 or 2 or 3 or 4 or 5 or 6 3458259
27 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 92255
28 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 1657343
29 26 and 27 and 28 1164
Appendix B: Letters of Information and Consent Forms

The following forms are in this appendix:

- Control Letter of Information & Assent for Students <18
- Control Letter of Information & Consent for Students >18
- Control Letter of Information & Consent for Parents
- Intervention Letter of Information & Assent for Students <18
- Intervention Letter of Information & Consent for Students >18
- Intervention Letter of Information & Consent for Parents
Research Project:

SmartAPPetite Adolescent Study Control Letter of Assent for <18

To whom it may concern,

Have you ever wanted to learn more about how to choose healthy foods, prepare healthy meals, or buy healthy options at restaurants? Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University are working with high school students like you to promote healthy living and healthy eating. We invite you to participate in a message-based nutrition intervention called SmartAPPetite. SmartAPPetite aims to provide users with teen-specific knowledge on healthy living and healthy eating. This study will take place in your high school this year, where your school will participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to you after the third survey.

What are we going to study?

The purpose of this study is to evaluate our message-based intervention, SmartAPPetite, to improve healthy food access, food knowledge, and dietary behaviours of high school students.

What would you have to do?

Complete the Youth Survey. You will be asked to complete a 40-minute online survey 3 times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks about you, your food knowledge, eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help remember the type and amount of food you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

You will receive a $10 gift card for completing the first survey, and $15 gift cards for completing each of the second and third surveys. Therefore, you will receive $40 in gift cards total for participating in this study. The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. You will earn up to 7 entries into the draw by registering for the study and completing each survey (1 entry for registering, 2 entries for each survey completed). Students who withdraw from the study will not lose any earned entries.

Do you have to participate?

No - you only have to participate if you would like to. You are also allowed to stop at any time or refuse to answer any questions. We will never share your information with
anyone else, not even your parents. You are allowed to see your information at any time. The researchers from Western University will be happy to answer any questions or concerns you have. All study activities occur during school time, or when necessary, on your own time.

What are the benefits and risks if I participate?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the app’s impact on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about you. We are also asking for your email address and postal code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. We are minimizing the risks you may feel as follows: All information collected in this study is kept strictly confidential. You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code. Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password-protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this assent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your assent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed.
according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below.

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study Assent Form

I have had all of my questions answered and agree to participate in this study.

Print Name: _____________________________

First name _____________________________

Last name _____________________________

Student’s Email Address: _____________________________

Today’s Date: _____________________________
Research Project:
SmartAPPetite Adolescent Study Control Letter of Information for >18

Dear Participant,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as diabetes, cardiovascular disease, cancer, obesity, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study.

The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Your school has been selected to participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to all students in the school after the third survey. Any high school-aged adolescents who can speak and read English are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your participation in our research.

Do we have to participate in this study?

Your participation in this study is completely voluntary. You do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you decide to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted] and any data collected from you will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to Complete the Youth Survey. The youth survey is a 40-minute online survey you will complete 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks you about yourself, your food knowledge, your eating habits, and your food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help you remember the type and amount of food that you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

Compensation
You will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if I participate?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the app’s impact on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about you. We are also asking for your email address and postal code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers.

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password-protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).
Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, you agree to participate in this study, and have had all questions answered to your satisfaction.
I am 18 years of age or older, and agree to participate in this study.
Student’s name: ___________________________________
Student’s School: ___________________________________
Student’s 2nd Period Teacher: ____________________________

Date: _____________________________________________
Research Project: SmartAPPetite Adolescent Study Control Letter of Information for Parents

Dear Parent/Guardian,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a study using a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as diabetes, cardiovascular disease, cancer, obesity, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Your child’s school has been selected to participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to all students in the school after the third survey. Any high school-aged adolescents who can speak and read English (and their parents) are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your child’s participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You and your child do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you or your child decide to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted], any data collected from you or your child will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to:

*Complete the Parent Survey.* This short 10-minute survey will ask questions about your family’s meal and shopping behaviours, as well as other information about your family socio-economic status. The Parent Survey is completely voluntary - your child can still join the study themselves if you decide not to fill out the Parent Survey; however, as the survey gives us critical information from the point of view of parents, we would really appreciate your participation.

If your child agrees to participate, they will be asked to:
Complete the Youth Survey. Your child will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks your child about themselves, their food knowledge, their eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which your child will be led through a guided online survey to help them remember the type and amount of food they ate the previous day. Surveys are completed in person at your student’s school during class time. Should your student be absent or need to remain in class, they still have the option to complete the survey later on their own time.

Compensation

If you participate in the parent survey, you will receive a $10 gift card. Your child will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give your child a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if my child participates?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens.

There is little risk to your child if he/she participates in this study, but there is a slight chance that you or your child may be uncomfortable sharing details of your family, such as economic status or eating patterns. We are also asking for your email address and postal code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers.

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You or your child will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a
secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:
[redacted]
Research Project: SmartAPPetite Youth Study Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, your agreement to allow your child to participate in this study, and have had all questions answered to your satisfaction.

By providing the following information, I agree for my child to participate in this study.

Student’s Name: ___________________________
Student’s School: ___________________________
Student’s 2nd Period Teacher: ___________________________
Parent’s Name: ___________________________

Do you agree to participate in the brief 10-minute parent survey, for which you will receive a $10 gift card for Amazon as a thank you for participating?

Yes No

IF YES → The survey will ask the following question before auto directing the parent to the parent survey on a new Qualtrics survey.
If you would like to receive a $10 Gift Card from Amazon as a thank you for participating in the survey, please provide your email address and we will email it to you within 4 weeks. Your email address will not be used for any other purpose then stated above.

_________________________________________________________
Enter your email address

_________________________________________________________
Verify your email address

IF NO → The consent form will be submitted to allow their child to participate in the study.
Research Project:
SmartAPPetite Adolescent Study Intervention Letter of Assent for <18

To whom it may concern,
Have you ever wanted to learn more about how to choose healthy foods, prepare healthy meals, or buy healthy options at restaurants? Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University are working with high school students like you to promote healthy living and healthy eating. We invite you participate in a message-based nutrition intervention called SmartAPPetite. SmartAPPetite aims to provide users with teen-specific knowledge on healthy living and healthy eating. This study will take place in your high school this year.

What are we going to study?
The purpose of this study is to evaluate our message-based intervention, SmartAPPetite, to improve healthy food access, food knowledge, and dietary behaviours of high school students.

What would you have to do?
Complete the Youth Survey. You will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks about you, your food knowledge, eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help remember the type and amount of food you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

You will receive a $10 gift card for completing the first survey, and $15 gift cards for completing each of the second and third surveys. Therefore, you will receive $40 in gift cards total for participating in this study. The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. You will earn up to 7 entries into the draw by registering for the study and completing each survey (1 entry for registering, 2 entries for each survey completed). You can also earn an additional entry each time you open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

Receive SmartAPPetite Intervention for 10 Weeks. If you have a smartphone or tablet device (with data or WiFi connectivity), you will be asked to download the free SmartAPPetite app and sign up for an account with your email address. You will receive up to 3 healthy eating and healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic

Participating in this study will provide you with an opportunity to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. You can also earn an additional entry each time you open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.
location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food. If you do not have a smartphone or tablet device you will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and healthy lifestyle about teens, related recipes, and local vendors of healthy food items close to their school.

Focus Group. Upon completion of the study, you may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your lunch break at school, and you will be provided a healthy nutritious lunch during the session. Further information about focus groups will be provided in a separate document. All focus groups will be audiorecorded to ensure we catch the whole conversation. If you do not want to be audio recorded then do not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, your name will not be used.

Do you have to participate? No - you only have to participate if you would like to. You are also allowed to stop at any time or refuse to answer any questions. We will never share your information with anyone else, not even your parents. You are allowed to see your information at any time. The researchers from Western University will be happy to answer any questions or concerns you have. All study activities occur during school time, or when necessary, on your own time.

What are the benefits and risks if I participate?

By participating in this research, you will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about yourself. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. You also have the option to turn-off GPS location services within the application at any time.
There is a chance that you may incur additional data charges in the use of the app. Research team members will show you how to control when the app uses data (cellular or wifi), and if you have any questions please contact us at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this assent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your assent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?
The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
**Research Project: SmartAPPetite Youth Study Assent Form**

I have had all of my questions answered and agree to participate in this study.

Print Name: _______________________ ______________________

First name   Last name

Date: __________

Student’s Email Address: ______________________________

Student’s Age: __________

Please indicate which way you would like to participate in the SmartAPPetite project:

0 Through a smartphone or tablet
0 By email

Focus Groups:
0 Please check the box if you would like to participate in the focus groups at the end of the study.
Research Project: SmartAPPetite Adolescent Study Intervention Letter of Information for >18

Dear Student,
Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as obesity, diabetes, cardiovascular disease, cancer, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Any high school-aged adolescents who can speak and read English are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You do not have to participate. You can each refuse to answer any survey questions and can choose to leave the study at any time. If either you or your parent decides to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted], any data collected from you will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?
If you agree to participate, you will be asked to:

*Complete the Youth Survey.* You will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks you about yourself, your food knowledge, your eating habits, and your food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help you remember the type and amount of food they ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

*Receive SmartAPPetite Intervention for 10 Weeks.*
If you have a smartphone or tablet device (with data or WiFi connectivity), you will be asked to download the free SmartAPPetite app and sign up for an account with your email address. You will receive up to 3 healthy eating and healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for
teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food. To participate in this study, your email address must be provided to our team so that we can connect you to your SmartAPPetite app. If you do not have a smartphone or tablet device you will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and healthy lifestyle about teens, related recipes, and local vendors of healthy food items close to their school. To participate in this study, your email address much be provided to our team so that we can send you email-based SmartAPPetite messages.

Focus Group. Upon completion of the study, you may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your lunch break at school, and you will be provided a be provided in a separate document. All focus groups will be audio-recorded to ensure we catch the whole conversation. If you do not want to be audio-recorded you may not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, direct quotes may be used, but your name will not be used.

Compensation

You will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students will also earn an additional entry each time they open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if I participate?

By participating in this research, you will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.
There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about yourself. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. You also have the option to turn-off GPS location services within the application at any time. There is a chance that you may incur additional data charges in the use of the app. Research team members will show you how to control when the app uses data (cellular or wifi), and if you have any questions please contact us at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by
contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?
The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Adolescent Study Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, you agree to participate in this study, and have had all questions answered to your satisfaction.

1. Study Participation:
Would you like to participate in this study?

Yes  
No

2. Group Discussion:
Would you like to participate in the audio-recorded group discussion, where anonymous direct quotes from the group discussions may be used by the research team in publications?

Yes  
No

I am 18 years of age or older, and agree to participate in this study.
Student’s name: ________________________________ 
Student’s School: ______________________________ 
Student’s 2nd Period Teacher: ____________________ 
Date: __________
Research Project:  
SmartAPPetite Adolescent Study Intervention Letter of Information for Parents

Dear Parent/Guardian,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as obesity, diabetes, cardiovascular disease, cancer, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Any high school-aged adolescents who can speak and read English (and their parents) are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your child's participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You and your child do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you or your child decides to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted] and any data collected from you or your child will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?
If you agree to participate, you will be asked to:
Complete the Parent Survey. This short 10-minute survey will ask questions about your family’s meal and shopping behaviours, as well as other information about your family socio-economic status. The Parent Survey is completely voluntary - your child can still join the study themselves if you decide not to fill out the Parent Survey; however, as the survey gives us critical information from the point of view of parents, we would really appreciate your participation. The survey is completed on your own time.

If your child agrees to participate, they will be asked to:
Complete the Youth Survey. Your child will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks your child about themselves, their food knowledge, their eating habits, and food purchasing behaviours. Part
2 is a 24-hour recall diary, for which your child will be led through a guided online survey to help them remember the type and amount of food they ate the previous day. Surveys are completed in person at your student’s school during class time. Should they be absent or need to remain in class, they still have the option to complete the survey later on their own time.

*Receive SmartAPPetite Intervention for 10 Weeks.* If your child has a smartphone or tablet device (with data or WiFi connectivity), they will be asked to download the free SmartAPPetite app and sign up for an account with their email address. They will receive up to 3 healthy eating and/or healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food. To participate in this study, your child’s email address must be provided to our team so that we can create a SmartAPPetite app account for your child.

*If my child does not have an smartphone or tablet device,* they will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and/or healthy lifestyle for teens, related recipes, and local vendors of healthy food items close to their school. To participate in this study, your child’s email address must be provided to our team so that we can send them email-based SmartAPPetite messages.

*Focus Group.* Upon completion of the study, your child may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your students’ lunch break at school, and they will be provided a healthy nutritious lunch during the session. Further information about focus groups will be provided in a separate document. All focus groups will be audio-recorded to ensure we catch the whole conversation. If you do not want your child to be audio-recorded, they may not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, direct quotes may be used, but your child’s name will not be used.

**Compensation**

If you participate in the parent survey, you will receive a $10 gift card. Your child will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give your child a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school.

Students will
earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students will also earn an additional entry each time they open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if my child participates?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.

There is little risk to your child if he/she participates in this study, but there is a slight chance that you or your child may be uncomfortable sharing details of your family, such as economic status, eating patterns. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. Participants also have the option to turn-off GPS location services within the application at any time. There is a chance that your child may incur additional data charges on their device by using the app. Research team members will show your child how to control when the app uses data (cellular or wifi), and if you have any questions please contact one of the research team members at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You or your child will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so
that children will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is deidentified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy. You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted]. The Lead Investigators of this project include: [redacted].
Research Project: SmartAPPetite Adolescent Study Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, your agreement to allow your child to participate in this study, and have had all questions answered to your satisfaction.

1. Study Participation:
Would you like your child to participate in this study?

   Yes                  No

2. Group Discussion:
Would you like your child to participate in the audio-recorded group discussion, where anonymous direct quotes from the group discussions may be used by the research team in publications?

   Yes                  No

By providing the following information, I agree for my child to participate in this study.
Student’s Name: ________________________________
Student’s School: ______________________________________
Student’s 2nd Period Teacher: ________________________________
Parent’s Name: ______________________________________

Do you agree to participate in the brief 10-minute parent survey, for which you will receive a $10 gift card for Amazon as a thank you for participating?

   Yes                  No
Appendix C: SmartAPPetite for Youth Survey

SmartAPPetite Study: Youth Survey

We need your help to better understand what aspects of nutrition are of interest to teens like you. Your honest answers to the items in this survey are very important to us. This will not take long to complete. Remember:

- We want to know what you think
- There are no right or wrong answers
- Everything you tell us will be kept strictly confidential
- Try to answer all the questions

A. General Information

1. I am a
   O Male   O Female   O I identify as (please specify) ____________________

2. What is your current age?
   O 13    O 14    O 15    O 16    O 17    O 18
   O 19

3. What grade are you currently in?
   O 9     O 10    O 11    O 12    O 13

4. How many people live (including yourself) in your main home? _______

5. Postal code at your main home: __ __ __ __ __ __ (e.g. N6A 5K6)

6. What is your ethnicity? (Please select all that apply)
   O White/Caucasian
   O South Asian (e.g., East Indian, Pakistani, Sri Lankan)
   O East Asian (e.g., Chinese, Japanese, Korean)
   O Middle Eastern (e.g., Egyptian, Iranian, Lebanese)
   O Latin American (e.g., Mexican, Columbian, Peruvian)
   O Indigenous (i.e., First Nations, Métis, or Inuit)
   O Black (e.g., African, Caribbean)
   O Other (Please Specify): ____________________
7. Do you own a smartphone?
   O Yes, with a data plan    O Yes, without a data plan    O No
8. Do you own a tablet or iPod?
   O Yes, with a data plan    O Yes, without a data plan    O No
9. Do you have access to WiFi at home?
   O Yes    O No
10. Do you use any food, nutrition, or health apps on your smartphone or tablet?
    O Yes    O No
11. Do you use any wearable fitness devices (e.g., fitbit, Garmin)?
    O Yes    O No
12. In general, how do you rate your own physical health?
    O Excellent    O Very Good    O Good    O Fair    O Poor
13. In general, how do you rate your own mental health?
    O Excellent    O Very Good    O Good    O Fair    O Poor
14. Physical activity is an activity that increases your heart rate and makes you get out of breath some of the time. Add up all the time you spend in physical activity each day. Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball.
   Over the past 7 days, how many days were you physically active for a total of at least 60 minutes per day?
   O 0    O 1    O 2    O 3    O 4    O 5    O 6    O 7
15. Do you have any health conditions that affect your eating patterns (select all that apply)?
    O I do not have a health condition that affects my eating patterns.
    O Food allergies
    O Celiac
O Crohn’s / Colitis
O Type-1 diabetes
O Type-2 diabetes
O Other (Please specify) _________________________
O Other (Please specify) _________________________

16. Based on my allergies or intolerances of certain foods, I cannot eat the following (select all that apply):
O I do not have any allergies or intolerances to food
O Eggs
O Gluten / Wheat
O Milk / Lactose
O Peanuts
O Sesame
O Other (Please specify) _________________________
O Other (Please specify) _________________________

17. I eat the following way (Select all that apply):
O Gluten-free
O Lactose-free
O Kosher
O Halal
O Vegetarian
O Vegan
O Other (Please specify) _________________________
O Other (Please specify) _________________________
O None of the above
B. General Eating Habits

1. In a typical day, about how many servings of fruit do you eat? Examples – 1 serving is equal to a piece of fresh fruit (like an apple), 1/2 cup of fruit __________ servings

2. In a typical day, about how many servings of vegetables do you eat? Example – 1 serving is equal to a small bowl of fresh or cooked vegetables, or 1 cup of green salad. Do not count French fries or potato chips. __________ servings

C. Nutrition Questions

1. During a typical day, how many meals do you eat? _________

2. During a typical day, how many snacks do you eat? _________

3. During a typical week, how many times do you go food shopping alone? _________

4. During a typical week, how many times do you go food shopping with a parent? _________

5. During a typical week, how often do you purchase food from the following types of locations?
   a. Supermarket or grocery store
      Times per Month: __________ OR Times per Week: __________
   b. Convenience store, corner store, gas station, or pharmacy
      Times per Month: __________ OR Times per Week: __________
   c. Fast food restaurant or coffee shop
      Times per Month: __________ OR Times per Week: __________
   d. Full-service/sit-down restaurant
      Times per Month: __________ OR Times per Week: __________

6. Please rate your level of agreement with the following statements.
Breakfast

7. During the last week, on which days did you eat BREAKFAST and where?

a. Monday:

O I did not eat breakfast

O Ate at home

O Ate at a free breakfast program at school

O I bought breakfast at school

O I bought a breakfast from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

b. Tuesday:

O I did not eat breakfast

O Ate at home

O Ate at a free breakfast program at school
O I bought breakfast at school
O I bought a breakfast from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

c. Wednesday:
O I did not eat breakfast
O Ate at home
O Ate at a free breakfast program at school
O I bought breakfast at school
O I bought a breakfast from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

d. Thursday:
O I did not eat breakfast
O Ate at home
O Ate at a free breakfast program at school
O I bought breakfast at school
O I bought a breakfast from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

e. Friday:
O I did not eat breakfast
O Ate at home
O Ate at a free breakfast program at school
O I bought breakfast at school
O I bought a breakfast from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

f. Saturday:
O I did not eat breakfast

O Ate at home

O I bought a breakfast from another place (Please specify place)

Place Name: _________________               Closest Intersection: _________________

g. Sunday:

O I did not eat breakfast

O Ate at home

O I bought a breakfast from another place (Please specify place)

Place Name: _________________               Closest Intersection: _________________

Lunch During the School Week (Monday - Friday)

8. During the last week, on which days did you eat LUNCH and where?

a. Monday:

O I did not eat lunch

O I ate at home

O Ate a lunch I brought from home

O Ate at a free lunch program at school

O I bought lunch at school

O I bought a lunch from another place (Please specify place)

Place Name: _________________               Closest Intersection: _________________

b. Tuesday:

O I did not eat lunch

O I ate at home

O Ate a lunch I brought from home

O Ate at a free lunch program at school
O I bought lunch at school
O I bought a lunch from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

c. Wednesday:
O I did not eat lunch
O I ate at home
O Ate a lunch I brought from home
O Ate at a free lunch program at school
O I bought lunch at school
O I bought a lunch from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

d. Thursday:
O I did not eat lunch
O I ate at home
O Ate a lunch I brought from home
O Ate at a free lunch program at school
O I bought lunch at school
O I bought a lunch from another place (Please specify place)

Place Name: _________________  Closest Intersection: _________________

e. Friday:
O I did not eat lunch
O I ate at home
O Ate a lunch I brought from home
O Ate at a free lunch program at school
O I bought lunch at school
O I bought a lunch from another place (Please specify place)

Place Name: _________________
Closest Intersection: _________________

9. During a typical week, how often do you leave school to buy lunch (e.g., from a fast food restaurant, convenience store, grocery store)?

Times per Month: _______ OR Times per Week: _______

10. During a typical week, how often do you leave school to buy snacks (e.g., from coffee shop, convenience store, grocery store)?

Times per Month: _______ OR Times per Week: _______

Dinner/Supper

11. During a typical week, how many evenings do you eat dinner? _______

12. During a typical week, how many evenings do you eat dinner with your family? _______

13. During a typical week, how many evenings do you prepare or help prepare dinner? _______

14. During a typical week, how many evenings do you eat food from restaurants (takeout or eat in) or pre-made dinners from stores (e.g., microwave dinners, canned chili or pasta)? _______

D. General Nutrition Knowledge Questions

This is a survey, not a test. Your answers will help identify which dietary advice people find confusing. It is important that you complete it by yourself. Your answers will remain anonymous. If you don’t know the answer, mark “not sure” rather than guess.

Thank you for your time.

The first few items are about what advice you think experts are giving us.

1. How many servings of fruit and vegetables per day do experts advise teens to eat as a minimum? (select one)

O 2 O 3 O 4 O 5 or more O Not Sure

2. Do health experts recommend that people should be eating more, the same amount, or less of the following items? (select one box per food)
3. How many times per week do experts recommend that people eat fish (e.g. salmon, tuna, tilapia)? (select one)

O 1-2 times per week  O 3-4 times per week  O Every day  O Not sure

4. How many times per week do experts recommend that people eat breakfast? (select one)

O 3 times per week  O 4 times per week  O Every day  O Not sure

**Experts classify foods into groups. We are interested to see whether people are aware of food groups and the nutrients they contain.**

5. Do you think these foods and drinks are typically high or low in added sugar? (select one per food)

<table>
<thead>
<tr>
<th>Food and Drinks</th>
<th>High in added sugar</th>
<th>Low in added sugar</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Diet cola drinks</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. Plain yogurt</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. Ice cream</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>d. Ketchup</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>e. Melon</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

6. Do you think these foods are typically high or low in salt? (select one per food)
7. Do you think these foods are typically high or low in fibre? (select one per food)

<table>
<thead>
<tr>
<th></th>
<th>High in fibre</th>
<th>Low in fibre</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Frozen vegetables</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>b. Bread</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>c. Baked beans</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>d. Red meat</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>e. Canned soup</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
</tbody>
</table>

8. Do you think these foods are a good source of protein? (select one per food)

<table>
<thead>
<tr>
<th></th>
<th>Good source</th>
<th>Not a good source</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Chicken</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>b. Cheese</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>c. Fruit</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>d. Baked beans</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>e. Butter</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
<tr>
<td>f. Nuts</td>
<td>O</td>
<td>O</td>
<td>0</td>
</tr>
</tbody>
</table>

9. Which of these foods has the most trans-fat? (select one)

- O Fish
- O Canola Oil
- O Store bought cookies, cakes and pastries
- O Eggs
- O Not Sure

10. The amount of calcium in a glass of whole milk compared to a glass of skimmed milk is: (select one)
11. Which one of the following items has the most calories per cup? (select one)

- Sugar
- Protein
- Fibre
- Fat
- Not Sure

12. Compared to minimally processed foods, processed foods are: (select one)

- Higher in calories
- Higher in fibre
- Lower in Salt
- Not Sure

The next few items are about choosing foods

13. If a person wanted to buy a yogurt at the supermarket, which would have the least sugar/sweetener? (select one)

- 0% fat cherry yogurt
- Natural plain yogurt
- Creamy fruit yogurt
- Not sure

14. Which would be the healthiest and most balanced sandwich lunch? (select one)

- Ham sandwich + fruit + blueberry muffin + fruit juice
- Tuna salad sandwich + fruit + low fat yogurt + water
- Egg salad sandwich + chips + low fat yogurt + water
- Not sure

15. Which would be the healthiest burger choice when eating at a restaurant: (select one)

- Crispy chicken burger
- Hormone-free burger
- Grilled chicken burger
- Fried fish burger
- Not sure
Looking at products 1 and 2, which one has the most calories (kcal) per biscuit (select one)

O Product 1  
O Product 2  
O both have the same quantity  
O Not sure

17. Looking at product 1, what are the sources of sugar in the ingredient list? (select one)

O Sugar and malt syrup  
O Sugar, fructose and lecithin  
O Sugar, fructose and malt syrup  
O Not sure

18. If the % Daily Value for sodium was greater than 15%, it is considered “high in” sodium: (select one)

O Agree  
O Disagree  
O Not Sure

19. “Light” foods (or diet foods) are always good options because they are low in calories. (select one)
This section is about health problems or diseases related to diet

20. Which of these diseases is related to a low intake of fibre? (select one)

O Constipation
O Anaemia
O Tooth decay
O Not sure

21. Which of these diseases is related to how much sugar people eat? (select one)

O High blood pressure
O Tooth decay
O Anaemia
O Not sure

22. Which of these diseases is related to how much salt (or sodium) people eat? (select one)

O Hypothyroidism
O Diabetes
O High blood pressure
O Not sure

23. Which one of these foods is classified as having a high Glycaemic Index (Glycaemic Index is a measure of how a food affects blood sugar levels, thus a high Glycaemic Index means a greater rise in blood sugar after eating)? (select one)

O Wholegrain cereals
O White bread
O Fruit and vegetables
O Not sure

24. To maintain a healthy weight people should cut fat out completely. (select one)

O Agree
O Disagree
O Not Sure

You are finished!

Thank you for completing the survey.
Appendix D: Ethics Approval for the SmartAPPetite for Youth Study

Western Research

Date: 14 December 2017
To: Dr. Jacqui Gililand
Project ID: 17024
Study Title: SmartAPPetite Adolescent Study
Application Type: NMSEB Amendment Form
Review Type: Delegated
Full Board Reporting Date: January 12, 2018
Date Approval Issued: 14 Dec 2017
REB Approval Expiry Date: 18 Sep 2018

Dear Dr. Jacqui Gililand,

The Western University Non-Medical Research Ethics Board (NMSEB) has reviewed and approved the WUDM application form for the amendment, as of the date noted above.

Document: Approved:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Type</th>
<th>Document Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartAPPetite Consent Control_2017-11-22_Class</td>
<td>Consent Control</td>
<td>22 Nov 2017</td>
</tr>
<tr>
<td>SmartAPPetite Consent Intervention_2017-11-22_Class</td>
<td>Consent Control</td>
<td>22 Nov 2017</td>
</tr>
<tr>
<td>SmartAPPetite_LOE Consent Control_2017-11-22_Class</td>
<td>Consent Control</td>
<td>22 Nov 2017</td>
</tr>
<tr>
<td>SmartAPPetite_LOE Consent Intervention_2017-11-22_Class</td>
<td>Consent Control</td>
<td>22 Nov 2017</td>
</tr>
<tr>
<td>SmartAPPetite Consent Survey_Final_2017-10-23</td>
<td>Survey Protocol</td>
<td>22 Oct 2017</td>
</tr>
<tr>
<td>SmartAPPetite Consent Survey_Final_2017-11-22</td>
<td>Consent Control</td>
<td>22 Nov 2017</td>
</tr>
<tr>
<td>SmartAPPetite Consent Online Survey_Final_2017</td>
<td>Online Survey</td>
<td>22 Oct 2017</td>
</tr>
</tbody>
</table>

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMSEB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMSEB who are named as Investigators in research studies do not participate in discussions related to reviewing and voting on such studies when they are presented to the REB. The NMSEB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000041.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Peterson, Research Ethics Officer on behalf of Dr. Jacqui Gililand, NMSEB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).
Curriculum Vitae

Name: Heather Jantzi

Post-secondary Education and Degrees:
- Acadia University
  Wolfville, Nova Scotia, Canada
  2013-2017 BSN
- The University of Western Ontario
  London, Ontario, Canada
  2021-2023 MSc.

Related Work Experience:
- Dietary Aide
  The Hospital for Sick Children
  2023 - Present
- Research Assistant
  The Human Environments Analysis Lab
  2021-2023
- Teaching Assistant
  The University of Western Ontario
  2021-2022
- Dietary Aide
  Chelsea Park Retirement Community
  2021-2022
- Six Sigma Black Belt
  Maple Leaf Foods
  2017-2020
- Teaching Assistant
  Acadia University
  2014-2017
Publications:


