Leveraging Social Media for Nutrition Interventions with Young Populations

Michelle M Chau

Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2020

Abstract

Leveraging Social Media for Nutrition Interventions with Young Populations

Michelle M Chau

This dissertation investigates how adolescents and young adults engage with social media in the context of health and wellness and explores new directions for the design of informatics interventions that utilize social media for promoting healthy nutrition among this population. Adolescence and young adulthood are critical points in the formation of life-long health habits, including healthy eating. Social media presents a unique opportunity for health promotion interventions for this population, given their high levels of engagement with social media in various areas of their lives. Yet contemporary interventions for promoting healthy eating utilize only a limited set of social media capabilities. In this dissertation, I approached these questions though a combination of studies of young adults' attitudes, preferences, and behaviors with social media, a deployment study of a novel informatics intervention for healthy eating among adolescents and young adults, and explorations of novel ways to incorporate machine learning approaches in identifying opportunities to inspire healthy behaviors.

Table of Contents

List of Tables and Figures

Acknowledgments

I would like to acknowledge the support of the many people who made this dissertation possible. I'd like to first thank my advisor, Lena Mamykina. From the start, Lena has always been supportive of my desire to conduct research with adolescents and young adults. She has been patient, encouraging, and provided critical mentorship. I would also like to thank my committee members. Suzanne Bakken, for her advice on rigorous methods and general encouragement. Adler Perotte, for his insights and expertise on machine learning. Andrea Grimes Parker and Jessica Ancker, for their feedback on this dissertation.

Thank you to my project collaborators for their hard work and contributions to the studies in this dissertation: Elena Ladas, Betsy Ginn, Marissa Burgermaster, and Maichou Lor.

To my fellow lab members, who have always given fresh perspectives and helpful feedback on research—Silis, Drashko, Elliot, Dan, Beth, Maria, Matt, and Pooja. And to the DBMI students for the many informatics (and non-informatics) discussions we've had over the years that made working on PH-20 a joy. A special thanks to—Amelia, Fernanda, Leo, Mollie, Amanda, and Alex.

I would also like to thank the faculty and staff members of DBMI. To George, Carol, and Noemie, for leading the department and graduate program. To Marina, for her thoughtful advice on all subject matters.

I’d like to thank the National Library of Medicine for providing the T15LM007079 grant that funded my training.

To my family and friends, who mean the world to me. To my parents, for supporting my love of learning. To my husband, Jay, for his steadfast love, belief in me, and support—both in life and in pursuit of this PhD. To my children, for bringing newfound joy into my world and challenging me in ways I never imagined.

Lastly, a thank you to all the research participants who used our application, gave us their feedback, and allowed us to tell their stories through our research.

Dedication

To my parents, Jay, Madeline, and Evan

Chapter 1: Introduction

Maintaining healthy diets is an ongoing challenge for adolescents and young adults. Over 80 percent of adolescents are not meeting dietary recommendations and diets tend to worsen during young adulthood (Niemeier et al., 2006; Shay et al., 2013). Long term, poor nutrition can lead to greater risks for cardiovascular disease, diabetes, and other chronic diseases (Mikkilä et al., 2005). Early interventions are needed to encourage healthy nutrition and prevent these problems in adulthood. Adolescents and young adults, however, present unique challenges for interventions. Complicating factors such as changes in social relationships, living arrangements, schooling, and employment can threaten progress in establishing healthy behaviors. At the same time, there are distinct opportunities for informatics interventions. Adolescents and young adults are heavy users of technology (Pew Research Center, 2019b). 95% of teens and 96% of young adults in the United States own or have access to a smartphone (Pew Research Center, 2019a; Pew Research Center, 2019b). As such, leveraging technology holds promise for developing engaging behavior change interventions.

Novel interventions are needed to effectively promote healthy lifestyles and engage adolescents and young adults in nutrition. Researchers have made use of technology to deliver interventions but, there remain significant gaps in these solutions. Most applications do not support actions to build new individualized habits (Karapanos, 2015). Goal setting and self-monitoring are common strategies used to support behavior change in nutrition interventions (Cullen, Baranowski, and Smith, 2001; Michie et al., 2009). Mobile applications can assist in setting goals and logging foods but fail to provide the feedback necessary to understand progress in reaching goals (Locke and Latham, 2002). Applications include educational components to increase nutrition knowledge but fail to incorporate individual behaviors and preferences,

making it difficult to translate knowledge into action (Worsley, 2002). And finally, few existing applications take advantage of social influences among peers – a major driving factor impacting behavioral choices of this age group (Bronfenbrenner, 1979).

There is growing interest in using social media for nutrition interventions for young people (DiFilippo et al., 2015; Dumas, Lapointe, and Desroches, 2018; Yonker et al., 2015). Social media—websites and applications that enable content creation, sharing, and participation in networking—may be a particularly well-suited delivery mechanism for several reasons. Incorporating a social component leverages peer influence at a time when friends can be more influential than family (Ali et al., 2015; Fortin and Yazbeck, 2015; Lau et al., 2011). Social media has been shown to be an effective strategy for facilitating peer relationships (Best, Manktelow, and Taylor, 2014). But perhaps most importantly, young people are already strongly engaged with social media. 97% of teens and 88% of young adults report using social media (Lenhart, 2015a; Lenhart et al., 2010). Sustained engagement is necessary for successful behavior change and leveraging media that individuals use habitually may help to promote such engagement (Karapanos, 2015). Moreover, young people are already using social media for health purposes. They are using social media to find and share health information, cope with illness, and, within nutrition, share meal photos (Holmberg et al., 2016; Logsdon et al., 2014; Moreno et al., 2011; Vaterlaus et al., 2015; Velden and El Emam, 2013). This presents new opportunities to leverage interactions typical for social media platforms for health promotion.

One particular aspect of social media embraced by adolescents and young adults is its focus on light-weight casual communication, and brief, media-rich content. Such social media platforms as Instagram and TikTok are particularly popular among these individuals who draw inspiration from images and brief videos shared on these platforms. These platforms may present

a new opportunity to promote healthy behaviors among these populations with inspirational images; however, there is limited knowledge on what images adolescents and young adults find inspirational in health. Furthermore, questions remain as to ways to efficiently and effectively identify inspirational images in the vast volumes of images shared in social media, potentially using computational image analysis techniques.

In summary, social media nutrition interventions for adolescents and young adults are currently in their nascence and many questions still remain. Several knowledge gaps include: 1) limited understanding of the scope and efficacy of social media in existing informatics interventions for adolescents and young adults; 2) limited understanding of how adolescents and young adults engage with novel technologies in the context of health and nutrition; 3) limited understanding of how adolescents and young adults use existing social media for health and wellness; and 4) what opportunities exist to leverage image-rich social media platforms to promote healthy nutrition for this population.

The purpose of this dissertation is to address these knowledge gaps and to explore novel methods for using social media in informatics nutrition interventions for young populations. The goals of this dissertation are: 1) to characterize nutrition-related informatics interventions that have used social media for adolescents and young adults; 2) to understand the nutrition-related behaviors and needs of adolescents and young adults to better design interventions; 3) to understand how young people are currently using social media for health and wellness; and 4) to evaluate the feasibility of a novel machine learning method to predict health-related social media images that inspire healthy behaviors.

1.1 Specific Aims

Table 1: Overview of aims and research questions

Aim	Study	Research Questions
Aim 1	Characterize the use of social media in nutrition interventions for adolescents and young adults	How has social media been used in nutrition interventions and what levels of success have the interventions achieved?
Aim 2a	Explore motivations and barriers to healthy eating among adolescents and young adults with a chronic disease	What are the motivations, attitudes, and barriers for healthy eating among adolescent and young adult survivors of pediatric cancer?
Aim 2b	Explore dietary behaviors, contexts, and experiences using a nutrition application	Did participants' healthy nutrition behaviors improve while using the application? Did participants' nutritional learning improve while using the application? What are the dietary behaviors, contexts, and experiences of participants using a nutrition application?
Aim 2c	Explore attitudes, behaviors, and the use of social media for health and wellness in healthy young adults	What are the contexts and health and wellness-related behaviors of healthy young adults? How are young adults using social media platforms for health?
Aim 3	Explore the feasibility of using a machine learning approach to identify inspiring health-related social media images for young adults	Can a machine learning approach effectively predict images labeled by young adults as inspirational for health?

Aim 1: Characterize the use of social media in nutrition interventions for adolescents and young adults

Research question: How has social media been used in nutrition interventions for adolescents and young adults and what levels of success have the interventions achieved?

Researchers are beginning to recognize the potential value of social media as a tool to deliver health interventions and learn about patient experiences. Social media is being used by researchers for recruitment, data collection, and for content analysis to study and observe

behaviors at scale (Hamm et al., 2014; Park and Calamaro, 2013; Shaw et al., 2015; Williams et al., 2014; Yonker et al., 2015). Social media interventions have been developed to address various health issues of adolescents and young adults including sexual and reproductive health; mental health; chronic diseases like diabetes and cancer; and for chronic disease prevention with physical activity and nutrition. However, the use of social media in health interventions is in its nascence and the effects on health outcomes, and specifically in the area of nutrition, remain unclear (Shaw et al., 2015; Yonker et al., 2015). As these interventions gain popularity, it is important to understand how social media is being used in these interventions and the efficacy of social media on adolescent and young adult outcomes.

In this aim, I conducted a systematic literature review to explore the landscape of social media interventions within the informatics and public health research communities. The goals of this aim were to 1) identify specific nutrition interventions using social media for young people; 2) characterize the types of intervention components used in the interventions; 3) characterize the types of social media components used in the interventions; and 4) to review the emerging evidence regarding the efficacy of interventions that utilize social media for improving nutrition among adolescents and young adults.

The contribution of the aim is an inventory of social media interventions that promote nutrition among adolescents and young adults. The review provides a description of the types of social media, and the programmatic and technological components utilized within the interventions. It also provides an overview of study designs, measures, and outcomes reported for all studies, and a synthesis of the interventions' achievements and gaps that remain.

Aim 2: Explore attitudes, behaviors, and contexts for healthy eating among adolescents and young adults

To develop effective informatics solutions to improve dietary behaviors and nutrition, it is important to understand the beliefs, motivations, and contexts underlying the health behaviors that are specific to adolescents and young adults. First, adolescents and young adults face a unique set of challenges in health management requiring targeted interventions (Sawyer et al., 2007). The transition from adolescence to young adulthood is a distinctive time during the life course when individuals face new life experiences and learn the skills to adapt to these changes (Lenz, 2001). Within these groups, research has found that diet and eating behaviors are influenced by multiple factors at the individual, social, and environmental levels (Neumark-Sztainer et al., 1999). However, much of this research has been conducted in small settings and may not be generalizable. Because behaviors are contextually based, explicating these factors within our target group is necessary to inform the design of an effective health intervention.

Social media is emerging as a valuable tool for people to share food experiences and learn about nutrition. People are using social media to share food-related experiences and information, and to track diets (Abbar, Mejova, and Weber, 2015; Holmberg et al., 2016; Mejova et al., 2015; Vaterlaus et al., 2015). The study of usage patterns among young adults is less explored. Social media sharing behaviors of teens have been investigated more generally (boyd, 2015). However, there remain significant knowledge gaps around young peoples' social media behaviors around nutrition. In order to gain a better understanding of how to design social media technologies for youth, we need to learn how they use social media for nutrition.

Aim 2a. Explore motivations and barriers to healthy eating among adolescents and young adults with a chronic disease

In the first part of Aim 2, I explored general attitudes towards healthy eating among adolescents and young adults with a chronic disease– survivors of pediatric cancer. Among children and adolescents diagnosed with cancer, advances in therapies have led to an approximate 80% survival rate (Oeffinger et al, 2006). However, damage from radiation and chemotherapy treatments result in higher long-term morbidities of chronic diseases including obesity and cardiovascular disease. For these reasons, healthy weight management, a healthy diet, and adequate physical activity are often a priority for pediatric cancer survivors (Rock et al, 2012). As such, this population presents a unique perspective of adolescents and young adults who have suffered from serious illness and now face long-term risks that may increase awareness of and motivation for chronic disease prevention. This sub-aim addresses the following research question:

Research question: What are the motivations, attitudes, barriers, and contexts for healthy eating among adolescent and young adult pediatric cancer survivors?

In order to answer this question, I conducted an exploratory study with adolescents and young adults who are survivors of pediatric cancers. This study included a set of qualitative focus groups to explore motivations, attitudes and barriers to healthy eating among these individuals.

The contribution of this sub-aim is a characterization of motivations, attitudes, and barriers to healthy eating within this population, and a set of implications for the design of informatics interventions for promoting healthy eating.

Aim 2b. Explore dietary behaviors, contexts, and experiences using a nutrition application

In the second part of Aim 2, I expanded my investigations from the more general attitudes to more specific perceptions regarding the use of technology for nutrition management. Specifically, I examined how survivors of pediatric cancer engage with an informatics intervention for nutrition management that focuses on nutritional goal setting, meal logging, in-the-moment meal assessments, dietitian feedback on meal assessments, and a social media-like feature to view examples of meals from peers. This sub-aim answers the following research question:

Research questions:

- Did participants' healthy nutrition behaviors improve while using the application?
- Did participants' nutritional learning improve while using the application?
- What are the dietary behaviors, contexts, and experiences of participants using a nutrition application?

To answer this question, I conducted a five-week pilot study with 19 adolescents and young adults using an informatics nutrition intervention called Mealyzer. A quantitative analysis explored changes in nutritional learning and behaviors. An endline qualitative study with 7 adolescents and young adults was conducted. Interviews explored experiences and impressions using the application for goal setting, meal logging, in-the-moment assessments, and receipt of dietitian feedback. Use of previous health applications and preferences for application design was also explored.

The contribution of this sub-aim is a characterization of ways adolescents and young adults with a chronic condition engage with an informatics intervention for promoting healthy nutrition that combined self-monitoring with expert feedback and examples of healthy eating

from peers. I draw on these findings to outline a design space for future informatics interventions.

Aim 2c. Explore attitudes, behaviors, and the use of social media for health and wellness in healthy young adults

In the last part of Aim 2, I expanded my investigations from individuals with pediatric cancer to a more diverse population: healthy young adults that are transitioning into independent living. This sub-aim pursued the following research questions:

Research questions:

- What are the contexts and health and wellness-related behaviors of healthy young adults?
- How are young adults using social media platforms for health?

To answer this question, I conducted a mixed methods study to explore a) attitudes, behaviors, and contexts around health and wellness related activities and b) how young adults are using social media for health and wellness. First, I conducted a set of qualitative interviews with a group of young adults to understand personal perspectives on health and wellness, health routines and goals, and the use of social media both generally and for health. Further, using a survey, I characterized current internet and social media usage, the breadth of platforms being used, and levels of trust in various types of social media.

The contribution of this sub-aim is generalizable knowledge of the influences, attitudes, behaviors, and contexts surrounding health and diet behaviors in young adults without chronic illnesses. A second contribution is additional insight into how young adults use social media for health and wellness and their preferences for interactions with social media.

Aim 3: To explore the feasibility of using a machine learning approach to identify inspiring health-related social media images for young adults

Nutrition interventions have increasingly relied on mobile platforms and social media with most assuming nutritional decisions are rational, targeting intentions such as goal setting and self-monitoring (Karapanos, 2015). However, in the absence of motivation and time to process information, nutrition choices are often automatic and based on heuristics (Cohen and Babey, 2012). Thus, this aim seeks to approach nutrition choices from the perspective of dual process theory, which suggests that decision making can take two forms: rational and slow during which individuals plan and weigh evidence, and fast, in-the-moment, during which individuals base decisions on heuristics and affect (Evans, 2008). Although substantial research has explored the design of established methods such as goal setting, how to design interventions that address fast times is less understood. Based on my Aim 2 research showing adolescents and young adults frequent use of image-based social media for inspiration and time as a barrier to health tracking and self-monitoring, I propose image-based social media is well suited for interventions that deliver health inspiration messaging during these fast times. Cues such as visual salience and content that elicits an affective state like happiness are frequently cited heuristics that have the power to affect judgement (Petty and Cacioppo, 1986). The use of images is a simple way to deliver heuristic messaging quickly. These approaches are particularly well-suited for adolescents and young adults as heuristic cues are used more frequently at younger ages compared to analytic reasoning (Gerrard et al., 2008).

Previous studies have explored inspirational social media content using qualitative and manual methods (Simpson and Mazzeo, 2017). However, there is an active area of research in computer vision that explores aesthetic preferences and sentiments evoked from images and

prediction for multimedia retrieval and image recommendation tasks (Brachmann and Redies, 2017; Machajdik and Hanbury, 2010; Shin and Kim, 2010; Wang and He, 2008). Previous methods relied on utilizing visual design principles, such as the rule of thirds, as features for classification(Brachmann and Redies, 2017). However the advent of convolutional neural networks has made possible state-of-the-art performance on image classification tasks without handcrafting features (Krizhevsky, Sutskever, and Hinton, 2012). The application of these techniques within health and specifically how to identify inspirational images for nutrition and young populations is underexplored.

Research question: Can a machine learning approach effectively classify social media images as inspirational in health?

In this aim, I explored the feasibility of using convolutional neural networks (CNN) pre-trained on ImageNet to learn to classify social media images as inspirational for health for adolescents and young adults. I report on the approach for using a CNN for this purpose, and on the accuracy achieved with a training set of 600 images annotated by 6 participants (100 images per participant, selected from social media channels they find inspirational in health overall).

The contribution of this aim is a report on the feasibility of this approach and on challenges and limitations to using computational methods to identify inspirational images in health. I discuss future directions for the design of methods that combine computational image analysis with a human-centric perspective.

1.2 Significance

This dissertation proposal is significant in that it explores the use of social media—a relatively novel delivery mode—for nutrition informatics interventions for adolescents and young adults.

Current literature provides considerable evidence that adolescents and young adults are an important sub-population for nutritional interventions. While these individuals are typically relatively healthy, they are at high risk of adopting unhealthy behaviors that may impact their health later in life. Furthermore, social influences play an important role during this time and social media presents a unique opportunity to deliver interventions that are commonly used and highly influential. This dissertation examines how adolescents and young adults engage with novel informatics interventions for promoting healthy nutrition using both a literature review and a direct qualitative study thus helping to both summarize existing evidence and generate new original evidence. Furthermore, it explores novel intervention methods for using social media for nutrition that may be potentially adapted to other areas of health. This dissertation attempts to broaden our knowledge of the cognitive processes underlying nutrition behaviors, the contexts under which young people make health-related decisions, as well as provide a potentially engaging approach to designing informatics interventions compatible with these processes and contexts.

1.3 Contributions

The contributions of this work include the following:

1) A characterization of the current state of social media utilization in interventions for promoting healthy eating among adolescents and young adults in the form of a systematic review. This review identified both successful strategies and limitations in the current approaches as well as opportunities for future interventions in this space.

2) A set of qualitative studies that examined attitudes and behaviors regarding nutrition among young people, including both an open-ended interview study, and a qualitative study of how

young adults engaged with a novel informatics intervention. These studies combined provide a deep analysis and contribute to the existing knowledge of this previously under-explored area.

3) An analysis of social media use by adolescents and young adults, with the specific focus on health and wellness. This analysis contributes to the rapidly growing body of knowledge on the use of social media by adolescents and young adults by adding a previous under-explored health focus.

4) A feasibility study of a machine learning approach to identify images inspirational for health among images shared on social media. This approach can build a foundation for the design of future interventions for health promotion among adolescents and young adults and suggest new directions for incorporating machine learning methods in the design of interactive interventions in health.

1.4 Limitations

This dissertation has several limitations. The study in Aim 2b had a small sample size due to low recruitment and high attrition. This limits the generalizability of results. Additionally, different populations of adolescents and young adults were studied in this dissertation potentially limiting the generalizability of results. Studies in Aim 2a and 2b used samples of pediatric cancer survivors, thus limiting generalizability of the findings to broader populations. The study in Aims 2c and utilized samples of healthy young adults who volunteered to participate in the study about health and nutrition; their attitudes and behaviors may not generalize to a broader population of young adults. Lastly, the feasibility study in Aim 3 used a data set which may have been insufficient for training of the CNN classifier.

Chapter 2: Background and Related Work

2.1 Background on adolescence, young adulthood, health, and nutrition

Adolescents and young adults represent two age groups spanning contiguous developmental stages on the transition to adulthood. According to the World Health Organization, adolescents are defined as individuals aged 10 to 19 (WHO, 2017). The age ranges for young adults are less distinct with a lower age threshold of 18 to a maximum age of 25 to 30. In general, these groups are considered to be healthy. However, adolescence and young adulthood are times when individuals begin engaging in behaviors with potential short-term health risks such as substance abuse and sex (Kann, 2016). Yet, more insidious behaviors like poor diets and physical activity that present risk for chronic disease also begin to deteriorate during this period (ibid.). Many high school students fail to meet dietary recommendations. According to the Centers for Disease Control, only 61% report eating one or more vegetables and 5% report eating any fruit per day in the week prior (ibid.). Among young adults aged 18 to 30, less than 10 percent meet the federal intake recommendations for fruits or vegetables (Lee-Kwan, 2017). On the contrary, dietary consumption of fast food and sugar-sweetened beverages are high with 77% reporting eating fast food and 61% consuming more than 6 sugar sweetened beverages per week (Sorgi et al., 2015).

Behaviors learned during adolescence and young adulthood form the foundation for long-term adult health (Forrest and Riley, 2004). It is an important time for early intervention but, also a significant period of transition. Adolescence is characterized by dramatic physical, mental, and social changes. It's a period of increased independence as young adults leave home for the first time and take on adult roles. New opportunities to learn healthy behaviors arise with new responsibilities of becoming an adult. Diet-related activities such as purchasing meals, buying

groceries and cooking at home are among the new responsibilities that young adults must learn. Despite the promise of this period, there remain barriers to healthy behaviors. Being generally healthy, these groups typically have less interaction with the health care system. Moving into young adulthood, structural barriers such as lack of health insurance or becoming disconnected in the transition from pediatric to adult care can further limit contact with health care (Garvey et al., 2013). On the individual level, health is not always a priority. Time constraints and competing life priorities mean young adults often place a low importance on health (ibid.). Similarly, these concerns often play a role in barriers to healthy eating. Food choice among these groups is affected by multi-level factors including access to food, financial resources, social support from family and friends, social norms and individual taste preferences (Neumark-Sztainer et al., 1999).

2.2 Interventions for nutrition for young people

”Interventions” refer to activities associated with reducing risks and threats to health. In public health, there is a long history of intervention research that seeks to identify novel methods for reducing health risks and educating participants in specific areas of health and disease management. Typical health intervention components include: provision of resources; emotional/peer support; group/individual counseling; education; or skills-based content (Salam et al., 2016). Teaching skills is often a large component of interventions and can include strategies for behavior change; cognitive behavioral therapies; coping; communication; life skills; and self-management of health (Sansom-Daly et al., 2012). These interventions can take place in various settings or ”places or social contexts in which people engage in daily activities and where different factors interact to affect health and well-being” (Institute of Medicine,

2014). Interventions can take place in a variety of such settings including within communities, schools, families, and with individuals alone (ibid.).

Interventions in informatics for nutrition

Clinical interventions have attempted to utilize technology to improve the nutrition of adolescents and young adults at risk for chronic diseases. Previous nutrition interventions have explored a variety of approaches to tackle behavior change including teaching general nutrition information and skills for healthy eating. Interventions have increased healthy diet intake by educating participants on the relationship between health and diet, dietary guidelines and benefits of consuming five or more daily servings of fruits and vegetables (Chen and Wilkosz, 2014; Di Noia, Contento, and Prochaska, 2008; Ezendam, Brug, and Oenema, 2012; Mangunkusumo et al., 2007). Studies included online nutrition programs, social media campaigns, and electronic messages to increase knowledge of healthy foods and their benefits (Ezendam, Brug, and Oenema, 2012; Hackman and Knowlden, 2014). Others teach skills for healthy eating such as estimating portion sizes, understanding food labels and calculating calorie balances (Chen and Wilkosz, 2014; Doyle et al., 2008).

Although these interventions have achieved some success, these outcomes are often not sustained. A systematic review of computer-based interventions targeted at overweight youth found that few of these approaches achieved long-term effects (Ajie and Chapman-Novakofski, 2014). Several individual studies recognized this limitation and suggested a need for interventions to sustain these improvements (Di Noia, Contento, and Prochaska, 2008). Thus, new approaches are needed that can provide ongoing assistance in sustaining dietary changes.

Personal informatics

Personal informatics tools allow users to collect data to explore and reflect on one's own behaviors (Li, 2010). Engaging young people in their health through self-monitoring and decision-making using computer-assisted applications has shown promise for improving nutrition and physical well-being. Behavior monitoring, activity logging, and goal setting are common intervention features used to engage young people in health tracking. These features may be particularly useful given lack of self-regulatory skills for maintaining healthy behaviors among young adults (Strong, 2008). Setting goals combined with self-monitoring can enhance awareness of behaviors and has shown promise for effecting health change (Cullen et al., 2001; Shilts et al., 2004; White & Skinner, 1988). These approaches have resulted in increased self-efficacy for healthy eating (Casazza and Ciccazzo, 2007; Long and Stevens, 2004), increased healthy food consumption (Chen and Wilkosz, 2014), reduced body fat (Williamson et al., 2006), and lower increases in body mass index (Haerens et al., 2006).

Research on youth-specific personal informatics tools has identified design considerations for these groups. With personal informatics tools, young people may not aim to change behaviors but instead use them for self-discovery (Cafazzo et al., 2012; Potapov, 2019). Further there are considerations related to peer relationships and identity management. Young people have greater concerns for how their data conforms with norms and perceptions of themselves (Potapov, 2019). Moreover, youth can perceive health tracking apps as unpopular among peers and only for adults which can affect use (Chan et al., 2017).

Sharing nutrition data with peers

Sharing data with peers using technology is another method of promoting healthy nutrition. Such interventions can leverage the influence of peers who may exert more influence

than parents during adolescence (Lau et al., 1990). This is particularly true for diet where research has found friends can influence consumption of both unhealthy and healthy foods (Ali et al., 2011; Wouters et al., 2010; Wouters & Geenen, 2013). Types of data shared within diet-related interventions have included step counts, goals, and diet logs (Chung et al., 2016; Godino et al., 2016; Lytle et al., 2014; Smith et al., 2014; Svetkey et al., 2015). The RealUs intervention with adolescent boys included public goal setting and peer coaching with behavioral tracking and goals reviews found improvements in eating breakfast (An et al., 2013).

Reflection with food images

A number of researchers have explored how images encourage reflection on diet (Chung et al., 2017; Cordeiro et al., 2015; Schaefbauer et al., 2015). Cordeiro et al examined how photo-based meal capture provides a less burdensome approach to food logging compared to more quantitative logging of nutrition (Cordeiro et al., 2015). Upon reflection, images prompted greater recall of context around meals which helped elucidate nutritional triggers and trends (Cordeiro et al., 2015). However, few such technologies have been developed for nutrition with adolescents and young adults in mind. In the Human Computer Interaction research community, Grimes Parker developed TalkBack which used food advertisements to probe children into reflecting on their preferences for foods (Parker et al., 2013).

2.3 Social media for health among adolescents and young adults

Social media is a potentially engaging area of exploration for informatics interventions for young people. Social media enables users to create, interact, collaborate and/or share in the process of creating and consuming content. User-generated content is the main attraction and can include user-specific profiles, lists of users who share connections, and the ability to view and

traverse lists of connections. Teens and young adults are highly engaged with social media with three quarters of teens and 90% of young adults spending time on social media (Lenhart, 2015b). Over a third use Facebook, Instagram, or Snapchat (Lenhart, 2015b). Young people are already leveraging social media to find health information; share information on health (Moreno et al., 2011; Velden and El Emam, 2013); and as a means of coping with various conditions (Logsdon et al., 2014). These levels are important to consider in the development of behavior change interventions as engagement is crucial for long-term engagement.

Another reason to consider social media is peer influence and the effects of social networks on health. This is a time when peers begin to exert more influence than parents (Lau, Quadrel, and Hartman, 1990). Particularly with dietary behaviors, research has found peer effects for consumption of snacks, fast foods, and mixed effects for healthier foods (Ali, Amialchuk, and Heiland, 2011; Wouters et al., 2010). Unhealthy habits can become more similar to friends' and, long-term, in adulthood, peers can exert more influence than family on risks of obesity (Christakis and Fowler, 2007; Wouters et al., 2010).

More generally, social media can facilitate social support. Research across multiple disciplines suggests that social support is an influential factor in achieving positive health outcomes. Being a member of social networks can influence individual behavior choices by setting norms, influencing knowledge on health issues, or through methods of social control such as the use of stigma (Krieger, 2001). Participation in social networks also builds social capital among its members. Social capital is a concept that describes a nonmonetary form of power resulting from the positive consequences of participation in groups and networks (Portes, 1998). Increased social capital often yields greater access to individuals and resources that can benefit health.

As a relatively new technology, researchers cite several potential benefits and drawbacks of using social media for health. Among the benefits are increased socialization and support; exposure to learning opportunities; increased access to new information; and access to shared, tailored information (Moorhead et al., 2013; O'Keeffe, Clarke-Pearson, and Media, 2011). However, there are also documented drawbacks. The quality and reliability of information found on social media can be poor (Moorhead et al, 2013). Moreover there are potential risks for those participating in social media (Moorhead et al, 2013). Exposure to risky behaviors on social media can make them seem normative (Alhabash, 2015). There are also risks of harmful social interactions including cyberbullying and harassment (Best et al, 2014). Privacy is also a concern when health information is shared in these public venues (Chassiakos et al., 2016; O'Keeffe, Clarke-Pearson, and Media, 2011). Although there are privacy concerns, qualitative research with young people shows that they are aware of these issues surrounding social media (boyd, 2015). Having grown up with social media, young people have different concepts of privacy compared to other age groups (boyd, 2015). In many cases, they are aware of privacy issues and selective about how and where they share information (Velden and El Emam, 2013).

Social media is already being used for adolescent and young adult health interventions. Applications have been created in the areas of sexual and reproductive health, substance abuse, mental health, chronic disease, cyberbullying, and other topics (Hamm et al., 2014; Park and Calamaro, 2013; Shaw et al., 2015; Williams et al., 2014; Yonker et al., 2015). It's been used for recruitment, to collect data, and to analyze behaviors (Hamm et al., 2014; Park and Calamaro, 2013; Shaw et al., 2015; Williams et al., 2014; Yonker et al., 2015). Within interventions, it's been used to deliver educational content, promote social support, facilitate communications,

encourage self-reflection, and support self-monitoring (Hamm et al., 2014; Park and Calamaro, 2013; Shaw et al., 2015; Williams et al., 2014; Yonker et al., 2015).

2.4 Review of theories

This dissertation uses health promotion theories and models and psychological constructs that have been previously applied in the area of nutrition and behavior change. The following theories and models were used to guide intervention and study design and to explicate findings: 1) Social ecological models; 2) Social cognitive theory; and 3) Dual process theory.

Social ecological model

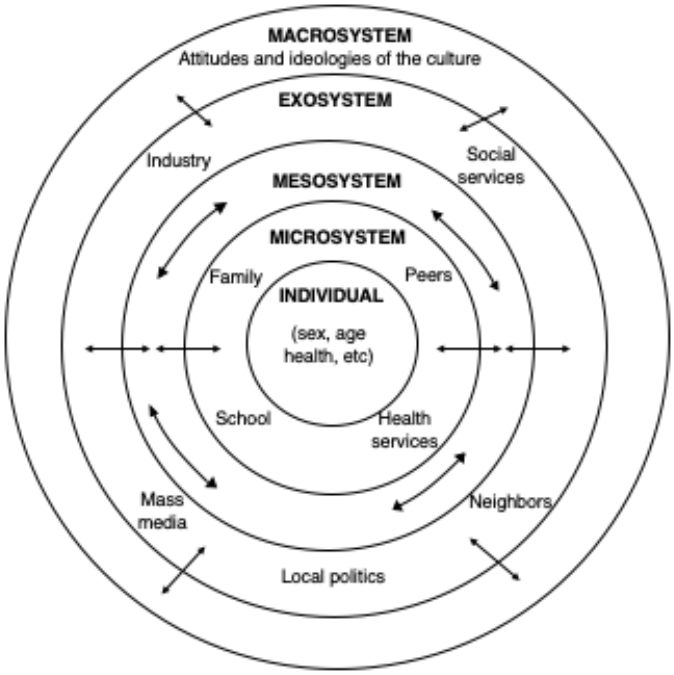
The Social ecological model by Urie Bronfenbrenner is a systems approach researchers use to understand the range of influences and contexts under which nutrition behaviors occur (Ory, Jordan, and Bazzarre, 2002). The original application models human development as the result of processes, individuals, contexts and time (Bronfenbrenner, 1979).

The theory recognizes and explicates the multiple levels of influence on an individual's development. It theorizes that individual behaviors and development are the result of an interplay between personal and environmental factors. Within the levels of influence are people, institutions, organizations, and policies that an individual interacts with, and, that interact with each other, to constrain choice and shape health.

The social ecological model depicts these influences as multiple layers surrounding an individual at the center. The layer closest to the individual is the microsystem which includes the people, organizations, and structures with which an individual has immediate direct contact (Figure 2.1). This can include parents, family, schools, communities and neighborhoods. This level has the most direct effects on an individual. The next level is the mesolayer that includes

the systems within the environment that connect various structures. For example, the educational system within a community that connects a child with their school would be considered part of the mesolayer.

Figure 2.1: Social ecological model (Bronfenbrenner, 1979)



The broader political, social, and economic conditions create the exosystem. At the outermost levels are the attitudes and beliefs within society that create the macrosystems. As such, the health and development of individuals are shaped by the behavioral choices made within this contextual environment. For example, individuals living in environments that promote increased food consumption and non-healthful foods in the form of policies, availability for sale/consumption, and social norms are at increased risk of making poor food choices (Gauvain and Cole, 2005). Lastly, a time component was added to the social ecological model incorporating a life course perspective. This chronosystem incorporates changes and consistencies over time in the individual and in the environment. In the context of this

dissertation, time adds a perspective on aging. As adolescents and young adults age, individuals mature, and environments change, behaviors may be affected.

In this dissertation, I primarily focus on interventions at the innermost layers of the Social Ecological model —the individual and their behaviors and choices within the contexts of their environments. The choice to focus on individual behaviors leverages the strengths of informatics and the widespread adoption of smartphones and advances in these technologies (Pew Research Center, 2019a). Public health interventions at the outermost levels have experienced success. However, there are drawbacks. Policy and community level approaches limiting food choice relies on buy-in from politicians and community leaders. Moreover, these types of interventions can be viewed as paternalistic (Goldberg, 2013). Traditional in-person interventions are often limited by geographical settings and one size fits all approaches. Informatics interventions, at the individual level, on the other hand have several advantages. With the availability of portable devices and widespread access to the internet, they are not limited by geographical boundaries. Secondly, they are potentially more flexible and can be tailored to incorporate individual needs and preferences (Free et al., 2013). Specifically with behavior change and self-management, mobile solutions can be accessible at the time and place when users need it most during their everyday lives. Specifically for individuals who *choose* to change nutrition behaviors, interventions can be made available to them when they are making food choices throughout the day.

Social cognitive theory: Observational learning

Social cognitive theory by Albert Bandura is used in health promotion to address the socio-structural and personal determinants of health (Bandura, 1998). Social cognitive theory specifies factors that play a role in the development of competencies related to physical and

emotional well-being and the self-regulation of health habits. Personal factors, the environment, and individual behaviors interact to create social contexts in which health choices are made. Within this dissertation, I focus on the knowledge structure component of social cognitive theory that includes observational learning.

Social cognitive theory posits that individuals have knowledge structures to guide complex patterns of behaviors. These knowledge structures are developed by learning modeled behaviors, through trial and error, from instruction, and from synthesis of information. One specific type of learning that occurs within social contexts is observational learning (Bandura, 1999). It states that individuals learn by observing others model behaviors and through the influence of examples.

This type of learning is not simply mimicking behaviors. But rather, those who observe, learn rules for actions and can discern similar rules across different examples. Once these rules are learned, individuals can apply them to unseen situations and new behaviors. Individuals choose to replicate these behaviors when they are observed to show favorable outcomes.

Social cognitive theory deconstructs observational learning into four sub-functions: attentional processes; cognitive representational processes; production processes; and motivational processes (Bandura, 2004). *Attentional processes* describe the factors that influence how individuals decide to observe and filter specific information from events. These include ”cognitive skills, preconceptions, and value preferences of the observers [...] conspicuousness, attractiveness, and functional value of the modeled activities themselves (ibid.).” *Cognitive representational processes* enable individuals to remember these rules and behaviors. This includes retention– observing and transforming information into rules for new behaviors. Biases can be introduced through preconceptions and emotional states. Recall includes reconstructing

experiences. The *production process* encompasses the acts of transforming rule conceptions into actions through execution and modification. The success of this step can be heavily influenced by an individual's specific skill sets. And lastly *motivational processes* explain the incentives behind performing behaviors. These can be external, vicariously observed, or self-incentives. All these processes are affected by the observer's individual attributes of perceptions, cognition, preferences, and skills.

Dual process theories

Dual process theories are used to describe how people process information based on different contexts and how this affects message interpretations and attitude changes. A number of frameworks fall under the umbrella of dual process theories (Evans, 2008). These frameworks can be organized by how they characterize individuals within contexts as 1) an irrational actor; 2) individual as a social actor; 3) individual as an actor in a social environment; and 4) individual as a self-regulated actor (Houlihan, 2018). Common to them all is a theory of two systems of cognitive processes that work to influence beliefs. The first system is often described as peripheral, fast, intuitive, automatic and belief-based. It often relies on heuristics learned over time and is cued when relevant features of messages bring to mind prior knowledge. The other system is central, slow, and reflective thinking. It is cued by instructions for reasoning or when people have greater abilities or opportunity to think reflectively or critically.

Below I describe a prominent theory within the dual process theory family.

Elaboration likelihood model

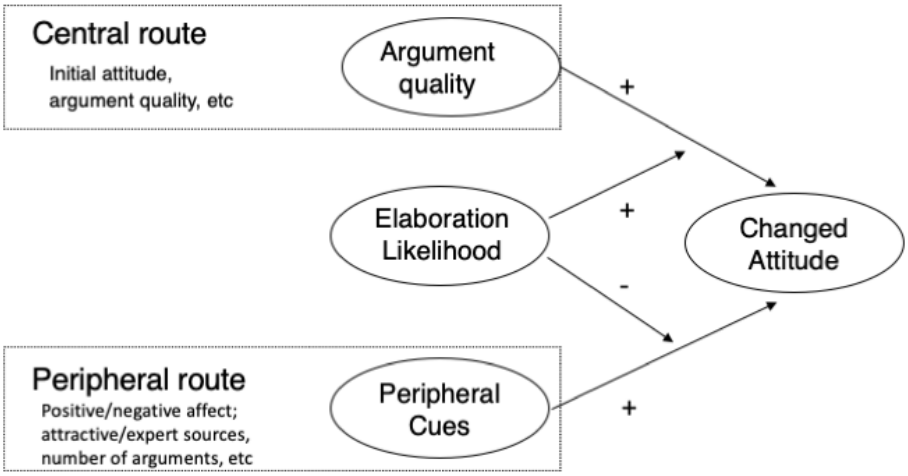
The elaboration likelihood model is one specific instance of dual process theory that has been used in health promotion and behavior change (Petty, Barden, and Wheeler, 2009). It

provides a general framework for understanding the cognitive processes underlying persuasive messaging. It theorizes that message features can influence one's likelihood to "elaborate", that is, think about the issue-relevant arguments contained in a message, and that this process affects whether a person is persuaded into believing a message. Elaboration likelihood changes depend on individual and situational factors. The theory describes attitude change processes as occurring through two routes of persuasion–central and peripheral (Petty and Cacioppo, 1986).

The central route involves careful consideration of the issue, relevant information presented, and how it relates to one's individual knowledge base. During this consideration, attitudes may change in favor or against the argument. This process requires being motivated and/or having the ability to think critically about the issue at hand. Motivation, in this case, may be related to the perceived relevance of the topic to the individual or whether a person is generally inclined to critically consider issues. Their ability may be influenced by intrinsic factors such as reasoning skills or external factors such as distractions being present. This system and line of argument consideration is hypothesized to lead to better processing and greater likelihood of being incorporated into a person's beliefs and remaining a more strongly held belief.

The peripheral route is the second system of processes that occurs during times when individuals lack the motivation or the ability to carefully consider the arguments in a message. This type of attitude change occurs with the use of processes that require less consideration than those in the central route. Examples of the types of heuristics spurred by the peripheral route include counting numbers of arguments, messaging that "elicits an affective state" such as happiness, and others. All of these provide a cue that the argument presented may be of high quality without requiring intense processing of the message.

Figure 2.2: Elaboration likelihood model (Petty and Cacioppo, 1986)



In addition, the central and peripheral processes interact with each other and with factors during message delivery to influence an individual's attitude. Dual processes occur across a continuum and can occur separately or together. Two distinctive routes of persuasion based on motivation and ability to process information in messages are influenced by individual and situational factors. Message features that can affect motivation or ability to think about a subject (extent and direction of thinking) include things like source credibility, number of arguments, likeability, and visual salience. They can be internal to the person or be related to the situation. For example, environmental cues like pleasant sounds may influence a person's attitude. All of these combined changed elaboration likelihood which work to change attitudes.

Chapter 3:

Aim 1: Characterize the use of social media in nutrition interventions for adolescents and young adults

3.1 Introduction

In recent years, nutrition education interventions have increasingly relied on computing and information technologies, particularly mobile platforms and social media (DiFilippo et al., 2015; Yonker et al., 2015). Adolescents and young adults are particularly amenable to such solutions, as they exhibit high levels of smartphone and social media usage and, thus, are likely to be receptive to using these platforms for health (Pew Research Center, 2019a; Pew Research Center, 2018). Novel computing and mobile-based platforms for health and nutrition leverage the popularity of mobile technologies among youth to deliver nutrition-related educational content, to facilitate counseling and communication with clinicians, and to encourage behavior logging and self-assessments (Ajie and Chapman-Novakofski, 2014). Thus far, many of these efforts have focused on translating previous expert-developed programmatic content and interactions with professionals into experiences using technology.

To reflect a growing number of nutritional interventions with technological components, recent systematic literature reviews have included such interventions for adolescents and young adults. However, these previous reviews focused on broader age groups (Free et al., 2013; Hamm et al., 2014; Hebden et al., 2014; Laranjo et al., 2014; Maher et al., 2014; Merolli, Gray, and Martin-Sanchez, 2013; Wang et al., 2016; Williams et al., 2014) and health conditions (Cushing and Steele, 2010; Hamm et al., 2014; Laranjo et al., 2014; Maher et al., 2014; Merolli, Gray, and Martin-Sanchez, 2013; Plotnikoff et al., 2015; Shaw et al., 2015; Yonker et al., 2015), or on

specific behaviors and clinical outcomes such as vegetable intake or weight loss (Nour et al., 2017; Wickham and Carbone, 2015). Others focused on theoretical foundations used to inform programmatic elements of the interventions (Dute, Bemelmans, and Breda, 2016; Hackman and Knowlden, 2014). In terms of technology, reviews have examined delivery methods such as computer, web, and mobile devices (Ajie and Chapman-Novakofski, 2014; Chen and Wilkosz, 2014; Hamm et al., 2014; Quelly, Norris, and DiPietro, 2016). None, however, specifically examined the effect of nutrition and diet interventions for adolescents and young adults that incorporated social media. Thus far, only two reviews focused more generally on health and social media among adolescents and young adults. As a result, the effect of social media interventions on health outcomes remains unclear, with one review showing no significant outcomes and another describing the purpose of social media components in interventions (e.g. for recruitment; communication; etc.) but not examining outcomes (Shaw et al., 2015; Yonker et al., 2015).

The purpose of this study was to fill these gaps and to review the emerging evidence regarding the efficacy of interventions that utilize social media for improving nutrition among adolescents and young adults. Our specific goals were: 1) to identify technological features included in these interventions, 2) to evaluate evidence from randomized and non-randomized studies for using social media in nutrition interventions for these age groups, and 3) to identify areas that require further research. In sum, this study aimed to answer the following research question:

RQ1: How has social media have been used in interventions and how successful have these interventions been?

3.2 Study Design and Procedures

Search strategy

Our methods followed the PRISMA systematic review guidelines (Moher et al., 2015). We searched five electronic databases: PubMed, CINAHL, EMBASE, PsycINFO, and ACM Digital Library. Keywords included 1) age group (e.g." adolescent" and "young adult"), 2) nutrition (e.g. "diet", "food", etc,) and 3) social media and technology (e.g. "social media", "Facebook", "Instagram", "Internet", "mobile applications", "computer", etc). For searches that produced excessively large numbers of results, searches were further limited to having a social component ("social" or "peer(s)") in the full-text. Papers retrieved were limited to those published in English for a period of ten years. Given the rapidly changing nature of social media technologies, the time period included the most recent and still relevant interventions; it also captured the earliest references to "social media" in the literature. References from relevant articles were manually searched for citations and added for review. See Appendix A.1 for search terms.

Eligibility criteria

The following inclusion criteria were used to select articles eligible for review: 1) targeted adolescents (10-19) and/or young adults (18-25) who are healthy, or have a health challenge, such as being overweight, obese, or have a chronic disease; 2) included a nutrition education or behavior change component, or outcomes related to improving nutritional knowledge or dietary changes (e.g. increase fruits/vegetable intake; reduce fast food/sugar-sweetened beverages intake); and 3) included a social media website, application, or homegrown technology that allows users to communicate or share information with peers. Exclusion criteria

included interventions targeting eating disorders, families, or parents; or articles that are not peer reviewed (e.g. dissertation/thesis). We excluded studies without an evaluation component due to our interest in the impact of interventions on clinical or behavioral outcomes.

Study selection

Two reviewers conducted all article screenings with conflicts discussed and, if needed, adjudicated by a third reviewer. An initial review was completed to screen database results based on title and abstract. Articles that did not fit inclusion criteria and duplicates were excluded. A full text review of articles was completed and reasons for exclusion were documented. Once final articles were determined, additional manuscripts from the research studies were added. Study design characteristics, intervention features, measured outcomes, and significant outcomes were extracted from the final articles.

Risk of bias

Final articles were assessed for bias using the Downs Black Checklist for Measuring Quality in Health Care Intervention Studies (Downs and Black, 1998) by two reviewers. The checklist is used to assess heath care study quality and is adaptable for study designs from experimental to non-experimental.

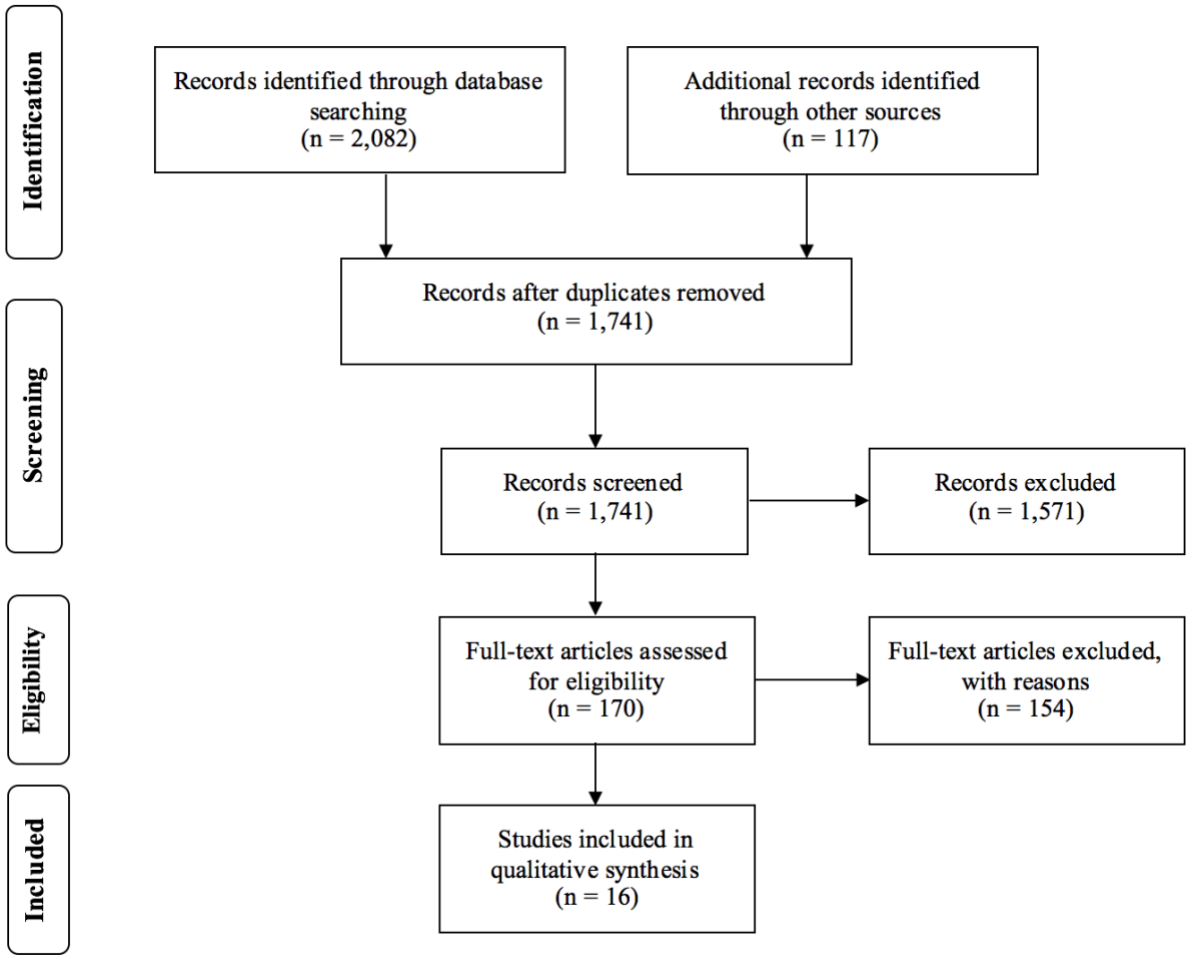
3.3 Results

Search results

The initial database searches produced 2,082 articles: 1,234 from PubMed; 42 from CINAHL, 532 from EMBASE, 201 from PsycINFO; and 73 from ACM (Figure 3.1). An

additional 117 were included from other sources such as article references and known articles not captured with searches. After 458 duplicates were removed, 1741 articles were screened for titles and abstracts and 1,571 were excluded. Articles were excluded for the following reasons: not including social media, including irrelevant age groups, targeting eating disorders, not including an evaluation component, and not including a nutrition component or outcomes. We excluded systematic reviews but searched the references. During full text screening, 170 articles were assessed for eligibility; of these 154 were excluded for reasons listed above. Our final qualitative analysis includes 16 studies.

Figure 3.1: PRISMA flow diagram of search strategy



Quality Appraisal

Although the majority of studies were randomized controlled trials, study quality varied. Eleven studies met at least 60 percent of the Downs Black criteria indicating good quality (Smith et al., 2014; Allman-Farinelli et al., 2016; An et al., 2013; Doyle et al, 2008; Godino et al., 2016; Kulik et al., 2014; Lana et al., 2014; Laska et al., 2016; Leme et al., 2015; Svetkey et al., 2015; Whittemore and Grey, 2013). Four studies were of fair quality meeting 50 percent of the checklist (Hutchesson et al., 2016; Jones et al., 2014; Napolitano et al., 2013; Nawi and Jamaludin, 2015). The remaining study did not sufficiently report key study characteristics to assess quality (Chung et al., 2016). See Appendix A.2 for results from the quality appraisal.

Theoretical frameworks used to design interventions

Nearly all studies utilized theoretical frameworks to inform the design of application features and intervention content. This included individual behavior models like the transtheoretical model (Allman-Farinelli et al., 2016; Lana et al., 2013; Svetkey et al., 2015), theory of reasoned action (An et al., 2013), self-determination theory (An et al., 2013; Smith et al., 2014), trans-contextual model of motivation (Smith et al., 2014), and theory of planned behavior (An et al., 2013; Godino et al., 2016). One used the Attitude-Social Influence-Self-efficacy model based on the theory of planned behavior specific to fruit and vegetable consumption (Lana et al., 2013). Seven studies used interpersonal behaviors models such as control (Allman-Farinelli et al., 2016), social cognitive (An et al., 2013; Leme and Philippi, 2015; Lytle et al., 2014; Smith et al., 2014; Svetkey et al., 2015; Whittemore, Jeon, and Grey, 2013), and social network theories (Lytle et al., 2014). One accounted for broader influences using ecological models of health behavior(ibid.). Three studies described using general

cognitive behavioral strategies (Doyle et al., 2008; Hutchesson et al., 2016; Kulik et al., 2014) or behavioral change techniques to design interventions. Technology use theories, such as the theory of interactive technology, were also used (Whittemore, Jeon, and Grey, 2013). Three studies did not report using theoretical frameworks. One used a formative study with focus groups to solicit design ideas from participants (Chung et al., 2016). The others did not describe the design process (Napolitano et al., 2013; Nawi and Jamaludin, 2015).

Intervention features

The analysis identified broad families of features included in the reviewed interventions: social media; communication mechanisms; health tracking; tailoring; education; social support; and gamification (Figure 3.2).

Social Media

Social media features were categorized based on the function, purpose or activity for which it was used and by specific platforms. The three main functions of social media in the interventions were 1) to facilitate communications and relationships among peers; 2) to support self-tracking and gamification; and 3) to share content among research staff and participants. We expand on these below.

One of the more common uses of social media was to facilitate communication, relationship building, and social support among peers. Blogs were used to disseminate information and allow commentary by community members (Allman-Farinelli et al., 2016; An et al., 2013). More extensive interactions including support seeking, relationship building, problem solving, and behavior sharing were supported through online discussion forums (Lana et al.,

Figure 3.2: Study Intervention Features

KEY ● = tech-mediated, nutrition; **O**=tech-mediated, not nutrition;
■ = in-person, nutrition; □=in-person, not nutrition

	Study (Last name, publication year)															
	Allman-Farinelli 2016	**An 2013**	**Chung 2016**	**Doyle 2008**	**Godino 2016**	**Hutchesson 2016**	**Jones 2014**	**Kulik 2015**	**Lana 2014**	**Laska 2016**	**Leme 2016**	**Napolitano 2014**	**Nawi 2015**	**Smith 2014**	**Svetkey 2015**	**Whittemore 2013**
Significant study outcomes	✓	✓	✓	✓		✓			✓	✓	✓	✓		✓		✓
Features																
Social media																
Method of delivery																
Facebook					●			●				●				
FitBit			●													
Pinterest			●													
Twitter			●													
WhatsApp											●					
Homegrown website	●	●		●	●	●	●		●	●			●	●		●
Homegrown mobile app	●				●									●	●	
Function																
Information dissemination/modules	●	●	●							●	●	●		●		●
Online discussions forums / Blogs	●			●	●	●	●	●	●	●			●			●
Post questions	●		●													
Messaging		●	●					●	●	●	●					
User profiles/avatars		●		●						●					●	
Peer assessments/support		●						●				●		●	●	
Nutrition and health resources									●	●		●				
Prompts to track			●												●	
Log/post goals and behaviors		●	●		●					●				●	●	
Communication																
Generic messaging					●			●		●		●				
Messaging clinicians/ research staff	O				●			●		●						●
Tracking health																
Food diary	●	●	●	●	●	●	●		●	●	■				●	●
Physical activity diary	O	O	O	O	O	O	O			O	■			O	O	O
Other behavior tracking		O		O			O			O						
Goal setting		●			●	●	●O			●		O		O	●	●
Feedback/coaching	■	●	●	●	●		●O			●		●O			●	●
Prompts to track		●			●										●	
Tailoring																
Messages	●	●O	●											●		
Feedback or recommendations	■	●	●	■	●	●				●		●			●	
Goal setting					●	●				●						
Education																
Method of delivery																
Workshops/classes								■□		■□	■□			□		
Automated messages		●			●□	●			●		●	●■		●	●	
Static online information or links	●		●		●□	●			●			●	●○		●	
Emails / Newsletters	●			●	●□	●					■□					
Modules or videos or podcasts		●		●■			●□		●	●		●			●	●
Content																
Recipes/meal planning/health tips	●■		●		●	●		■□		●■		●				
Peer support skills								■□				●		□		
Individual stress/coping skills								■□		●■		●				●
Other lifestyle modification										●■	■□	●				
Social support (not from social media)																
Family engagement				■			■□	■□			■			□		
Peers		●	●								●	●		□	●	
Motivational messages											●			●	●	
Gamification																
Behavioral challenges			■				●							O		

2013; Doyle et al., 2008; Hutchesson et al., 2016; Lytle et al., 2014; Jones et al., 2014). Smaller group interactions were offered through private groups, messaging, and chats using Facebook, WhatsApp, Twitter and homegrown apps (Kulik et al., 2014; Napolitano et al., 2013; Leme et al., 2016. In some cases, interactions were open-ended to allow participants to organically discuss topics of interest (Allman-Farinelli et al.; 2016, Lytle et al., 2014; Doyle et al., 2008; Hutchesson et al., 2016) which in one case was monitored by a professional (Hutchesson et al., 2016). However, three interventions supplied topics (Chung et al., 2016) and structured activities with assigned partners (Svetkey et al., 2015a; Kulik et al., 2014) for discussion.

Social media was also used to support sharing of tracking activities and gamification. Public and selective sharing of goal setting, diet logging, and physical activities were included in five interventions (Smith et al., 2014; Svetkey et al., 2015a; Lytle et al., 2014; Godino et al., 2016; Chung et al., 2016). Two included assessments (Smith et al., 2014) or coaching (An et al., 2013) from peers. Diet and exercise related games and challenges were included (Smith et al., 2014; Svetkey et al., 2015a; Godino et al., 2016) with one application enabling public results posting (Smith et al., 2014). Homegrown applications or existing social media platforms such as Twitter (Chung et al., 2016) and Fitbit (Chung et al., 2016) were used for these activities.

Lastly, social media was used to share content among study staff and participants. This included educational information, messages (Leme et al., 2016), reminders (Chung et al., 2016), polls (Napolitano et al., 2013), and health-related event information (Napolitano et al., 2013). Three studies supported multimedia content sharing including podcasts (Napolitano et al., 2013), photograph diary testimonials from peers (An et al., 2013), health-related images selected by

study staff from Pinterest sent through Twitter (Chung et al., 2016), and video messages from peer coaches (An et al., 2013).

Other communication mechanisms

Communications outside of social media between study participants and research staff, professionals, and off-line with peers was another prominent feature. Technology-mediated private messaging (Chung et al., 2016; Leme et al., 2016), emails (Allman-Farinelli et al., 2016), and requests for online advice (Lana et al., 2013) with dietitians and research staff were available in three studies. Other studies relied on traditional communication methods such as phone calls (An et al., 2013; Lytle et al., 2014) including coaching calls with dietitians (Allman-Farinelli et al., 2016).

Features for tracking health behaviors

Outside of social media, websites and apps were used to track health activities with goal setting, monitoring, and feedback for personal use and for review by experts. Monitored activities included diet, physical activity, screen time, and triggers of body dissatisfaction (Doyle et al., 2008). Private online journaling, self-monitoring, and reporting of behaviors was featured in nine studies (Smith et al., 2014; Allman-Farinelli et al., 2016; Svetkey et al., 2015a; An et al., 2013; Godino et al., 2016; Doyle et al., 2008; Hutchesson et al., 2016; Chung et al., 2016; Jones et al., 2014). In most cases, these required manual logging, particularly for diet. However one study auto-tweeted physical activities via FitBit (Chung et al., 2016). Real-time location-based prompts were included in one study to encourage tracking (Godino et al., 2016). Other interventions used paper diaries (Leme et al., 2016; Kulik et al., 2015) and food recall surveys

(Lana et al., 2013) submitted to study staff to assess diets. Goal review and feedback were provided in the form of phone calls (Allman-Farinelli et al., 2016), messaging (An et al., 2013), reports (Napolitano et al., 2013) from avatars (An et al., 2013) automated feedback(Jones et al., 2014), and research and clinical personnel (Allman-Farinelli et al., 2016; Godino et al., 2016; Doyle et al., 2008; Hutchesson et al., 2016; Napolitano et al., 2013; Kulik et al., 2015). One study offered online tracking bars for self-review (An et al., 2013).

Tailoring

Ten studies utilized tailored or personalized content to provide specific, relevant information for study participants to change behaviors (Allman-Farinelli et al., 2016; An et al., 2013; Chung et al., 2016; Doyle et al., 2008; Godino et al., 2016; Hutchesson et al., 2016; Lytle et al., 2014; Napolitano et al., 2013; Smith et al., 2014; Svetkey et al., 2015a). Interventions were customized for demographic characteristics like gender (Allman-Farinelli et al., 2016; Doyle et al., 2008) or based on stages of change (Allman-Farinelli et al., 2016). One application allowed users to set their own goals (Godino et al., 2016). Tailored content most commonly included types of message received (An et al., 2013), feedback (Svetkey et al., 2015a; Godino et al., 2016; Doyle et al., 2008; Hutchesson et al., 2016; Chung et al., 2016), and educational materials (Doyle et al., 2008). In one case, personalized feedback reports with text and visuals were generated for participants (Napolitano et al., 2013).

Education

The most common educational component was diet and nutrition information to users. This included nutrition of foods (Allman-Farinelli et al., 2016), recommended daily servings and

sizes(Allman-Farinelli et al., 2016; Doyle et al.; 2008, Kulik et al., 2014; Chung et al., 2016), infographics and photos of healthy foods (Chung et al., 2016) and recipes (Lytle et al., 2014). Building skills associated with healthy eating such as meal planning (Allman-Farinelli et al., 2016; Napolitano et al., 2013), goal setting (Kulik et al., 2014; Napolitano et al., 2013), monitoring diet (Kulik et al., 2014; Napolitano et al., 2013), and contextualizing target behaviors (Allman-Farinelli et al., 2016) was included. Several included features for teaching how to understand situations that lead to unhealthy behaviors such as nutritional triggers (Napolitano et al., 2013), stress (Napolitano et al., 2013), and special occasions (Napolitano et al., 2013). One extended this to teach cognitive approaches (problem solving, cognitive restructuring) to manage such issues (Kulik et al., 2014). Along with nutrition, interventions integrated educational content on physical activity such as daily recommendations and explanations of energy balance (Smith et al., 2014; Allman-Farinelli et al., 2016; Doyle et al., 2008; Hutchesson et al., 2016; Kulik et al., 2014; Chung et al., 2016).

Most educational content was delivered using technology. App and website libraries of articles, links, videos were available to view (Allman-Farinelli et al., 2016; Lana et al., 2013; Lytle et al., 2014). One study used Facebook to house content (Napolitano et al., 2013). In other cases, content was sent to users through text messages (Leme & Philippi, 2015; Hutchesson et al., 2016), messages from avatars (An et al., 2013), email (Hutchesson et al., 2016), and Twitter (Chung et al., 2016). Other interventions relied on non-technical modes of delivery such as in-person workshops (Leme & Philippi, 2015), classes (Leme & Philippi, 2015) and sessions (Smith et al., 2014; Kulik et al., 2014) led by professionals or through printed materials (Allman-Farinelli et al., 2016; Leme & Philippi, 2015).

Social support

Interventions included features to facilitate social support outside of the use of social media with peers. Parents were given information on children's progress and how to support healthier lifestyles through periodic newsletters and meetings (Smith et al., 2014; Leme & Philippi, 2015; Doyle et al., 2008; Kulik et al., 2015; Jones et al., 2014). Peer support was leveraged through in-person and technology-mediated methods. These included mentoring (Smith et al., 2014), teaching support skills (Kulik et al., 2015) and peer coaching with review tracking(An et al., 2013), and personalized video feedback, motivational messaging (Svetkey et al., 2015; Leme & Philippi, 2015), and phone calls (An et al., 2013). In some cases, participants were asked to seek support within existing social networks by sharing goals and results (Godino et al., 2016) or having non-study buddies (Napolitano et al., 2013).

Gamification

Gamification, the use of game design elements in non-gaming contexts to engage participants (Deterding et al., 2011), was used to encourage learning health information and practicing health behaviors. Quizzes were used to assess nutrition knowledge (Lana et al., 2013; Lytle et al., 2014; Jones et al., 2014). Behavioral dietary challenges were used to increase engagement and add competition to healthy eating (Godino et al., 2016). Personal and group challenges promoted increases in physical activity (Chung et al., 2016). Reward systems were popular for incentivizing intervention activities such as completing quizzes (Hutchesson et al., 2016), viewing and reading content (Lana et al., 2013), playing games (Lana et al., 2013), and providing comments and feedback to other users (Lytle et al., 2014). In only one case, points were able to be redeemed for tangible prizes and gift cards (Lytle et al., 2014).

Study characteristics

Target population

Participants included adolescents and young adults with individual studies focused on one of these subgroups (Figure 3.3). Four studies targeted one gender—three for females and one for males (Hutchesson et al., 2016; Kulik et al., 2015; Leme et al., 2016; Smith et al., 2014). Eight studies recruited students from secondary schools, colleges, and universities (Chung et al., 2016; Jones et al., 2014; Laska, Lytle, et al., 2016; Leme et al., 2016; Napolitano et al., 2013; Nawi & Jamaludin, 2015a; Smith et al., 2014; Whittemore et al., 2013). Minorities represented 27 to over 70% of the study populations in twelve studies (Allman-Farinelli et al., 2016; An et al., 2013; Chung et al., 2016; Doyle et al., 2008; Godino et al., 2016; Jones et al., 2014; Kulik et al., 2014; Laska, Lytle, et al., 2016; Napolitano et al., 2013; Nawi & Jamaludin, 2015b; Svetkey et al., 2015a; Whittemore et al., 2013). Income levels were reported in six studies (Allman-Farinelli et al., 2016; Hutchesson et al., 2016; Laska, Lytle, et al., 2016; Leme et al., 2016; Smith et al., 2014; Whittemore et al., 2013); two studies (Leme et al., 2016; Smith et al., 2014) explicitly served low-income populations and the remainder served broader income levels (Leme et al., 2016; Smith et al., 2014). Typical inclusion criteria included: normal to obese body mass index (BMI); general good health; suboptimal diet or physical activity behaviors; and access to the internet and computer or mobile phone. Typical exclusion criteria were being pregnant; taking specific medications; in a weight loss program; having medical conditions precluding them from intervention activities. One study included nutrition outcomes focused on participants who were quitting smoking (An et al., 2013).

Figure 3.3: Study Characteristics

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Allman-Farinelli, 2016 (Australia)	TXT2BFit	Young adults aged 18-35 at risk overweight w BMI 23-24.9 with >2kg weight gain in past 12m, or BMI of 25-31.9. Also failing to meet key health behavior	Two-arm parallel RCT	n=250	12 weeks intervention; 9 month follow-up	Process of change; Control theory; Transtheoretical model	Primary: Measured and self-reported weight gain Secondary: daily fruit/vegetable intake; weekly sugar sweetened beverage (SSB) intake; weekly take-out meals; frequency and minutes of physical exercise	✓	Intervention grp: weighed less at 9 months; had greater likelihoods of meeting fruit/veg/take-out food/SSB intake.	Smartphone app for self-monitoring; Community blog to talk with researchers and participants	100% used coaching calls; 82.4% completed all. 90.9% reported using the text messages. Declines over time. Only 6.4% used the community blog. 74.5% did not access the mobile phone app.
An, 2013 (United States)	RealU2	Young adults aged 18-30 who reported smoking at least once in the last 30 days	Three group RCT: general interest messages; tailored health messages; tailored health messages + online video peer support	n=1698	6 week intervention; 12 week follow-up	Theory of reasoned action and planned behavior, social cognitive theory, and self-determination theory	Primary: Abstinence from smoking within 30 days Secondary: Number of days in last 30 days report eating breakfast, alcohol consumption, and exercise	✓	Abstinence from smoking (Tx1 = 11%,Tx2 = 23%,Tx3 = 31%); Change in number of days: eating breakfast (Tx1=2.64,Tx2=6.51,Tx3=7.58), any drinking (Tx1=-.79, Tx2=-1.9,Tx3=-2.34), binge drinking (Tx1=-1, Tx2=-1.16,Tx3=-1.87), and exercise (Tx1=1.74,Tx2=4.57, Tx3=5.08)	Website with tailored messages + peer support online that included peer coach reviewing tracking, goals, and recording a video for the participants	In all groups, ~80% completed 4 out of 6 sessions. In tailored message + online peer support group, peer coaches completed 60% of calls; 48% of postings resulted in views.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Chung, 2016 (United States)	Tweeting to Health	College student who are healthy or overweight	Pre-post	n=12	2 month intervention and follow-up	Used formative study using focus groups to inform design	Height; Weight; Body fat percentage; self-reported intake of fruits/vegetables/SSBs; looked at Twitter messages; felt supported by group or study team; report any lifestyle changes	✓	Reported increased fruit (92%) /vegetable intake(58%); Decreased sugar sweet beverages (67%). Compliance with daily FitBit wear (99%OW/73%HW of days) and dietary logging (82%OW/73%HW of days)	Log dietary intake via Twitter to FitBit app; receive twitter motivating messages; wear Fitbits; see others' Fitbits; feed of healthy photos from Pinterest	Fitbit device wear was 99% OW and 78% of all days for OW and HW respectively. OW participants logged at least some dietary intake in Fitbit food diary on 82% of days versus 73% for HW participants.
Doyle, 2008 (United States)	Student Bodies 2	Adolescents aged 12-18 who are at risk of overweight or overweight (≧85%)	RCT	n=83	16 weeks intervention and follow-up at 20 weeks	Cognitive behavioral strategies	Primary: Weight; height; eating disorder attitudes and behaviors Secondary: Dietary and physical activity related behaviors	✓	Difference in BMI post-intervention not sustained through follow-up. Decrease in shape concern (2.17-Tx; 1.96-Control). Intervention group greater use of dietary skills and physical activity related skills compared to control (no data reported). Report satisfied with discussion group but want more interaction.	Asynchronous moderated online discussion group with profiles; Private online journals	SB2 participants read 29.9% (SD, 27.3) of the Internet material (range, 0–90.7%), and 35% of the participants (n=14) viewed < 10% of the screens. 79% were satisfied with the program, 15.8% neither satisfied nor dissatisfied, and 5.3% dissatisfied. 63.2% were satisfied with the discussion group, 22.5% of the participants believed that there was not enough interaction.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Godino, 2016 (United States)	Project SMART	Overweight or obese college students aged 18-35	RCT	n=404	24 month intervention and follow-up	Michie's taxonomy of twenty-six behavior change techniques. Intervention mapping and theory of planned behavior	Primary: weight. Secondary: weight, BMI (kg/m2), waist circumference, arm circumference, systolic blood pressure, diastolic blood pressure, heart rate, and the level of engagement with intervention components. Physical activity, dietary intake, sedentary behaviors, eating behaviors, SSB consumption, eating away from home, quality of life, depression, self-esteem, psychosocial outcomes and social support.		Intervention group experienced greater weight loss at 6 months (–1·33 kg) and 12 months (–1·33 kg). However, at 24m, there was no significant difference in weight loss.	Facebook to connect participants; Smartphone sharing features to share goals, challenge participation, and health behaviors to Facebook; website with blog.	Defined as interactions with the intervention. Declined over time: 98 (9– 265) interactions at 6 months, 76 (0– 222) at 12 months, 41 (0–198) at 18 months, and 12 (0–161) at 24 months.
Hutchesson, 2016 (Australia)	Be Positive, Be HealthE	Overweight female young adults aged 18-30	Pre-post	n=18	3 months	Cognitive behavioral therapy strategies	Weight; waist circumference.	✓	Significant reductions in weight, BMI, and waist circumference.	Online discussion group	Usage high for some features but declined over time. Other features had poor engagement. Discussion forum engagement poor throughout study.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Jones, 2014 (United States)	StayingFit	Ninth grade students	Feasibility parallel, non-randomized design	n=336	None specified.	None specified.	Primary: Height and weight. Secondary: Weight and shape; nutrition; physical activity	✓	BMI did not change. Significant changes in eating fruit, vegetables, consumption of soda for healthy weight. Significant changes in eating fruit for overweight.	Discussion board with questions posted for reaction.	Reported satisfaction with program content and implementation.
Kulik, 2015 (United States)	None specified.	Overweight girls aged 13-17	Pilot randomized control intervention	n=41	16 weeks	Cognitive behavioral strategies	Social support and eating habits scale; social support and exercise scale; child and adolescent social support scale; adherence measured as number of brief check-ins and chat discussions; dietary intake; physical activity;		Both groups experienced weight loss but no significant difference between groups (enhanced -6.4 vs control -6.47 lbs). Enhanced group experienced greater social support -- friend encouragement for healthy eating (enhanced 15.05 vs control 9.24) and friend support for exercise (enhanced 25.74 vs control 17.18).	Control include a standard cognitive behavioral weight loss program with 8 in-person meetings. Enhanced: standard program + peer support that included 8 in-person meetings (control) + small group activities + Facebook peer sessions.	High attendance of in-person sessions. Adherence to online support component low. 89% completed at least 4 sessions and had weight and questionnaire at Wk 16. Only 4 participants completed more than half the possible prescribed communication. 6/19 (32%) completed half of the chats with their Study Buddy and 4/19 (21%) completed half of the possible check-ins with other group members. 32%(6/19) communicated with the group leader at least 75% or more of possible online contacts.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected results)
Lana, 2014 (Spain and Mexico)	Prevencanadol	Adolescents aged 12-15	Three group RCT: control; online intervention; online + SMS	n=2001	9 months	ASE Model; Transtheoretical model	Primary: Total behavioral cancer risk (smoking regularly; eating <5 pieces of fruit or vegetables; eating >=3 fat foods per day; quotient of cancer protecting to risk foods; obese or overweight; drinking excessively; physical activity less than 360 min per week; being in sun without sunscreen)	✓	9 month outcomes: % not eating enough fruits decreased for all groups (-66.8 vs -62.6 vs -71.5). The enhanced "online + SMS" had a negative change in % who are overweight and obese (6.2 vs 23.8 vs -19.6) .	Discussion group online	Not reported. 36.8% completed posttest.
Laska, 2016 (United States)	Choosing healthy options in college environments and settings (CHOICES)	Normal to overweight young adults aged 18-35 in two-year community and technical colleges	RCT	n=411	24 months	Ecological theories; social cognitive theory; social network theory	Diet: Weekly consumption of fast food, SSBs, breakfast, meals prepared at home; PA and screen time: energy expenditure leisure time, leisure time physical activity, television, computer use; sleep: total daily, days not getting enough rest, difficulty staying away more than 2 days, takes 30 minutes to fall asleep 3-7 nights per week.	✓	At 24 months, experimental group experienced reduction in fast food consumption (1.3 per week vs 1.4 in control) and increases in difficulty staying awake.	Social networking website to share behaviors.	Engagement in the website activities was also mixed with more than half of intervention participants logging onto the website during the first month, but then declining to 25–40% during the following 23 months of the intervention.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Leme, 2016 (Brazil)	Healthy Habits, Healthy Girls–Brazil program	Adolescent girls (mean age 16)	Cluster RCT in 10 public schools in low income communities	n=253	6 months	Michie's taxonomy of twenty-six behavior change techniques. Intervention mapping and theory of planned behavior	Body mass index; waist circumference; leisure time physical activity; sedentary behaviors (watching tv and using computers); dietary intake	✓	Intervention group: waist circumference (-2.28); screen time (-0.63 hr/day), sedentary activities (-0.92 hr/day, and veg(1.16 servings per day) /fruit intake (0.26 servings per day).	Includes twice weekly WhatsApp informational and motivational messages to users; group chat created for participants and moderator.	Intervention fidelity 60% for PA sessions; 53% for PE classes; and 80% for weekly nutrition and PA key messages. WhatsApp messages sent reported; not if they were read.
Napolitano, 2014 (United States)	None specified.	Young adults from a university aged 18-29 with BMI 25-50	Three armed RCT: Facebook; Facebook + texts + feedback; control	n=52	8 weeks	None specified.	Height and weight. Physical activity behavior, goal setting and planning, physical activity self-efficacy, weight self-efficacy, adapted social support for diet and exercise, engagement/compliance, consumer satisfaction	✓	Facebook Plus group had significantly greater weight loss at 8 weeks (-2.4) vs Facebook (-0.63) vs control (-0.24)	Facebook delivered intervention with online content,	Facebook group: 23.5% "liked" study-related posts; 41.2% posted or commented on study related content at least once; 88.2% responded to event invitations at least once. Facebook Plus: 22.2% "liked" the study-related posts on the Facebook group. 77.8% posted or commented on study-related content at least once. 72.2% responded to event invitations at least once.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Nawi, 2015 (Malaysia)	obeseGo!	Adolescents aged 16 with BMI >25	Cluster RCT in 6 secondary schools	n=108	12 weeks	None specified.	Height and weight. Waist circumference. Body fat.		No significant effects on outcomes.	Interactive chat sessions on website.	Not reported.
Smith, 2014 (Australia)	ATLAS	Adolescent boys aged 12-14 who are at risk for obesity	Cluster RCT in 14 schools in low income communities	n=361	8 months with 18 month follow up	Self-determination theory, social cognitive theory, transcontextual model of motivation	Height and weight. Body fat percentage. Physical activity. Muscular fitness. Resistance training skill competency. Recreational screen time. Sugar-sweetened beverage consumption. Physical self-concept. Subjective well-being. Pathological video gaming. Aggression. Daytime sleepiness. Motivation in school sports. Psychological needs satisfaction. Motivation to limit screen-time. Screen-time rules. Physical activity behavioral strategies.	✓	Reduced screen time (mean: -30 min/day), sugar sweetened beverages (mean: -0.6 glass/day). Increased muscular fitness (mean: 0.9 repetition) and training skills (mean: 5.7 units).	Smartphone with physical activity logging and peer assessments of resistance training skills	95% of participants agreed or strongly agreed that the ATLAS program overall was enjoyable. 49% and 15% of participants had used the iPhone and Android apps. Did not report by feature.

Author, year (Country)	Intervention name	Target population	Study design	Sample size	Duration	Theoretical models	Outcomes measured	Significant nutrition related results	Significant results	Social media feature	Feasibility (selected findings)
Svetkey, 2015 (United States)	CITY	Young adults aged 18-35 with BMI>25	RCT: control; personal coaching + smartphone; mHealth	n=365	24 months	Social cognitive theory; and transtheoretical model	Weight change at 6, 12, and 24 months. Change in dietary pattern and physical fitness.		No significant weight loss across groups.	Smartphone app: Buddy system to send pre-determined messages and basic profiles; challenge games; and tracking of diet, exercise, and weight.	Used the app 4.6 times/day in the first 6 months and 0.7 times/day in the final year.
Whittemore, 2013 (United States)	HEALTH[e]TEEN	Adolescents aged 14-17	Cluster RCT in 3 schools: school based internet obesity prevention programs HEALTH[e]TEEN vs. HEALTH[e]TEEN + CST (coping skills training)	n=384	6 months	Theory of interactive technology; and social cognitive theory.	Sedentary behavior, nutrition behavior, physical activity, self-efficacy, satisfaction, and usage.	✓	Significant increases in self-efficacy, healthy eating behaviors, fruit and vegetable intake, moderate and vigorous exercise, and stretching exercises. Decrease in sugary foods, junk food, and sedentary behaviors.	Included in all experimental groups: A blog for health coaching and social networking.	Usage used in statistical analysis but not reported.

Study designs

The majority of studies, thirteen out of sixteen, used a randomized controlled trial design (Allman-Farinelli et al., 2016; An et al., 2013; Doyle et al., 2008; Godino et al., 2016; Kulik et al., 2014; Lana et al., 2013; Laska, Lytle, et al., 2016; Leme et al., 2016; Napolitano et al., 2013; Nawi & Jamaludin, 2015a; Smith et al., 2014; Svetkey et al., 2015a; Whittemore et al., 2013). Two studies used non-experimental, pre/post design (Chung et al., 2016; Hutchesson et al., 2016). One used a parallel, non-experimental design (Jones et al., 2014).

Outcomes

Eleven studies had significant nutrition results (Figure 3.3). Six studies showed improvements in clinical outcomes including weight (Allman-Farinelli et al., 2016; Hutchesson et al., 2016; Napolitano et al., 2013), body mass index (BMI) (Doyle et al., 2008; Hutchesson et al., 2016; Lana et al., 2014), and waist circumference (Hutchesson et al., 2016; Leme et al., 2016). Dietary outcomes improved in eight studies including improvements in healthy eating behaviors(Whittemore et al., 2013) and fruit and vegetable intake (Allman-Farinelli et al., 2016; Chung et al., 2016; Lana et al., 2014; Leme et al., 2016; Whittemore et al., 2013) and reductions in unhealthy consumption of alcohol (An et al., 2013), sugar-sweetened beverages (SSBs) (Allman-Farinelli et al., 2016; Chung et al., 2016; Smith et al., 2014), sugary foods (Whittemore et al., 2013), junk food (Whittemore et al., 2013), and fast food (Laska, Lytle, et al., 2016). Interventions improved physical activity with increases in exercise (An et al., 2013; Whittemore et al., 2013) and fitness and training skills(Smith et al., 2014). Reductions were seen in screen time (Leme et al., 2016; Smith et al., 2014) and sedentary activities (Leme et al., 2016;

Whittemore et al., 2013). Lastly, in one study, users perceived enhanced peer support for healthy eating and exercise (Kulik et al., 2015).

Feasibility and engagement

Limited measures of feasibility such as acceptability and demand are included in thirteen studies (Allman-Farinelli et al., 2016; An et al., 2013; Chung et al., 2016; Doyle et al., 2008; Godino et al., 2016; Hutchesson et al., 2016; Jones et al., 2014; Kulik et al., 2015; Leme & Philippi, 2015; Napolitano et al., 2013; Smith et al., 2014; Svetkey et al., 2015). These included app and website usage, frequencies of feature interactions, reading/viewing content, participation in peer communication activities, and reported satisfaction. Limited and different sets of features were reported across studies. Five studies reported declines in interactions over time (Allman-Farinelli et al., 2016; Godino et al., 2016; Hutchesson et al., 2016; Laska et al., 2016; Svetkey et al., 2015a). Among social media features, a community blog (Allman-Farinelli et al., 2016) and discussion board (Hutchesson et al., 2016) reported low participation. Participants were happy with a different discussion board but wanted more interaction (Doyle et al., 2008). Peer communications' participation was mixed, with some studies reporting low participation (Kulik et al., 2015), while others reporting high participation (Allman-Farinelli et al., 2016; An et al., 2013). Fitbit had high adherence with 78 to 99% consistently wearing the device and food logging (Chung et al., 2016). Facebook had high event invitation responses, moderate to high post commenting (Napolitano et al., 2013) but low recommended peer chats (Kulik et al., 2015). Among general features, high usage was reported with in-person sessions (Kulik et al., 2015; Leme et al., 2016), text messaging (Allman-Farinelli et al., 2016), and online educational sessions (An et al., 2013; Kulik et al., 2015). Use of websites and apps was mixed (Laska,

Sevcik, et al., 2016) to low (Doyle et al., 2008; Allman-Farinelli et al., 2016; Smith et al., 2014), often with declines over time (Laska, Sevcik, et al., 2016; Svetkey et al., 2015b) However, studies reported high satisfaction with content (Doyle et al., 2008; Jones et al., 2014; Smith et al., 2014).

3.4 Discussion

The primary goal of our review was to evaluate available evidence regarding the use of social media in interventions designed to improve dietary behaviors and nutritional literacy among adolescents and young adults. This study fills an important gap in the existing knowledge regarding the efficacy of social media interventions in nutrition. Despite the growing recognition of social media's potential to help young individuals improve health, few systematic reviews specifically examined this question. Previous reviews provide a partial account including descriptions of social media use without evaluation of outcomes (Park and Calamaro, 2013; Yonker et al., 2015) and featuring few interventions with no sustained outcomes (Shaw et al., 2015). While others have reviewed the use of social media for health (Yonker et al., 2015), to the best of our knowledge, this review was the first to focus exclusively on use of social media for improving nutrition among adolescents and young adults.

The results show that use of social media in public health interventions for improving nutrition among adolescents and young adults is limited but promising. Of sixteen studies reviewed, eleven had significant nutrition outcomes suggesting social media may be valuable for delivering interventions for adolescents and young adults. The majority used high-quality study designs and showed clinical outcomes improvements, increases in healthy dietary behaviors, or

reductions in unhealthy habits. Many studies were conducted in racially and ethnically diverse populations.

Studies serving low income (Leme et al., 2016; Smith et al., 2014) populations and broader income levels(Allman-Farinelli et al., 2016; Hutchesson et al., 2016; Whittemore et al., 2013) showed significant nutrition outcomes. All this suggests that interventions that incorporate digital technologies and, in particular, social media have a high potential of reaching diverse groups of adolescents and young adults.

However, together with these encouraging results, this review highlighted a number of limitations in the current research. First, while this review focused specifically on interventions that incorporate social media, it is important to note that the majority of reviewed interventions were complex, and included multiple features together with and often primary to social media. Many interventions included nutrition and behavior change features to help individuals better understand their dietary habits, make informed choices, and learn healthy eating skills. These included diet and activity tracking and feedback and educational content delivered using automated messages or online media. Several incorporated practical nutritional content, such as recipes and meal planning, helping to translate education into practical changes in diets. Finally, several included tailoring, such as personalized guidance on interpreting and modifying nutritional choices. Because these interventions were evaluated holistically, separating the impact of social media from the impact of other features remains a challenge. Further research is needed to compare the impact of social media with the impact of other interventions for healthy nutrition among adolescents and young adults, and to examine the relative contribution of social media to the impact of complex interventions.

Second, social media use in the included studies was conservative and engagement with social media was limited. Many interventions relied on traditional discussion boards and blogs to facilitate communication and disseminate information. Others developed homegrown websites but incorporated similarly traditional discussion boards. While feasibility and usage of features were not uniformly reported, those studies that included data on user engagement showed mixed to low usage and decline in use overtime for these simpler forms of social media. These findings suggest that future interventions for healthy nutrition should consider leveraging newer and more innovative social media platforms that have new affordances and can inspire new health behaviors. These findings are further supported by studies that were screened, but did not qualify for the review. Many were not evaluated for clinical effectiveness but included innovative social media. For example, studies within this group found adolescents (Holmberg et al., 2016) and the general public (Abbar, Mejova, and Weber, 2015; Mejova et al., 2015; Sharma and De Choudhury, 2015) are using social media platforms to document and share meal photos, learn recipes, and showcase food preparation (Vaterlaus et al., 2015). Though subject to reporting bias, taking photographs is perceived as faster and simpler than keeping standard food diaries (Higgins et al., 2009; Martin, 2014). In other such studies, researchers are using social media posts to learn about food choice influences (Sharma and De Choudhury, 2015) , to incorporate photo-sharing of meals (Park, Nahm, and Rogers, 2016; Yi-Frazier et al., 2015), and to allow users to collectively reflect on the food environment (Parker et al., 2013). Though not targeted towards young people, others have explored social collaborative learning for collectively identifying healthy diet through food image tagging (Linehan et al., 2010; Mamykina et al., 2016) and improving nutritional knowledge through crowdsourcing (Burgermaster et al., 2017; Mamykina et al., 2016). Another area that has received considerable attention outside the clinical

domain is gamification. Studies in this review using online games saw limited long-term engagement (Hutchesson et al., 2016; Lana et al., 2014; Laska, Lytle, et al., 2016). However, behavioral challenges and reminders led to sustained engagement and diet logging in one study (Chung et al., 2016). Others have used games to introduce heuristics for healthy eating (Khanana and Law, 2013; Mansour et al., 2009). Although these technologies are innovative in design, evaluation is needed to determine the effectiveness in improving nutrition. Third, while some studies in this review did examine the efficacy of social media as a novel mechanism for delivery of behavioral interventions, many used social media to add social support component to a more traditional behavioral intervention. In many cases, the interventions required that the participants socialize with other users of the same intervention, rather than leverage their existing social connections and networks. Our review shows that while both of these approaches appear to have a positive impact on behaviors, adding social components to behavioral interventions does not always lead to high user engagement. This is consistent with findings of previous studies of social media usage patterns that suggest that individuals are more likely to use social media sites to maintain existing social networks, rather than to develop new relationships (Heimlich, 2011). Consequently, leveraging existing social media platforms and existing social connections may help to increase low adoption and engagement barriers and help to more fully leverage the positive impact of social media on individuals' health.

Further, there remain aspects of social media within the adolescent and young adult population not explored within studies included in this review. One notable trend is the popularity of platforms that support transient communication channels that leave no permanent traces like SnapChat and Whisper. Though young people increasingly seek an anonymous component in social media, reliance on anonymity in communication around nutrition may

inadvertently reinforce unhealthy eating behaviors and facilitate the spread of misinformation (Syed-Abdul et al., 2013). Anonymity may remove barriers to sharing nutritional experience but, future research should examine dangerous unintended effects. Another area that has not received sufficient attention is tailoring of individuals' access to social media about nutrition. Studies in this review tailored content to individuals' characteristics (Allman-Farinelli et al., 2016; An et al., 2013) but, none tailored social media content. Such tailoring can further promote observational learning among individuals.

Finally, future research can address methodological issues in the current studies. Although most studies used randomized controlled trials, few included long-term follow up to examine sustainability. Feasibility and engagement of technical features also need to be consistently included and operationalized to understand their roles in affecting outcomes. Most included only clinical and behavioral outcomes. However, the influence of these interventions on social support and the possible effect of social support on intervention outcomes is unclear. Three studies (Godino et al., 2016; Kulik et al., 2015; Napolitano et al., 2013) examined social support but only one found adolescents to have greater feelings of healthy eating support(Kulik et al., 2015). Lastly, more evidence is needed to understand which features contribute to improved outcomes. Using study designs such as cross-over or factorial design could provide such insight.

Limitations to our study include potential exclusion of relevant articles. Our search strategy may have been missing useful keywords. For example, terms describing adolescents and young adults are not standardized across disciplines and some synonymous terms may have been missed.

Chapter 4: Aim 2: Identify attitudes, behaviors, and contexts for healthy eating among adolescents and young adults

In order to design informatics interventions, we need to understand the beliefs, motivations, and contexts underlying nutrition-related behaviors that are specific to adolescents and young adults. This group faces unique challenges in health requiring targeted interventions (Sawyer et al., 2007). The transition to adulthood is when individuals face new life experiences and learn the skills to adapt to these changes (Lenz, 2001). Within these groups, diet and eating behaviors are influenced by multiple factors at the individual, social, and environmental levels (Neumark-Sztainer et al., 1999). However, much of this research has been conducted in small settings and may not be generalizable to all adolescents and young adults. Because behaviors are contextually based, explicating these factors within our target group is necessary to inform the design of effective health interventions.

4.1 Aim 2a. Motivations and barriers to healthy eating among adolescents and young adults with a chronic disease

Pediatric cancer survivors are joining a growing number of adolescents and young adults who suffer from chronic disease. With more effective therapies, the overall mortality from pediatric cancer is decreasing (National Cancer Institute, 2014). While this is encouraging, survivors are at higher risk for late-effect chronic medical conditions, such as obesity and cardiovascular disease, due to both the underlying condition and side effects of therapy (Diller et al., 2009; Lipshultz et al., 2015).

Interventions to manage nutrition, physical activity, and lifestyle choices can mitigate the effects of such diseases. These groups, in particular, confront a unique set of challenges in the self-management of chronic disease. Rapid social, physical, and emotional developments characteristic of this period impose added obstacles for the management of medical conditions. As such, interventions designed to address the distinctive challenges of those with chronic diseases are needed.

The purpose of this sub-aim is to understand the unique needs, preferences, motivations and behaviors of adolescents and young adults with a chronic disease—pediatric cancer—in relation to healthy lifestyles. This study used qualitative methods to answer the following research question:

RQ1 What are the motivations, attitudes, and barriers to healthy eating among adolescent and young adult pediatric cancer survivors?

Study Design and Procedures

Sample

The study included N=8 adolescents and young adults aged 13 to 25 in the transition phase (three months before completion of treatment) or who were survivors of cancer (more than one year after completion of treatment).

Setting

This study was conducted at the Herbert Irving Child and Adolescent Cancer Center at Columbia University Medical Center–a large academic medical center in New York City. The Center serves as the outpatient facility for the Division of Pediatric Hematology/Oncology/Stem Cell Transplant. The Center practices an integrative wellness approach with staff that include

physicians, nurses, nurse practitioners, psychologists, registered dietitians, child-life therapists, music therapists, art therapists, acupuncturists, masseuses, and integrative therapy practitioners.

Recruitment

Recruitment was completed using two established mechanisms within the Herbert Irving Child and Adolescent Cancer Center. Eligible participants visiting the outpatient center for a routine medical visit were identified by the research team through the division's electronic scheduling system. Following patient identification, research team members approached the patient's physician to obtain approval for contacting the eligible participant. If the eligible participant agreed, a study investigator approached the patient and parents/guardian to inquire about participation in the study. Additionally, study team members contacted patients with whom they have ongoing clinical relationships or their parent/guardian by phone to invite to participate. Recruitment, screening, and enrollment were conducted by a registered dietitian on the research staff. The Institutional Review Board approved this study; all participants and their legal guardians provided appropriate consent and assent before participating.

Focus groups

The study included two 90-minute focus groups with adolescent and young adult patients and survivors of pediatric cancer. The focus groups were led by the principal investigator of the research study (LM). Three researchers including the principal investigator and the registered dietitian of the Cancer Center were present at the first focus group (MC, LM, and BG). The second focus group included two researchers (LM and BG). The goal of the focus groups was to solicit direct patient feedback and participation in designing an application aimed at improving the lifestyle behaviors of pediatric oncology patients. The research team convened the group to

discuss specific issues related to lifestyle behaviors. Topics discussed included: general attitudes towards food and healthy eating; understanding of healthy eating; attitudes and barriers to healthy eating; and opportunities for interventions. The interview guide is included in Appendix B.1. Focus groups were digitally recorded.

Analysis

Digital recordings were transcribed verbatim by a transcription service. The transcripts were checked for accuracy by one researcher (MC). Two researchers with training and experience in qualitative research (MC and LM) reviewed transcripts and conducted inductive thematic analysis in group sessions. The two researchers read the transcript and open-coded on a line-by-line basis. Throughout the process, the two researchers discussed the meaning of the text and came to agreements on how to code each section; all disagreements were resolved through discussion and consensus building. Categories and larger themes were identified through an iterative process of coding and summarization. The researchers reviewed and clustered themes. Transcripts were analyzed using Microsoft Excel software.

Results

Below are the key themes from the focus group analysis.

Living as a survivor

Even after remission, cancer played a recurring role in the lives of pediatric survivors. Their diagnoses were often the impetus for a nutritional awakening. Participants discussed how cancer, chemotherapy, radiation, and medications increased awareness of diet and their bodies. Treatment and recovery resulted in multiple changes to dietary practices to accommodate fluctuating nutritional requirements. This consciousness continued with regular visits to nutritionists and in daily food choices. The impact of cancer extended beyond diet. Confronting a

severe illness at young ages forced participants to mature more rapidly than peers. Participants experienced a sense of loss at not having a "normal" childhood or adolescence and felt different from others. Cancer had limited their physical mobility and school and social experiences. While most of these challenges were in the past, survivors acknowledged that cancer played a formative role in their lives.

Adopting healthy behaviors

Influences. Participants discussed the multilevel—individual and social—influences on health behaviors. According to the Social Ecological model, individual development is affected by multiple levels of influence—individual, interpersonal, community, organizational—that participants explicated in our discussions. Individual circumstances and preferences influenced choices. Personal health issues such as vitamin deficiencies and food sensitivities put restrictions on diet. Family and friends influenced how participants ate, lived, cooked, shopped, and exercised. Living with parents or others making strides towards healthier lifestyles facilitated the adoption of better eating habits. Conversely, those less concerned with nutrition made it harder. Within certain social circles, participants described having to avoid unhealthy, culinary temptations.

Motivation. One of the major challenges of maintaining a healthy lifestyle is initiating and sustaining motivation. Needing dedication to stay healthy was a common theme heard throughout the focus groups. One participant described the initiation process as being about "self-control and forming a habit. (P2)" Consistently making healthy choices was a constant battle of motivation to succeed and refraining from indulgences.

Trusted information sources. Trust emerged as an important requirement when seeking information about health. As one survivor said, "trust […] is a really big thing for adolescents

(and) young adults. (P2)" Participants wanted advice from close friends, the cancer community, professionals, and verified applications and websites. Some shared meal photos and asked about diet from peers. Others wanted to interact with professionals who "know what they are talking about (P4)" and utilized clinical visits and classes to learn about nutrition.

Barriers. A number of obstacles made it difficult for participants to adhere to healthy diets. Time management was an often-cited reason for poor diet choices. Busy schedules led participants to skip meals or grab whatever food was convenient. Food was often an afterthought behind school and work commitments. Beyond their control, however, food options were constrained by available resources. Limited choices in neighborhoods and schools left participants with few healthy choices. Finances were a limiting factor with one participant lamenting "it's not like you have enough money, 70 percent of the time you're eating what the school has. (P6)"

Strategies for healthy living

"Keep it simple". In general, most participants did not follow specific diets. Instead, they independently developed strategies to stay healthy. When choosing and cooking meals, participants wanted to "keep it simple" with easy routines and recipes. As one participant explained, "as long as you don't overcomplicate yourself, it will be easier to make a habit of it. (P2)" Soups and sandwiches were popular choices. Pre-packaged plans and all-in-one meal choices like smoothies removed the burden of having to decipher what is healthy or not. Others developed straightforward rules that did not apply limitations but instead relied on always including a healthy food. As participant five described, "I still eat everything, I still go out a lot […], but I make sure I have vegetables. (P5)" Many health maintenance tactics focused on

finding a balance among their choices. For example, one participant described “my portions, they’re not controlled but maintaining an active lifestyle… that helps.(P6)”

Self-discovery of foods and preferences. Transitioning to a healthier lifestyle was a self-discovery process of learning what foods were nutritious and worked for each person. Along the way, participants discovered the effects of different foods on their bodies. They described how eating vegetables made them feel “more energized” and fried foods led to an “upset stomach. (P1)” Participants also identified novel ways to substitute the less wholesome foods they liked with better options. One participant said, “I don’t feel like you have to give up what you like to eat… I just switched some things.(P5)” These substitutions included baking rather than frying; zucchini noodles instead of pasta; and light salmon, not regular tuna. Many found they needed variety in their meals. A participant (P7) who worked with a nutritionist to plan meals found she “never followed” it and didn’t “like to eat the same things every day.” Similarly, in settings where the food selection was limited such as school, participants found themselves tired of the monotony of the “same thing day in and day out. (P6)”

Using technology for inspiration. Most participants previously experimented with mobile fitness and nutrition applications. However, only one felt the process of self-tracking with apps useful and regularly logged activities. The remainder found mobile apps to be burdensome and not accurate. Some started using apps but then “don’t care enough to keep up with it. (P1)” Instead, inspiration for health was found through the use of social media. Photo sharing on Instagram and Tumblr were common methods used to find motivation and ideas for healthy living. A number of participants followed food and health accounts to look for recipes. One participant recalled seeing “pictures of healthy food” that she “didn’t know could look so good. (P1)” Another participant talked about creating her own intervention with a friend where they

exchanged photos of their meals to keep each other accountable. Others used social media to search for encouraging quotes and images to sustain their motivation. One participant described how she "saw this picture of a cancer survivor […] I screen shot it and kept it. (P4)"

Discussion

The focus group results suggest several design implications for interventions. Frequent participant use of social media to search for motivational messages and healthy living ideas calls for a prominent social media component in interventions. Food, recipe, and photo sharing could be useful motivators. Personal and environmental influences on health habits suggest the need to tailor informatics interventions for specific dietary needs and individual circumstances. And lastly, trust emerged as an important requirement for information sources and applications. Our findings suggest a strong need to vet information and feature reputable sources in applications.

Limitations

There were several limitations to this study. First, it used a convenience sample that was small so results have limited generalizability. Second, no demographic information was collected during focus groups and there is no characterization of the sample.

4.2 Aim 2b: Explore dietary behaviors, contexts, and experiences using a nutrition application

Introduction

Mobile health is playing a growing role in chronic disease prevention, offering new approaches for delivery of nutrition education and other interventions for improving diet (Burke et al., 2015; Kavey et al., 2003). Specifically, there are a growing number of interventions delivered through mobile technologies using apps that support goal setting and behavior change (Kerr et al., 2016; Patrick et al., 2013). Use of mobile technologies presents a particularly promising direction for adolescents and young adults given their high degree of adoption and proficiency with these devices among these populations (Pew Research Center, 2019a). This combination of access, ubiquity, and reliance makes mobile applications a promising platform to deliver support in real-time.

Despite these efforts, there remain significant gaps in the design of technological interventions for promoting healthy lifestyle choices among adolescents and young adults. Setting goals combined with self-monitoring has been shown as a promising strategy in inspiring behavior change(Cullen et al., 2013; Shilts, Horowitz, and Townsend, 2004; White and Skinner, 1988). However, individuals often fail to successfully translate goals into changes to their actions (Gollwitzer, 1999). Moreover, many technological interventions do not offer the regular feedback necessary to understand progress in reaching goals (Locke and Latham, 2002). Others fail to provide realistic examples of how to meet goals. Education and games can build nutrition knowledge, but without incorporating skill-building, individual behaviors, and preferences, it can be difficult to put knowledge into practice (Worsley, 2002). Technological interventions that

incorporate social media can have a positive impact on individuals' diets (Chau, Burgermaster, and Mamykina, 2018).

In this research, we investigated how adolescents and young adults make nutritional choices while using a smartphone app, Mealyzer. Mealyzer, a native Android and iOS application, was designed to facilitate health and nutritional coaching between adolescents and young adults and health and wellness counselors. Similar to other technology-mediated health coaching solutions, Mealyzer included features for logging daily meals by taking photos and for setting personal nutritional goals by choosing from the list suggested by their health coaches. In addition, Mealyzer included several new features, not explored in previous research. These features were suggested by coaching literature and by our exploratory studies with pediatric cancer survivors and their health coaches and included the following: 1) to promote ***in-the-moment reflection and support nutritional decisions***, for each newly logged meal, Mealyzer asked users to evaluate the meal on whether it fits their selected nutritional goals. Mealyzer helped the users track their progress towards meeting nutritional goals by displaying summary statistics on proportions of meals that met and did not meet each goal.; 2) to promote ***nutritional learning***, Mealyzer provided users with comparison of their own evaluations of their meals, and evaluations by health coaches; and 3) to facilitate ***peer influence and observational learning***, for each nutritional goal chosen by users, Mealyzer showed them images of meals that meet and do meet this goal captured by other users of Mealyzer, also pediatric cancer survivors.

This application was deployed in a 5 week pilot study. This research aimed to answer the questions:

RQ1: Did participants' healthy nutrition behaviors improve while using the application?

RQ2: Did participants' nutritional learning improve while using the application?

RQ3: What are the dietary behaviors, contexts, and experiences of participants using a nutrition application?

Methods

Description of Intervention: Mealyzer

Based on the findings from Aim 2a, we identified preferences of pediatric cancer survivors for using mobile technologies for health management. These included: 1) an ability to personalize features as individual preferences and influences played a large role in health management; 2) employing simple strategies to make sustaining healthy behaviors easier; 3) including advice from trusted sources; and 4) using photo sharing or images as a medium for learning and being inspired. We used these findings and literature on coaching to guide the design of Mealyzer. Specifically, given the participants' desire to receive advice from trusted sources, we conceptualized Mealyzer as a technology-mediated coaching application. Furthermore, to address the participants' interest in learning simple strategies to sustain health behaviors, we introduced features supporting observational learning from peers and peer influence. Finally, given the participants' wide use of photo sharing in different areas of their lives, we relied on capturing, viewing, and sharing of meal photos as the main mode of interaction between coaches and users, and for promoting observational learning and peer influence.

The resulting prototype of Mealyzer included several features. Two of them were *typical* for coaching applications: 1) goal setting and 2) meal logging. Three features were *novel* and were grounded in the coaching literature and the results of the exploratory study in Aim 2a. These features included: 3) in-the-moment assessment on how well new meals fit nutritional goals (in-the-moment reflection), 4) feedback on accuracy of meal assessments as compared to

that by an expert health coach (learning about nutrition), and 5) an ability to view meals that meet and do not meet specific nutritional goals captured by other users (peer influence). We describe these in more detail below:

Goal setting (Figure 4.1 A). Mealyzer's My Goals page included the following nutritional goals identified by health coaches: 1) eat more vegetables; 2) eat more fruit; 3) eat more lean proteins; 4) eat more whole grains; 5) eat more low-fat dairy; and 6) eat more low glycemic index foods. Users were free to choose from this list of goals and choose those that were consistent with their own preferences and perceptions regarding healthy diet. Users could add and remove goals at any time.

Meal logging (Figure 4.1 B). Users logged meals by taking a photo, entering the type of meal (e.g. breakfast, lunch, dinner, morning snack), and recording a list of ingredients. Users were encouraged to add food details that were difficult to see in photos but would be helpful for meal evaluations (e.g. whole wheat vs regular pasta). A free-text note section allowed users to add any free-form comments about the meal.

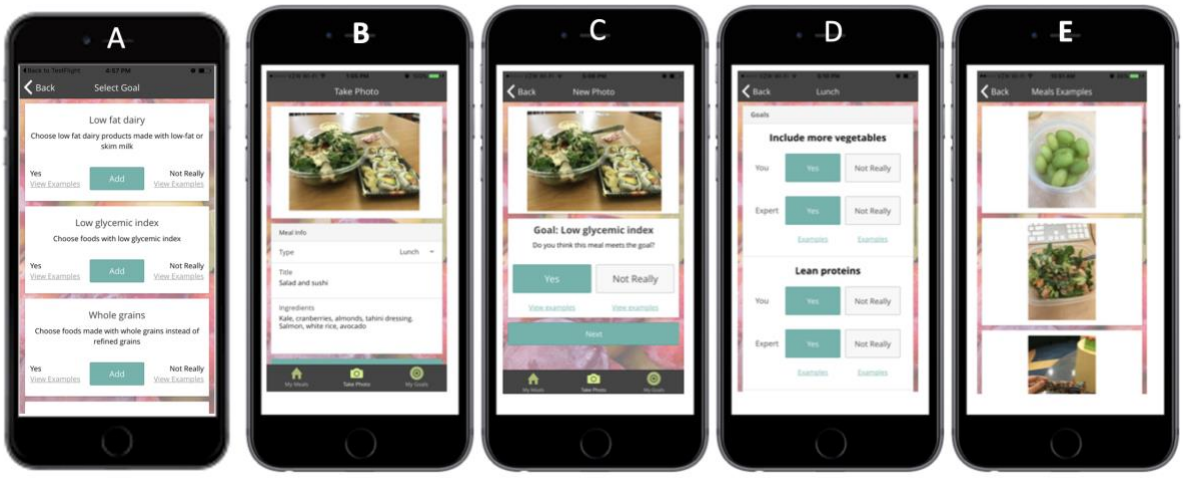
In-the moment meal assessment (Figure 4.1 C). Upon logging a new meal, Mealyzer showed users a prompt for each selected nutritional goal, asking "Do you think this meal meets the goal?" with two possible answer options, "Yes" and "Not really". All captured meals were saved in the participants' meal log accessible from Mealyzer's home screen. The *My Goals* page provided summary information regarding users' progress towards achieving their selected goals. Organized by nutritional goal, it showed a tally and percentage of meals that have met or have not met these goals since logging their first meal. It also provided links to images of users' own meals that fit and did not fit goals as well as links to the example meal images from the community.

Feedback on accuracy of meal assessments (Figure 4.1 D). Mealyzer posted each captured meal (photo and text description) to a meal assessment queue accessible by their health coach via a password-protected web app. Coaches received notifications about newly posted meals awaiting assessment via email and were asked to assess each meal on their fit with goals chosen by that participant. We encouraged coaches to submit their evaluations in a timely manner, however, they were free to do it at their convenience. Once evaluations were submitted, the participants received push notifications that new meals were evaluated by coaches. These evaluated meals were added to participants' meal logs in Mealyzer, and flagged as meals with coaches' assessments. For each such meal, Mealyzer presented users with a comparison of their assessment and assessment by the coach, with discrepant assessments highlighted in red. For each meal evaluated by coaches, this comparison was then included together with the meal's photograph and description in the meal log, which could be accessed at a later time.

Viewing meals captured by others (Figure 4.1 E). To help users learn what meals meet or do not meet nutritional goals, Mealyzer included a set of positive and negative examples for each goal. The initial set of examples were provided by health coaches. As users captured their meals and assessed them on fit with different goals, Mealyzer added meals that met and did not meet different goals to their corresponding set of examples, after having gone through a review and approval process by coaches. This feature served two separate goals. First, it was meant to help users translate more abstract and general goals into concrete meal choices. In addition, it was designed to promote observational learning among peers and peer influence. Observational learning is a construct within Bandura's Social Learning theory, which suggests that behaviors can be effectively learned by observing others or through the influence of example (Bandura,

1999). Meals shared by other participants were intended to expose users to different ways their peers met or failed to meet the same nutritional goals.

Figure 4.1: Mealyzer screenshots for a) goal setting; b) logging meals; c) user meal evaluation; d) dietitian feedback and e) example meal images



Setting

This study was conducted at an outpatient child and adolescent pediatric cancer at Columbia University Medical Center—an academic medical center in a large, urban city in the United States. The Center practices an integrative wellness approach with staff that include physicians, nurses, nurse practitioners, psychologists, registered dietitians, child-life therapists, music therapists, art therapists, acupuncturists, masseuses, and integrative therapy practitioners.

Participants

Recruitment was completed using two established mechanisms within the cancer center. Eligible participants visiting the outpatient center for a routine medical visit were identified by the research team through the division's electronic scheduling system. Following patient identification, research team members approached the patient's physician to obtain approval for

contacting the eligible participant. If the eligible participant agreed, a study investigator approached the patient and parent/guardian to inquire about participation in the study. Additionally, study team members contacted patients with whom they have ongoing clinical relationships or their parent/guardian by phone to invite for study participation.

This mixed methods study used a convenience sample of N=19 adolescents and young adults aged 13 to 27 in the transition phase (three months before completion of treatment) or who were survivors of cancer (more than one year after completion of treatment). The Institutional Review Board approved this study; all participants and their legal guardians provided appropriate consent and assent before participating.

Procedures and Deployment

Recruitment, screening, and enrollment were conducted by a member of the research team, a registered dietitian (RD) at the cancer center. Research team members consented participants, installed the application, and provided an initial training to review application features. Each participant was shown how to set goals, submit and evaluate meals, and review feedback from the coach. It was also explained that meals would be selected by coaches to anonymously share with the community as examples. Users were directed to look at the examples for guidance on the types of meals that fit goals. Participants were also given a handout and directed to a study website with the training information.

Each participant was asked to use the application for five weeks beginning with the first logged meal. One RD at the cancer center served as a coach for all participants. All participants knew the coach and several had well established personal relationships. Feedback from the coach was not available during the first seven days of use to establish a baseline of participant

knowledge for comparison in later analysis. Meal submissions, coach evaluations, and usage information was collected during this time.

Participants were contacted twice (Day 3-5 and 14) to follow up, troubleshoot issues, and encourage users to continue logging meals. Emails were sent when application updates were released. After five weeks, participants were invited for individual interviews. Participants were compensated $40 at the end of the study.

Interviews

Individual interviews were conducted with users at end line to better understand their experiences using the system and to solicit ideas for future iterations of the application. Three researchers (MC, BG, and LM) conducted the first two interviews together; MC and BG conducted the remaining interviews. Interviews began with the main researcher (MC) describing the goal of the study and requesting permission to record participant responses. MC led the interviews; the two other researchers asked questions as well. Interviews were conducted using a semi-structured guide (Appendix B.2) that included questions about: 1) use of previous mobile health apps; 2) experiences with Mealyzer including setting nutrition goals, logging meals, in-the-moment assessments, dietitian feedback, viewing examples feeds; and 3) potential design ideas. Additional questions were asked to elicit more information on topics that emerged throughout the interview. Interviews were digitally recorded. Each interview lasted approximately 60 minutes. After the interviews, the researchers debriefed if there was time available.

Qualitative analysis

Digital recordings were transcribed verbatim with a transcription service. A researcher (MC) checked transcripts for accuracy. Two researchers (MC and LM) with training and

experience in qualitative research conducted inductive thematic analysis. The two researchers collaboratively read through several transcripts and open-coded on a line-by-line basis in multiple sessions, which led to the development of the codebook. The remaining analyses was conducted independently by MC using the codebook; during this time the codes in codebook were iteratively revised to reflect new findings. The two researchers met in subsequent sessions to review results and discuss and resolve any coding discrepancies. Categories and larger themes were identified through an iterative process of coding and summarization until consensus was achieved on the final set of categories and themes. We used NVivo 11 software for the analysis.

Usage log analysis

Usage logs recorded interactions with Mealyzer including opening the app, setting goals, logging meals, viewing previous meals, and viewing exemplar meals. Descriptive statistics (medians and ranges) were used to characterize participant usage and understand features used within Mealyzer. Health tracking features was examined using number of meals logged. Overall study participation was examined using number of days in the study according to the last time participants used the application or were in contact with a research staff member. Goal setting features was examined using number of goals ever selected and times changed. Reviewing feedback and meals, which can only occur simultaneously, was examined with number of times viewing feedback and meals. Use of the example meal feature was examined with number of views of example meals.

Goal evaluation accuracy and goal achievement

Goal evaluation accuracy was measured as correct if the user meal evaluation matched the expert coach evaluation. Goal achievement was measured as when the expert coach answered Yes to meeting a goal. Descriptive analysis was conducted using scatter plots with a linear

smoothing to identify potential trends in the relationship between goal accuracy/achievement and meal sequence over the study period. Proportions calculated by meal sequence include only groups of at least 3 meals or more.

Results

Demographics

The nineteen participants in the pilot study were aged 15 to 27 at enrollment. Over half (11/19) were diagnosed with leukemias and lymphomas. The remaining participants had brain and spinal, germ cell, kidney, eye, and other undisclosed cancers. Half were survivors at least one year off treatment, three were recently off-therapy, and one was still on therapy. The status of 3 participants is unknown.

The qualitative study included all participants who agreed to be interviewed. In total, 7 patients participated in the qualitative interviews. Participants of the interviews were aged 18 to 27, 4 were male, 3 were female, and were from diverse racial/ethnic backgrounds (Hispanic (3), Black(3), and White(1)). Most were students and/or employed living with family.

Application usage

Table 4.1 includes usage for all participants. Overall, our pilot study showed mixed levels of engagement. Six users did not log any meals; the main reasons reported for non-usage were lost to follow up (n=3) and problems with installation of the app (n=3). Excluding non-users, the remaining participants stayed in the study for a median 29 days and recorded a median 11 meals per user. Users who participated in endline interviews were more active users. They logged a median 18 meals and remained in the study a median 35 days (the full five weeks). These users viewed previous meals or feedback a median of 27 times. Usage of goal selections, changing goals, and viewing example meals were similar across subgroups.

Table 4.1: Mealyzer usage during the five week pilot study

Mealyzer usage	All users (N=19)	Users logged at least one meal (N=13)	Users interviewed (N=7)
Median meals logged per user [range]	3 [0,34]	11 [1, 34]	18 [10, 34]
Median days in study [range]	6 [0, 35]	29 [1, 35]	35 [26, 35]
Median number of goals ever selected [range]	5 [0, 7]	7 [3, 7]	5 [3, 7]
Median times changed nutrition goals [range]	1 [0, 8]	1.5 [0, 8]	0 [0, 6]
Median views of previous meals or feedback [range]	3 [0, 61]	21 [0, 61]	27 [19, 61]
Median views of example meals [range]	2 [0,37]	5 [0, 37]	5 [0, 37]

Goal accuracy and achievement

Figure 4.2: Changes in goal accuracy (agreement between users' own evaluation and evaluation by the coach) over time, across all meals sequence proportions (N=54) (left image) and by nutritional goal (right images).

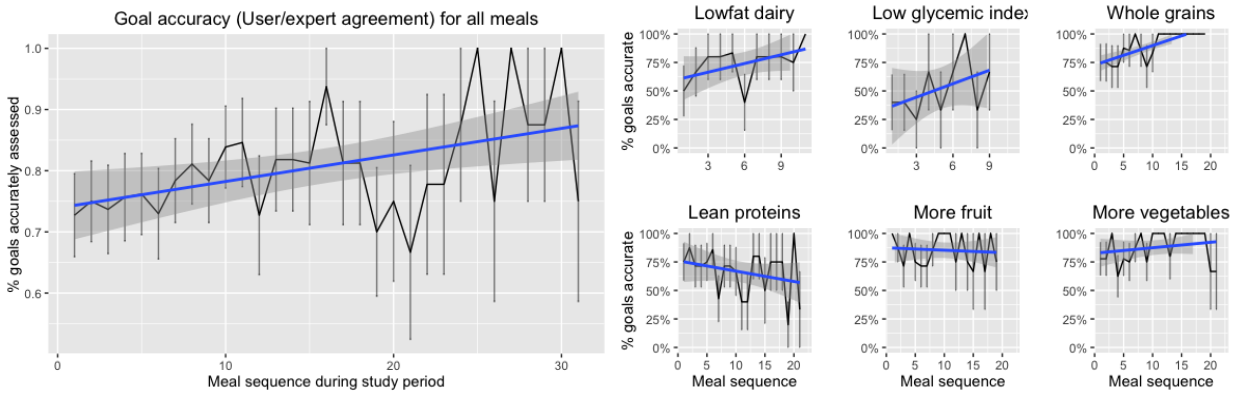
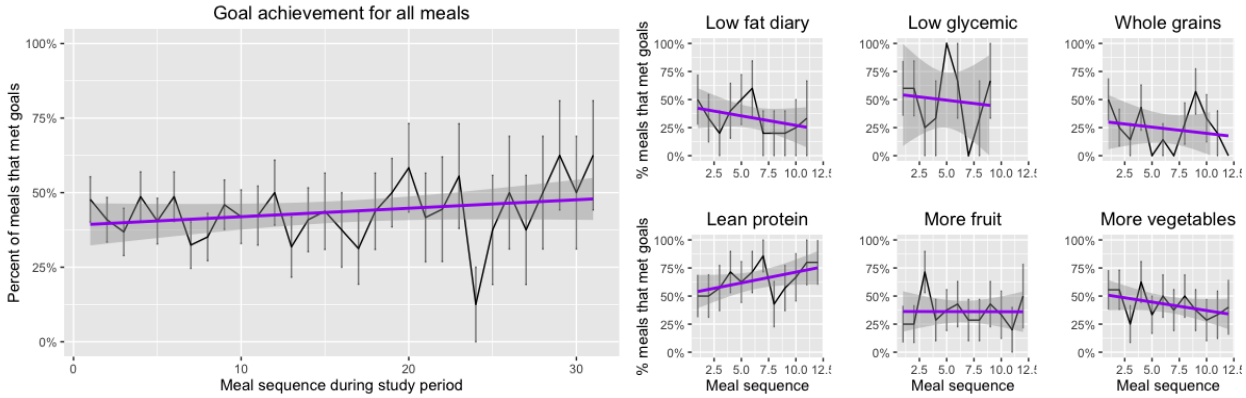


Figure 4.2 shows proportion of meals with accurate goal assessments (user-coach agreement) by sequence of meals during the study period. Results are presented for meals overall (lef image) as well as for each individual goal (right images). Notably, the participants showed high levels of accuracy (user/expert agreement over 70%) at baseline for meals overall; further, there is a potential upward trend for all meals suggesting an overall increase in accuracy over time.

Analysis of accuracy for each of the six goals shows that for all but two, the participants showed accuracy over 50% at the start. Over time, there was an even split between the goals: three showed upward trends, two showed no change overtime, and one, "include low glycemic index foods," proved difficult to assess and showed decreases in accuracy overtime.

Figure 4.3 shows proportion of meals where goals were achieved by sequence of meals. Overall, goal achievement, as defined by the expert assessment, was poor throughout the study period showing users met goals, on average, less than half their meals. By specific goals, the goal of lean proteins showed highest levels of achievement. For the remaining goals, attainment was at or below 50% with decreases or no changes over time.

Figure 4.3: Changes in goal achievement over time across all meals (N=54) (left image) and by nutritional goal (right images).



Qualitative study themes

Our analysis identified four themes: 1) heightened awareness of personal health needs; 2) learning through logging meals and feedback from the coach; 3) social influences on eating and nutrition on and offline; and 4) fast, slow decisions on nutrition. Below, we elaborate on these themes with illustrative examples.

Heightened awareness of personal health needs

The experience of having cancer and long-term relationships with the health care system led to a heightened awareness of health among participants. Many had increased awareness of nutrition, diet, and how it affects their bodies, and how they feel. Cancer treatments changed food preferences and nutritional needs and resulted in long-term chronic health concerns. As a result, participants had specific motivations for using Mealyzer and setting goals. Participants wanted to make changes to their diets and saw Mealyzer as an opportunity to accomplish this. Nutrition goal selection was driven by a desire to change specific behaviors. Some talked about wanting to "get used to" eating healthier foods and choosing goals to complement nutritional needs. Others viewed setting goals as a challenge to learn and better understand nutrition.

"someone like me that has got one kidney should be really drinking a lot of water, not constantly drink soda." – P5

When discussing personal health and nutrition goals, many reported having personal health goals that were not included in the application. These involved increasing or reducing specific foods and beverages based on nutrition e.g. more foods with iron or less sugary sodas. Others focused on categorizations of food preparation e.g. home cooked foods. Others focused on the effects of consuming foods on their bodies such as gaining weight or muscle.

"Eat like less red meat or others, I don't really eat red meat, I eat chicken, chicken, chicken. Yeah, eating more, I guess home cooked stuff versus eating out, eating more natural food or stuff without preservatives." -P1

Learning through logging meals and feedback from the coach

Overall, the participants found Mealyzer to be simple, easy to use, and visually appealing. We experienced initial challenges installing the app due to poor cellular network

connections at the cancer center, which led to several participants giving up and not using the app. Outside of these initial difficulties, users experienced few technical problems with features. Setting and changing goals, meal submissions, and accessing example feeds generally occurred without issue. The logging process of taking a photo and entering meal ingredients was less tedious compared to other applications that required users to specify portion sizes. Moreover, participants liked the look of the app finding it aesthetically pleasing.

Increased awareness of nutrition patterns

The participants found that setting goals and logging served as reminders to eat healthy. Users put additional thought and effort into preparing and buying meals to meet goals. The process of logging also led to greater awareness of eating habits and how they compared to their nutritional goals. The participants reported that taking photos and entering ingredients compelled them to examine the nutrition of foods and reflect on their eating habits.

> *"if you can kind of keep track for yourself, like things that you ate that day or maybe it was lacking vegetables and the next meal I could change… not that I would really forget, but then if you have a running tab of what you ate that day, it might make it easier for the next meal." – P4*

Further, comparing meals with goals and viewing cumulative goal achievement rates on the summary page helped them notice trends that they could act on. It also encouraged information seeking when they didn't understand a goal.

> *"I would just take pictures, eat what I eat, and when I see the percentages wow, this is how I eat regularly this is really bad. Okay I eat whole wheat, great wow, I mean that doesn't balance everything else out." – P5*

Feedback from the coach was a widely appreciated feature. Participants liked being able to interact with and receive feedback from a respected authority in nutrition. Several felt this was Mealyzer's most valuable feature. Most users felt the feedback was useful. When the feedback from the coach matched user assessments, it confirmed their knowledge of nutrition. Many felt they learned the most when their evaluations did not match those of the coach. In these cases, they felt increases in their nutritional knowledge.

> *"it actually helped me when I was taking the pictures because I actually knew that someone was seeing what I was eating and like say letting me know that I was doing it right and was eating right."- P6*

Feedback from the coach needs more clarity, personalization, and path to action

While most participants found simple "yes"/"not really" assessments to be useful, they had unanswered questions about meals with discrepant assessments between users and coaches. Meals with multiple ingredients required more complex judgment with goal assessments; feedback on these meals required greater disambiguation as to what parts of the meal met or did not meet specific goals. At times, participants focused on ingredients that met their goal (such as lean turkey on a sandwich for lean protein goal), while the coach focused on those that did not (non-lean cheese on the same sandwich), which often led to discrepancies and confusion. The complexity of the goal selected also made a difference. Goals like add vegetables or fruit were obvious to users. For the most complicated goal of low glycemic index, it was completely unclear to users what made a meal meet this goal or not; for this goal, the comparison with the assessment by the coach was not useful.

"Like lean proteins. I don't think I was ever told what foods contain that. So I tried to figure it out. So does chicken have that? Does a turkey sandwich have that? It would show no then yes, then no, yes then no. But then I still couldn't figure it out. That's where I'd go wrong… if fried or not fried chicken has lean protein or not. I'm still confused about that." - P5

For many, the feedback spurred questions about nutrition that were left unanswered. Participants wanted to know what actions to take to remediate the nutrition of their meals. Specifically, they wanted more straightforward instructions on how to change their meals or what qualified for goals. They talked about getting suggestions of recipes or items to substitute within meals to meet specific goals. They were motivated to make changes but needed more ideas on how to improve.

"maybe make suggestions and – or you can maybe add this or try whole grain rather than a regular pasta or just like – just some little actual words would be nice."- P3

Social influences on eating and nutrition on and offline

Learning from example meals

Nearly all participants had established practices of sharing food experiences with personal social networks on- and off-line. Despite this, use of social features within Mealyzer was low. Participants viewed examples meals at the onset of the study but few returned. First, the design of the app required extra steps to access examples of user meals that meet and are contradictory to goals. With no additional prompts, users were unaware of the growing feed. Further, to ensure that the examples were consistent (or contradictory) with goals, all examples

were curated by the coach who used strict criteria for making such determinations. This led to a sparse set of "idealized" meals, inconsistent with individuals' eating habits and largely uninspiring.

"some of them look nice, but this sounds bad, but you wouldn't expect somebody to just sit down and eat a plate of peas." –P2

Participants, in general, wanted a more direct way to learn which meals fit goals. Ingredient lists were not included so the contents were often unclear to the users. Participants also wanted to understand how specific goals were met by the meal. Others wanted straightforward ways, in general, to understand the types of meals that fit goals e.g. adding nutritionist-approved food lists and definitions to goals rather than guessing ingredients in meal photos.

"for someone to look at the photo and sometimes guess what's in the meal, and I think it might help more, like if you have a list, people just like copy the list and paste it on their, like whatever app they use. I know some people use like some list on their apps and stuff like when they go shopping" – P4

Sensitivity to judgement

The process of submitting meals and receiving evaluations from the coach brought on a range of emotions that played a role in logging decisions. Most participants were comfortable sharing meals with a health coach, who most knew personally. But, participants also wanted to submit meals that fulfilled Mealyzer's goals. Having a meal evaluated as meeting goals or being selected to include in the Examples was an additional source of pride.

"an unhealthy meal like it's easier to find that than it is to like make an actual meal that fits your goals. But I think you kind of feel, it's like, you're proud when you make a meal that you know is like going to get you, that meets your goals" -P3

Conversely, feelings of guilt and being judged arose when eating unhealthy meals. This affected logging. They were reluctant to submit meals that didn't meet any of the goals. And when they did, feelings of guilt emerged. The origins of these feelings were less clear. Some held personal stances on not meeting their own expectations.

"There were days I just did not want to take photo. I felt ashamed. I felt so bad. Like I can't take this picture of chips. I felt like I was cheating myself." - P5

For others, the appearance of their meals led them to exclude specific meals. Participants didn't want to post visually unappealing meals. Yet, they were also reluctant to capture meals deemed "special" or particularly aesthetically pleasing, and instead shared them to social media.

"sometimes I didn't like the presentation. I guess I didn't want to put like something that wasn't really good looking… I don't think it's worth taking a picture" – P3

Participants were comfortable with feedback from the coach, but were less enthusiastic about feedback from peers. Most felt unqualified to provide feedback, feared "criticism" would be misunderstood and hurt users' feelings, and were skeptical of peer feedback. Concern about imposing judgment or hurt feelings appeared as a strong theme. When discussing features to increase engagement, participants considered introducing social competition. Yet, while many

saw competitions as motivating, all were concerned about casting "winners" and "losers" and the negative consequences of competition.

Finally, participants appeared sensitive to their image among peers. While most were open to sharing with experts and other cancer survivors, many wished for a clean separation between their health-focused circles, and their broader social networks and for a way to manage how their data and records are shared within these networks.

"it's a personal thing for somebody, like people don't like to put themselves… like label themselves like hey I'm a cancer survivor […] if you have a choice to do that, then it would be cool." – P5

Fast, slow decisions on nutrition

Throughout discussions, a broad theme emerged regarding two types of contexts for making decisions about food and nutrition that vary based on time available for meal planning and selection. While this theme was relevant for their experiences with coaching, it nonetheless sheds new light on the context and constraints in which daily nutritional decisions are made. We describe those as fast and slow contexts below.

Participants had busy schedules that involved school, employment, and social obligations. They described skipping meals, eating on the run, and making choices under time constraints. Often this resulted in choosing the most easily accessible foods regardless of nutrition. We label this context as "fast", "on the go" mode, characterized by limited time for carefully considering different options, and by the need for fast action. Most participants felt that Mealyzer, with its focus on logging and reflection on goals and nutrition, was inconsistent with and inadequate to address their needs in these fast contexts.

"I never just eat. I like doing other things. So it's like I'm eating here and doing other things, and so if I […] I would try to put it (a meal photo) in (Mealyzer), and then I'll get side-tracked and do something else and I'll forget to finish." – P3

On the other hand, participants described many experiences when they were not in a hurry, and are more open to reflection and planning. Notably, these times do not necessarily coincide with actual eating experiences; for example, grocery shopping was mentioned as a more appropriate time to reflect on nutritional choices than time immediately prior to meals consumed on the run. We label these contexts as slow and thoughtful. During these slow times, the participants were more willing to engage with Mealyzer, reflect on their goals and past choices, as well as plan future meals.

"If I go on food shopping, it's like, 'Okay, what am I going to be cooking this week?' Right? And then you're like grabbing these groceries and stuff and more of involved and time consuming process. So I feel like you have more time to think about it and more time to evaluate what I'm getting. " – P7

Discussion

Mobile technologies present new opportunities for behavior change interventions for adolescents and young adults. Meal logging and goal setting are common features included in mobile health interventions for nutrition. The study of Mealyzer adds to this body of research by focusing specifically on technology-mediated coaching in health and on the experiences it creates.

The study showed that for both goal attainment and accuracy of goal assessment, the results were mixed and different among goals. Goal accuracy was generally high with upward

trends over time for three out of six nutritional goals available in Mealyzer, suggesting that simple feedback from the coach can lead to improvement in individuals' ability to accurately gauge whether their meals meet their nutritional goals. At the same time, goal achievement showed little change over time. This could indicate that changing individuals' behaviors and nutritional choices requires more than understanding the types of meals that meet goals. For example, it could mean that individuals may need more concrete suggestions for how to change meals that do not meet goals, or how to overcome barriers to changing nutritional choices. However, this could also indicate a flaw in the design of the meal evaluation feature: for some meals, "not really" response may indicate that the goal was not applicable to the meal (such as "choose low fat dairy" and a meal that does not include any dairy products), rather than a meal contradicting the goal.

Qualitative interviews highlight positive perceptions, while also suggesting opportunities for future work. Specifically, in-the-moment assessment of meals on their fit with nutritional goals, in conjunction with goal setting and logging, were associated with increased reflection on nutrition and greater motivation to eat healthier. Goal assessments guided users with a framework for evaluating meal nutrition at the time of meals. Previous studies have encouraged reflection at the time of nutrition decision-making with methods such as point of sale interventions in stores and restaurants (Bedi et al., 2010; Liberato et al., 2014; Reitberger et al., 2014) and just in time context sensitive prompting with mobile apps (Schembre, 2018). Our results suggest mobile technologies can use simple methods of directing attention towards explicit nutrition goals at the time of meals for increasing reflection and improving nutrition.

In regard to engagement with the coach, Mealyzer included only minimal features for enabling communication between coaches and users. We made this design choice to decrease the

burden on the coach, and also to encourage more independent management of nutrition by the users. The study showed that even this minimal engagement had a positive impact on participants' perceptions of their nutritional knowledge. When the assessments of meals were aligned between the users and the coach, their understanding of nutrition was confirmed. However, discrepancy in assessments generated questions; and without written explanations, the utility of this feedback was limited. This was apparent with complex meals, where it was unclear how feedback applied to different meal components. Research supports these findings showing that correctness feedback with explanations is more helpful for learning about nutrition compared to simple correctness feedback (Burgermaster et al., 2017). This suggests that including explanations with feedback should be a feature included in nutrition interventions. Although expert feedback is useful, generating it is labor intensive. Future research can investigate scalable methods for generating feedback such as crowdsourcing with peers (Turner-McGrievy et al., 2014), using Amazon Mechanical Turks (Noronha et al., 2011), and just-in-time interventions (Schembre, 2018).

Features that focused on observational learning by providing example meals captured by peers suffered from low utilization. And when users did see these examples, they found them uninspiring. In terms of design, such features need to be more prominent to encourage use. Participants reported enjoying viewing meal images from friends and family but had little interest in interacting with other users. Future design directions can investigate interventions where networks are based on relationships with strong rather than weak social ties. Moreover, it is unclear what makes images appealing to users. Research can also investigate the characteristics of images that users find engaging and whether it is the images or their personal connections to those who post that is important in providing engaging content.

Our findings suggest that nutritional decision making broadly occurs within two processes related to time and reflection on nutrition. This phenomenon is supported by dual process theory that features two systems of cognitive processes that influence behaviors and beliefs (Evans, 2008; Houlihan, 2018). The first is fast, intuitive, and belief-based. It's cued when features bring to mind prior knowledge learned over time. The other system is slow where reflective thinking is cued when individuals have greater abilities or opportunities to think critically. The theory has been applied to multiple domains of health including nutrition (Houlihan, 2018). Nutrition may be an important consideration for food choices (Glanz et al., 1998). However, in the absence of motivation and time, dietary decisions are largely automatic and based on heuristics and contextual cues (Cohen & Babey, 2012). Our findings suggest that behavioral interventions should accommodate these processes and consider investigating fast approaches for younger populations. Rationalist approaches that include self-monitoring may not fit the lifestyles of these groups. Mobile applications interventions for fast times that provide supportive messaging at the time of need are being explored generally within other health domains(Bae et al., 2018; Bidargaddi et al., 2018). However, more research is needed to identify strategies for intervening on nutrition.

Lastly, discussions around creating greater social interactions with users were met with little enthusiasm. Our findings highlight sensitivities around feeling misunderstood, judged, constructive criticism, and competition with these groups. Similar sentiments have been documented in research on the relationships of young people (Anderson et al., 2016; Bisafar & Parker, 2016). This suggests that interventions with adolescents and young adults should implement positive social interactions that will encourage engagement.

Limitations

Our study had a number of limitations. The pilot study experienced high levels of nonuse attrition with nearly half of participants joining the study and failing to access the intervention. Participants who did engage with the intervention did not log enough meals to perform a statistical analysis of effectiveness. Participants also reported selectively logging meals introducing response bias into our results. Moreover, participants interviewed in the qualitative study represent the most highly engaged participants within the study. Thus, the generalizability of our findings is limited.

4.3 Aim 2c. Explore attitudes, behaviors, and the use of social media for health and wellness among healthy young adults

Young adulthood is a time when individuals experience increased autonomies and transition from living with family to living on their own. Along this transition, there are opportunities to learn healthy behaviors and transform them into lifelong habits. Social media is emerging as a valuable tool for people learn about nutrition and food preparation, and share food experiences. These include posting food photos, meals at restaurants, and recipes (Holmberg et al., 2016; Mejova et al., 2015; Vaterlaus et al., 2015). People are also using social media as a tool for self-tracking to monitor their diets (Abbar, Mejova, and Weber, 2015). The study of social media usage patterns among young adults is less explored. The social media sharing behaviors of teens has been investigated more generally (boyd, 2015). However, there is little research into the area of youth's nutrition sharing behaviors on social media. One study used qualitative methods to explore how young adults use social media is used for diet and exercise (Vaterlaus et al., 2015). A Swedish study characterized Instagram food posts of adolescents finding most items were high calorie and low nutrition (Holmberg et al., 2016). There remain significant knowledge gaps around adolescents' and young adults' social media behaviors and informatics solutions. No studies have examined social media posts and user following patterns to understand these behaviors and influences. In order to gain a better understanding of how to design social media technologies for youth, we first need to learn about how young adults use social media for nutrition.

The purpose of the study was to examine social media usage and influences for health and wellness among young adults. The study used descriptive quantitative and qualitative

methods to understand social media usage patterns and influences on young adults. This study will address the following research question:

- ***RQ1:*** What are the contexts and health and wellness-related behaviors of healthy young adults?
- **RQ2**: How are young adults using social media platforms for health?

Study Design and Procedures

Sample

We recruited 25 young adults from the general public and from universities in the New York City area to participate in individual interviews. Eligible participants were between the ages of 18 and 27. Individuals were also screened for being regular or more than occasional users of social media for health and wellness. Exclusion criteria include those who have ever had an eating disorder.

Recruitment

Recruitment took place using advertisement flyers posted around the Columbia University Irving Medical Center (CUIMC), on designated community boards on local university campuses including within Columbia University, the City University of New York (CUNY) systems (Bronx Community College; Hunter College; CUNY Graduate Center, Baruch College, LaGuardia Community College), the Fashion Institute of Technology, and through an online recruitment mechanism at CUIMC called RecruitMe. Participants from previous studies who agreed to be contacted for future studies on their informed consent forms will also be contacted for recruitment. Institutional review boards at Columbia University Medical Center approved the full study protocol. The CUNY Human Research Protection Participation offices at Bronx

Community College, Hunter College, CUNY Graduate Center, Baruch College, LaGuardia Community College and the Fashion Institute of Technology all approved this study and recruitment on their campuses as non-affiliated researchers.

Interviews with young adults who use social media for health and wellness

The study used descriptive qualitative methods to understand social media health and wellness usage patterns and influences on young adults. The interviews focused on such questions as health and wellness behaviors, types of social media used, reasons for using social media for health and wellness, common behaviors, and attitudes towards the platforms, trust in information, among others. The interviews lasted for 60-90 minutes and were conducted in person or over the phone or skype; they were audio-recorded and transcribed verbatim for analysis. Appendix C.1 includes the interview guide.

Survey of demographic information and internet/social media usage

Participants were asked to complete a 25 question survey before the interviews (Appendix C.2). Topics covered included: 1) basic demographic information (race/ethnicity, age, education, etc); 2) general internet access; and 3) social media usage including reasons for use (Smith and Anderson, 2018), frequency of usage(ibid.), platforms followed, and types of health and wellness social media viewed.

Procedures

Individuals who were interested in study participation first took part in the verbal consent process to get permission for screening. They were then given information about the study and were screened for participation based on inclusion/exclusion criteria using a recruitment phone call and screening guide. If the participant fit the inclusion criteria, he/she was invited for an

individual interview. Participants were given the option to select a location of their choice for the interview if they did not want to come to the Department of Biomedical Informatics.

All subjects who joined the study were provided with the informed consent information sheet including the description of the study, potential risks, and researchers' and the Institutional Review Board's contact information. Upon arrival for the interview, the informed consent process was explained to participants and they were asked to sign consent forms and given a copy for their records. During the consent process, it was emphasized that enrolling in the study would not directly benefit them. If they were patients at CUIMC, they were informed that choosing not to participate would not affect treatment or care in any way. If they were students at Columbia University, they were informed that choosing not to participate would not affect their grades, access to resources, or any other services they receive at school. Participants were compensated with a $20 gift card for participation in the described study.

Data Analysis

Interviews with young adults who use social media for health and wellness

All interviews conducted were recorded and transcribed verbatim from audio recordings using a transcription service. Three researchers (MC, ML, and LM) analyzed the transcripts and conducted inductive thematic analysis. Two members of the research team (MC and ML) collaboratively read through the first three transcripts, open-coded on a line-by-line basis identifying semantically meaningful chunks, and assigned them categories based on their topic in multiple sessions. A codebook was created using the categories from the first three interviews. Two researchers (MC and LM) reviewed the codebook and list of categories, and grouped them based on their similarity. Two individuals (MC and LM) coded and identified themes for the remainder of the interviews. At the end of this process we identified a number of high-level

categories that summarize the most common themes describing social media practices for health and wellness among young adults. Additionally, an audit log was kept to maintain a record of key decisions made during the analysis.

Survey of demographic information and internet/social media usage

For the brief demographic and social media use survey, we used descriptive statistics to analyze survey results and provide an overview of the sample and usage of social media.

Results

Survey results

Demographics

Table 4.3: Participant Demographics (N=25)

	Number (%)		Number (%)
Sex		**Marital status**	
Female	20 (80)	Single	24 (96)
Male	5 (20)	Married	1(4)
Age			
18-19	4 (16)	**Parental education**	
20-24	13 (52)	**Mother's highest education level**	
25-27	8 (32)	High school diploma	6 (24)
Race		Associates degree	4 (16)
White	13 (52)	Bachelor's degree	7 (28)
Black	2 (8)	Graduate degree	6 (24)
Asian	8 (32)	Professional degree	2 (8)
Two or more races[1]	2 (8)		
Ethnicity		**Father's highest education level**	
Hispanic	5 (20)	No education	1 (4)
Current/Highest education level[2]		High school diploma	5 (20)
High school diploma	3 (12)	Associates degree	2 (8)
Associates degree	0 (0)	Bachelor's degree	3 (12)
Bachelor's degree	14 (56)	Graduate degree	5 (20)
Graduate degree	7 (28)	Professional degree	6 (24)
Professional degree	1 (4)	Don't know	3 (12)

Note: 1. Two participants reported two races (Black/Asian; White/Asian). 2. Current/highest education level categories include participants currently enrolled in a degree program but not yet graduated.

Results from the survey show diversity among the young adult participants (Table 4.3). The majority of participants were female (80%), between the ages of 20-24 (52%). There was a range of race/ethnicities reported: White (52%), Black (8%), Asian (32%), and two or more races (8%).

20% reported being Hispanic. One participant was married with two children; the remainder were unmarried and childless. The sample was highly educated with 88% enrolled in or having a bachelor's degree or higher education level. Parental education showed parents were highly educated as well. However, there was a wider range of education among mothers and fathers. 40% of mothers and 36% of fathers had an Associate's degree or lower level of education.

Internet access

In terms of accessibility, the young adults were well connected to the internet and technology. All participants (100%) had access to the internet and owned smartphones (data not shown). All except one participant (96%) owned a computer or tablet.

General social media usage

Table 4.4 shows the general social media usage of the young adults. Generally, the young adults were frequent users of social media. Nearly all (96%) viewed social media several times a day; the remaining participant said he viewed social media once a day.

Participants were asked for their top 3 social media platforms used; Instagram (96%), Facebook (76%), SnapChat (32%), and YouTube (32%) were the most popular.

In terms of any usage, all participants used Instagram. Nearly all used Facebook (96%) and YouTube (92%). Other platforms included Twitter (48%), GroupMe (40%), Google Hangouts (40%), Pinterest (36%), and WhatsApp (36%).

In terms of reasons for using social media, the young adults used it for socializing, information seeking, and entertainment. All participants said they used it to stay in touch with friends. Participants also used it to communicate with other people in their lives including family (88%), old friends (72%), and those with shared interests (60%). Other frequent uses of social media included: 80% to read news/politics, 88% to read about health, 88% for random

articles/memes, and 76% kept abreast of social media personalities. Less common but still substantial, social media was used for political reasons including activism (40%) and following politicians (48%).

Table 4.4: General social media usage (N=25)

	#	%		#	%
Frequency of usage			**Reasons for using social media**		
Several times a day	24	96	Socializing		
Once per day	1	4	Stay in touch with friends	25	100
Social media platforms used			Stay in touch with family	22	88
Top 3 social media platforms used			Connect with old friends	18	72
Instagram	24	96	Connect with others who have shared interests	15	60
Facebook	19	76	Making new friends	11	44
SnapChat	8	32	Finding romantic partners	7	28
YouTube	8	32	Information seeking		
WhatsApp	4	16	Reading news/politics	20	80
Twitter	3	12	Reading health	22	88
Reddit	3	12	Reading pop culture	18	72
Pinterest	2	8	Opinions of		
LinkedIn	2	8	Celebrities	16	64
Gmail	1	4	Politicians	12	48
Other	1	4	Social media personalities	19	76
Uses the following apps/sites[1]			Entertainment		
Instagram	25	100	Random articles / memes	20	88
Facebook	24	96	Local events	22	36
YouTube	23	92	Local shopping	9	16
SnapChat	16	64	Activism	10	40
Twitter	12	48	Self-promotion	4	16
GroupMe	10	40	Self-expression	1	4
Google Hangouts	10	40	Fashion/style	1	4
WhatsApp	9	36	Spiritual/Religious	1	4
Pinterest	9	36	Research	1	4
Tumblr	8	32			
Discord	4	16			
LinkedIn	3	12			
Tinder	3	12			
Kik	2	8			
Viber	2	8			
Line	2	8			
Google Duo	2	8			
Bumble	2	8			
Reddit	2	8			

Note: 1. Includes only apps/sites reported by at least 2 participants

Health and wellness on social media

Young adults in the sample had general interests in health topics (Table 4.5). All were interested in nutrition/food and 92% had an interest in fitness/exercise. 76% were interested in

general preventative health and well and stress management. Over half expressed interests in sexual reproductive health, mental health, beauty/skincare, and life hacks. Few (8%) were interested in chronic disease management. In terms of actual viewing of health topics on social media, nutrition/food and fitness were viewed by nearly all (92% and 96% respectively).

Table 4.5: Health and wellness topics: Interest and viewing on social media (N=25)

	Has interest in topic		Views topic on social media	
Health and wellness topics	**Number**	**%**	**Number**	**%**
Nutrition / food	25	100	23	92
Fitness / exercise	23	92	24	96
Weight loss	13	52	15	60
Weight / muscle gain	10	40	10	40
General preventative health / wellness	19	76	14	56
Chronic disease management	2	8	5	20
Sexual reproductive health	15	60	13	52
Mental health	15	60	16	64
Stress management	18	72	14	56
Substance abuse	0	0	1	4
Beauty/skincare	16	64	16	64
Life hacks	15	60	18	72
Others (write-ins):				
Saving money	1	4	--	--
Nursing care	--	--	1	4

Health information sources and trust

Table 4.6 shows health information sources and levels of trust in each source. In terms of sources of information, the most widely cited source was the general news (72%). This was followed by photo sharing apps/websites (68%) and video sharing apps/websites (64%). Over half used for-profit sites (e.g. WebMD), non-governmental sites, and personal websites/blogs.

Most (64%) of the participants trust or strongly trust health information they find online; the remainder are neutral. The most trusted types of sites were university-based (92%), physician/hospital based (92%), and non-governmental sites (88%) despite the majority of

participants citing limited usage of these sites as sources of health information. The least trusted sources were religious sources (10%), microblogging sites (13%), and question and answer sites (16%). Among the top three sources of health information, there were moderate levels of trust. For general news, 48% strongly trusted or trusted the source. For photo sharing, 36% strongly trust or trust the source. For video sharing applications, there was greater levels of trust (60% for instruction videos; 57% for informational videos).

Table 4.6: Trust in health information sources and trust (N=25)

	Number	%		
General level of trust in health and wellness info you find online				
Strongly trust	1	4		
Trust	15	60		
Neutral	9	36		
Distrust	0	0		
Strongly distrust	0	0		
	Use the source		**Trust/strongly trust source**	
Health information source	**Number**	**%**	**Number**	**%**
Friends	14	56	24	63
Family	9	36	24	63
General news	18	72	25	48
Physician/hospital websites	8	32	25	92
University websites	9	36	24	92
For profit websites	14	56	24	67
Government websites	9	36	23	78
Non-governmental health orgs	14	56	25	88
Religious websites	1	4	21	10
Online encyclopedias	15	60	25	32
Personal websites/blogs	13	52	24	21
Microblogging	5	20	23	13
Online communities	10	40	23	30
Question and Answer websites	7	28	25	16
Photo sharing apps/sites	17	68	25	36
Video sharing apps/sites	16	64		
Instructional videos	--	--	25	60
Informational videos	--	--	23	57
Other (write-in)				
Scientific journals	1	4	--	--

Qualitative results

Diversity of background and living experiences

The participants of this study came from diverse backgrounds and had very different life stories. Some grew up in affluent health-mindful households, focused on healthy diets and fitness. Others came from families that struggled financially and faced a variety of health and mental health challenges. This diversity was evident in their life circumstances at the time of the study. While some were students in an Ivy League university, others had unstable jobs and government subsidized health coverage. The multi-level influences on health, at the individual, community, and social levels, as described in the social ecological model, were apparent throughout interviews.

Health and Wellness

Perhaps not surprisingly, most individuals who volunteered to take part in this study, with the inclusion criteria of using social media for health, had high levels of health awareness and healthy lifestyles. Most cooked their meals at home and viewed home cooking as healthier. In addition, most had established exercise routines that often involved running, biking, jogging, gym, yoga, among other physical activities. Several considered the health consequences of not adopting healthy lifestyles.

> *"you only have one body and I want to like optimize every part, like I want to optimize my brain. I want to reduce stress. I don't want to have diabetes or something. So, I try to eat as healthy as possible" (P21)*

However, the participants noted that their lifestyles were not necessarily typical for their social circles:

"Yeah, typically, you know just my friends have very normal lifestyles and they eat whatever they want, you know, and they stay up till 3 in the morning. It's like, I don't do those things." (P22)

While most participants had relatively high levels of awareness and healthfulness in their lives, their journeys to this point were quite different. Some grew up in affluent fitness-oriented families and communities where healthy lifestyles was a part of their lives.

"[my community] it's really affluent like everyone plays soccer growing up and plays 800 different sports activities." (P1)

For others, transitioning into independent living was a point at which health came to the forefront of their attention:

"…once it's like college, that's when I realized that, oh I really need to think about what I eat and things like that. So I think, it's just be mindful of what I need to and not beat myself up if I just indulge in something." (P6)

Health is Personal and Subjective

Different participants had somewhat different ideas about what it means to be healthy and to have a healthy lifestyle. Participants defined being healthy in varying combinations of nutrition, physical activity, sleep, socializing, and mental health. Some defined it in terms of fitness and regular exercise; for others, healthy lifestyle focused on eating healthy, natural, nutritious diets. Others focused on levels of stress and mental health; some struggled with clinically diagnosed mental health diseases. Most participants held the opinion that health is defined differently for different individuals in unique and idiosyncratic ways, rather than following some social norms.

> "*I think for me, it's about like not following on the trends because like everyone has an opinion. So you just have to do what's right for you and what makes you happy. It's totally fine if you want like, like a piece of cake or something or oh my gosh, don't have like, you're like so extreme where it's just like, at the end of the day like we're all doing what we need to do to be healthy. So we don't all need to be insane, we all have very like unique bodies. Very unique bodies. So for me, it's just about doing like what I love and what works for me. That's what I've noticed so far about me because I get like do what everybody else is doing for example, like people love to go to the gym and that's a sure thing*." (P4)

Notably, most participants talked about health in terms of how it makes you feel: if you are healthy, you feel good.

> *"To me, I'm healthy. So, for me like if I'm taking care of myself and I feel like I'm in a good place, I consider myself to be healthy." (P18)*

Similarly, those who kept set exercise schedules often did it because regular exercise helped them feel better. For example, P5 described how she started training for a marathon during her first semester at college, and found that "*the running was super therapeutic in that time period*" (P5) and in general had a positive impact on mental health.

Physical and mental health

Some participants defined health purely in terms of physical fitness. For many, however, physical fitness was inseparable from mental health.

> *"So like mentally, it's just, you know brawn, you know like fully how you're doing. Like checking in with yourself. Because we tend to not check on things… ourselves and stuff… So like for me, it's about mental […] and then after that, it's like okay, and we do like a physical thing. And so the biking, […] it works with everything." (P4)*

Furthermore, for many participants, physical health had an impact on mental health as well. Many had busy stressful lives, packed with various daily activities that took a considerable toll on their mental wellbeing.

> *"I think I frequently try and fit too many things into like a week or a day and get to the point where I feel like I'm not my best self or like interacting with people the way that I normally would." (P5)*

For these participants, engaging in exercise gave a much-needed head space to reconnect with themselves:

> *"I think, being healthy for me involves thinking about mental health and physical health and how it's related. I think that's mainly why I started running, it was just because it was very good for mental health and stress reduction. So, yeah, it's even more like a mental boost to me than a physical boost because I think, I use it, kind of just like a break from school, and just like time for myself to think and so that's kind of how I felt about running." (P9)*

Balancing Health and Life

For most participants, maintaining healthy lifestyle involved an intricate and careful balance between busy schedules filled with work and school and attempts to eat healthfully and exercise. They resorted to eating out when their busy schedules prevented them from pursuing healthier options.

> *"Okay. So it kind of depends on the day because I have two days of clinical and three days just like didactic working stuff. So on one of those days, [I] get*

up at 8 o'clock, get ready, [and] eat a really good breakfast of cereals. Then just like 10 minutes before class starts, head to class because it's just super close. So do class until say 9 to 1, don't have lunch break, but I eat in class. That's fine." (P10)

Others worked on maintaining a balance between activities for health and social life:

"Weekends, maybe every other weekend, I will go out to a bar or something with my friends. And then Saturdays it depends … but you know I'll go do something with friends in the city or something." (P8)

In addition, most were budget-conscious, identifying low-cost ways to eat and exercise and trying to gain the most value of the money spent on healthy food and fitness.

"I walk a lot. I can't afford a gym membership, so I try to do exercise at home." (P6)

"Yes it's very within its own bubble except for the Hot Yoga. Because it is fairly expensive, I make sure I go three times a week." (P1)

For several, these cost considerations actually led to more frequent participation in gyms and other fitness classes.

"I wrote down the cost per use that if I went there five days a week then it would only cost me like $4 every time I went there instead of if I only go once a week it would cost me like $20 every time I go there." (P5)

Many also had practical constraints in their living arrangements, small or shared kitchen spaces, that had an impact on their ability to cook and store meals at home.

"I live in an on-campus building with two burners, so I don't have an oven. So it's usually something like a stir fry… I also have a mini fridge so that makes it harder." (P1)

Fast and Easy

Perhaps as a result of the practical constraints described above, most participants sought out ways to engage in healthy lifestyles in a simple way that did not require either financial or time investment, and valued both healthfulness and convenience:

"But, I mean, it's kind of what works for me, like what's convenient, that's like also healthy." (P9)

While most participants cooked meals at home, many of them sought out recipes that required few ingredients and were easy to make:

"I actually follow an Instagram account that is my like my main recipe following. All the recipes are like 10 ingredients or less and they take less than like 40 minutes to make." (P5)

Others developed routines to simplify their weekly meal preparations. Participants ate similar foods repeatedly to minimize the number of times they had to make choices about what to eat. In terms of process, participants reduced the amount of cooking required each week by cooking dishes that could last for several days and meals:

"I usually, mostly on the weekends and maybe on the week, early part of the week, Monday or Tuesday, I prepare a meal in a crockpot. So I will prepare the ingredients the night before and then just put everything inside it and then

when I come home, yeah, so I can usually get about three meals out of that and so I just get into, it could be dinner or lunch for work and then and I usually have it about like once a week…" (P6)

Some had rather elaborate routines to integrate healthy eating into their busy and at times hectic lifestyles. For example, P1 used a set of colored and differently sized food containers to pack their home-made food for the day, separating vegetables from proteins from grains into different containers.

"I actually brought it's like a nutritional box. I don't know what they call it. It's like 9 boxes the containers in different colors and different sizes and it's supposed to be like so you watch what you eat. The bigger box with a certain -- - the green color is for your vegetables and the smaller box is for your fats so you put a little parmesan in it or like the medium box is for carbs." (P1)

For others, cooking was not a feasible option. Several participants discussed having little interest in cooking, eating in school facilities where food was prepared, or not having time to cook. During these times, the quickest option selected was not always the healthiest.

Social media usage patterns

Social media use and platforms

Overall, the participants were quite fluent with social media and had a large repertoire of social media sites they participated in on a daily basis. These included the more traditional platforms, such as Facebook, Instagram, Snapchat, and Twitter, as well as a number of smaller platforms.

For most, however, different platforms served rather different purposes. For example, Facebook was a common choice for connecting with family and friends, and for sharing news and images with a small circle of trusted individuals. As a result, for many participants, Facebook posts were more intimate and private. In contrast, for several of the younger participants, Facebook was used as a means to connect to social groups and larger circles of friends and family but was not as commonly used to share information. Several mentioned only recently joining Facebook in college and the platform being geared towards older generations.

> *"don't use Facebook very much. It's more of like the older generation. But, like my grandmother is always on Facebook." (P23)*

Instagram was often used to reach a wider audience of mostly peers. As a result, for most, Instagram posts were less personal and often included reposting of funny memes and jokes. Some individuals preferred following accounts of those they liked or could feel connection to. Others preferred to cast a wide net and browse content by topic instead of following specific individuals:

> *"So, the big thing for me is going to the score tab and seeing what content is there like for that specific topic and from there, I can go through it. And I'll post like screenshot. When I like a post, I can always go back to that screenshot, I can always go back to it." (P18)*

Several participants had experiences participating in online discussion forums. These included a discussion forum on mental health (P2), a Facebook group for runners (P12), and Discord servers for gamers (P11, P18), among others. However, most preferred media that allowed for lightweight engagement that did not involve direct communication.

The intensity of social media use varied between participants. Most appeared to be moderating their use and were mindful of how much time they spend online. Others talked about being online most of the time throughout their days, even while studying, combining watching videos with playing games and chatting with friends.

> *"So pretty much from the moment I wake up like the first, I'd say five things I do, five-ish is I'll go to Discord and check my messages. I'll message. I'll check my email. Some type, it's like check it and Facebook… Then when I get up, I'll eat. Then normally when I'm done eating, I'll head back to my room and I'll actually get on the computer and from there I normally, either play Overwatch with Discord friends or I'll go on to like Facebook or YouTube, Spotify, but most of my day is definitely on Discord, I feel like... I have a tendency of putting my phone like on top of the lap board and I'll like play and watch videos at the same time." (P18)*

Different uses of social media

The participants engaged with social media in many different ways and for different reasons. Some of the main reasons reported included: 1) keeping in touch with friends; 2) researching and learning new things; 3) business opportunities; 4) self-promotion; 5) affirmation of identity; and 6) inspiration. I describe these in more detail below.

Keeping in touch with friends.

Most participants relied on social media to connect with other individuals. Most used it primarily to connect with family and friends they already had in lightweight ways such as liking images or forwarding posts. These participants were typically reluctant to make new connections online and stayed within their existing social circles:

> *"I primarily follow friends and family and then probably like meme pages…Because I feel like those is a form of communication keeping in touch with people. Now it's sending them to each other through Instagram." (P5)*

Others, however, used social media to make new acquaintances and friends. For example, P18 used social media to connect with others who played the same video games online:

"So I used to play immersive boxing. And a lot of other people did and from there like a community formed. So, a server was made for people that played boxing and from there I met a lot of people on it and I made a lot of friends. And from the friends that I meet there, I got closer to certain people and we would actually talk about health in terms of like, I guess mental health wise is like a big thing." (P18)

Research. Most participants used social media to seek information on topics of interest. Some used it to keep up with news and scientific discoveries. For example, P21 used Twitter to follow NASA, scientific journals, and other research agencies. However, most used it to research topics of personal interest. For example, for P4, who worked on developing a career in acting and modeling, YouTube was a source of videos on acting techniques.

"And there is this really great acting coach. She has like her for class, I think it's part film. And it's old ones. So we would go over like all like really great in your class." (P4)

Business opportunities. Another common view of social media was as a source of opportunity for business and profit. Some specifically sought out potential business opportunities or used social media as part of their professional branding.:

"Because that's what my Instagram is for, my opportunities. It doesn't have to be about drama. It doesn't have to be about anything else. My experience to me is for opportunities only." (P2)

Several participants had friends and acquaintances who had monetized their social media presence to earn money and free products. They would do this by showcasing products, becoming brand ambassadors, or including advertisements in their social media posts.

"She models for fashion… you can make a lot of money on doing this and I am sure she does, but just like my average, like my friends -- my close friends' average between a couple 100s to a 1000 dollars." (P23)

Several participants used social media, particularly Facebook, less for social connection and more for commerce:

"And then like honestly what takes up the most time on Facebook now is like the buy and sell groups so I'm really obsessed with." (P8)

Others used social media to seek out promotions and special deals from brands they follow or as a way to win products:

"No, I used to do, it was just like, like the picture, follow it, like some of the compliments and I won like $500 of home good stuff." (P6)

Self-promotion. Many participants viewed social media as a platform to influence others and for self-promotion:

"So definitely people who share, the stories that I actually want to watch with people who I can tell, like I'm doing it for self-promotion, they want to really help other people. So you could really tell." (P6)

Many actively monitored reactions to their posts from others, including likes and followers:

"I actually think it's interesting that I do get some satisfaction if someone likes a post that I put out." (P1)

"I only unfollow things that don't follow me back because I just like to be followed back. I like my follow count. I have noticed that I like my followers to be more than my following." (P2)

Others, however, were disapproving of those who seek validation through likes on social media:

"…why are you so self-absorbed and but also then like oh gosh you must need attention or like I guess I go back and forth I'm like is this like self-validation by the number of likes that you are getting …" (P5)

Affirmation of one's identity. Another common use of social media was to seek out individuals on social media who matched the participants' perceptions of their own identity, perhaps not easily revealed to others. For example, P4, who identified as part of the LGBT community, related that she was really impressed with an androgynous person who had a large following on social media, and saw this person as "cool" and as connecting with her own perception of self:

"very like androgynous looking and sometimes she will post like stuff like, oh I'm only a girl and looks like more manly. And that's been me, like a couple of times, whatever just being like a token person." (P4)

Similarly, P18, who talked about weight management challenges, found it to be reassuring to follow others who are overweight: watching their confidence and positivity about their bodies helped her to gain confidence in herself:

"But a lot of the people that I follow were generally, a lot of people I follow are overweight and they like dress with confidence and be confident yourself. And like when I watch these (shopping) hauls, it's like, these plus size women will try those clothes that most people would be like, oh, you shouldn't wear that and it's like watching them do that, it's like build confidence in myself." (P18)

Inspiration. Finally, one of the most common themes in the findings was individuals' view of social media as a source of inspiration. The participants talked about inspiration in different ways. For some, it was about finding other individuals who inspired them and served as role models. For example, P4 spoke of authenticity as an important characteristic that attracted her to individuals on social media and led her to follow them:

"To follow people who have authenticity. Like to make someone like you're inspired by this. Yeah, like not someone who is putting stuff like yeah, tell me to eat all those stuff, nothing like that you feel like they are just being fake about. Yeah, just like it's more about like for them about like money like promotions or. Then follow like people like that and just like friends who don't have like some sense like what are they about money, because it's just like a waste of time. So they are like, a lot of people follow people who have like substance and like just more about them." (P4)

When speaking of inspiration, the participants often described platforms that used rich visual media, photographs and videos, like Instagram, Pinterest and YouTube. For some, visual aesthetics were important; they had a particular feel for how they wanted visual representation to be and sought out images that were consistent with that:

"Yeah, so I have a lot of like specific requests, things that I follow. Just like very like aesthetic and like it reminds me of home and I really just like it and I always wanted my Instagram to look like that. Although never does, but like, that is like what I aspired to have an Instagram and stuff like… Like trees, no, like hiking." (P8)

"And just like, yeah, this part inspires me or just like short haircuts colors and just like this variety, it's like, wow, these are cool colors. I want to think this color will look good on my skin tone." (P4)

Seeking positivity

One of the dominant themes in the study was the participants' clear desire to view social media as a source of positive energy and inspiration. Some participants had complicated relationships with friends and family and social media presented an outlet to get away from the complexities and challenges of daily lives. It also allowed for a more light-weight and passive engagement, where one could engage by simply listening, rather than actively participating:

"Well that's I feel like more social media because I have been like listening. I don't want to talk to people especially not people I'm already dealing with because they are like their own drama fill." (P2)

Consistent with this, many participants gravitated towards lighter use of social media, by watching and reposting memes and jokes that entertained them, and could entertain others in their social circles:

"Maybe 2 or 3 weeks ago my posts were not as happy. I did post some stuff it wasn't like oh I hate my life or anything like that. I will never let people know that I'm down. But you'll know by what I'm posting." – P2

Similarly, most participants felt that social media was not appropriate for debate and for trying to articulate one's opinions in order to convince others. Instead, most opted for de-friending or hiding the posts of those they disagreed with in order to avoid open confrontation:

"I don't think my social media posts will change anyone's mind. I think it's just a platform to yell at each other … so I don't think it's worth saying

anything to them even though I really like to and they get riled upon seeing their post so I have found it's better to de-friend them and not follow them." (P2)

Generally, the participants were concerned about not imposing on others on social media, and had rather negative perceptions of those who did, either for commercial interests or to seek empathy:

"… like I would never post like me working out or anything like that and like I don't use Facebook to be like, oh, I am sick or whatever because I think personally when I see other people like do that… I feel like they are asking for something. And I don't want to be that kind of person." (P8)

Many participants made negative comments about others who exaggerate their challenges in order to seek attention from others:

"And like, it's not that they have an issue and they are asking for help. […] a friend of my mine complained that his bike he didn't have a basket for the bike parade and that was a huge thing that I was supposed to, I was like, that's enough for me. I'm not going to support you through this time of struggle." (P10)

Sharing and Trust

Generally, the participants appeared quite savvy in their appraisal of others on social media. Almost universally, they cited authenticity as the main quality they were seeking in others that would lead to trust.

"…it's people I don't trust and there is people who I do trust as in like, I just like, they just have like this trusting energy about them." (P4)

Commercial interests had eroding effects on trust. In contrast, those who appeared to be caring for their followers and to be driven by more altruistic motives were perceived as more trustworthy.

"Yeah, it's not even about like money for them. They just really care about like what their, yeah like what their subscriber people who are following them." (P4)

"So definitely people who share, the stories that I actually want to watch with people who I can tell, like I'm doing it for self-promotion, they want to really help other people. So you could really tell." (P6)

Similarly, lack of authenticity, excessive self-promotion, and obvious image management were viewed as a turn off:

"And it's kind of like, you like laugh at that because like because it just like shows how fake all the social media are. Like even if you look at entire team to take care of you, you still need to Photoshop and try to make it even better. Like this, woman who is like beautiful, faces, bodies, careers, you know. And then like why do you do that?" (P10)

Several participants felt it was widely known that people were not always showing their genuine selves on social media. One participant (P23) talked about a phenomenon among young adults of keeping separate social media accounts for your genuine self versus the more positive version of yourself you want to present on social media. Called Finstas (fake Instagram) and

Rinstas (regular Instagram), young adults have different followers for each account. One account, the Finsta, was used to share your real day-to-day life, both positive aspects and negative struggles, with close friends. The other account was for a wider group of followers and more curated to be positive.

Generally, the participants were differentiating in their level of trust between information that required expertise, like advice on medical treatment, and information and advice that did not have much potential for negative consequences:

"When it comes to food, the worst that can happen is that it does not taste very good" (P8)

In regard to sharing their own experiences, the majority of the participants felt uncomfortable sharing with others outside their immediate circle of family and friends:

"I did a lot of research, but I was just like, I could never make my own YouTube video. Like, again, it's kind of like sharing too much. I feel like this is… I don't want to be a part of that." (P8)

For most, sharing of personal experiences with others required some special occasion, like travel, special meals, or achievement of fitness goals.

Negative perceptions of social media

Despite the generally positive perceptions and experiences with social media, the participants were aware of the darker side as well. Some related accounts of themselves and others who became a subject of harassment or abuse on social media and were generally disapproving of unethical conduct by others:

"…these people will do anything for money just to bring somebody down who's been like constantly elevating their career … Another, you know, what I mean. So it's just like don't deal with people's lives like that and some people like they don't care." (P4)

Many were concerned about the time they spend on social media and the impact it has on their lives:

"I want to stay off social media. As of a week ago I have unlocked my phone 706 times. I have checked my apps 1126 times and I've used for 18 hours and 24 minutes." (P8)

Others were wary of over-reliance on opinions of others as a guide to one's own perception of identity and self-worth, and one's own behavior:

"And I like the new story feature although at times it is like exclusionary or like I have this younger sister….Like my youngest sister she is like 15 year old girl...It's like she watches people's Instagram stories and she is like why are they hanging out without me? Or like these people are here doing this and I'm not part of that." (P5)

Social media for health

Consistently with their regular use of social media, the majority of participants have previously engaged with social media specifically in the context of health and wellness.

Health information seeking

All participants had some experience seeking health information online and on social media. Most were pretty savvy in their appraisal of different sources, relying on more official

ones, like New York Times and Washington Post for general news, and Web MD for more general health information. However, some felt that Web MD, with its focus on actual diseases, was a dangerous source as it inevitably led to self-diagnosis of some disease:

> *"Sometimes the images -- I feel like Web MD as silly as it is and its option I don't trust it you can go down the rabbit hole freaking yourself out that you are like dying but it's something that's not bad at all." (P5)*

Many participants expressed skepticism regarding social media platforms as a reliable source of health information:

> *"I think that's a huge issue in society that people don't have any digital [literacy]. They read Twitter to the same regard as, you know New York Times which has all the resources or, you know… And that's just a huge detriment to society, I think." (P21)*

Several participants mentioned evaluating nutrition and medical advice on health-related social media sources based on specific cues associated with increased reliability including citing scientific and research studies and high levels of detail.

> *"he names studies too. He's saying like people on Mediterranean diets like eat like higher fat, have like higher tested better on like cognitive test or something. And like keto, people are just like baking and butter but actually like, it can be like avocados." (P21)*

However, when it came to more concrete and practical guidance cooking and fitness, most participants had clear preference for and were frequent users of social media:

"I actually would go to the Instagram app like if I'm looking for a workout or a meal to make or a stress management thing like… I follow a lot of like weekend cooks and weekend bodybuilders not that I'm trying to become a body builder but I like the things they suggest I like to follow them." (P1)

Some were interested in holistic medicine and natural remedies, like herbs and oils, for which limited information was available through reliable sources, and relied on social media for information (P4). Others relied on blogs of others with similar experiences, for example, in the case of exercise-related injuries:

"And I feel like a lot of the times things like that are helpful or if it's like a running related injury or it's something where it's more like physical therapy bound I found other people's like blogs helpful or just to be like okay like they were feeling these symptoms. I'm feeling these symptoms." (P5)

Others used social media to explore and learn about new areas of health they had not yet navigated. Several participants regularly used YouTube to view opinions on health products, learn how to manage their skin and hair, and view cooking tutorials. One participant discussed being interested in childbirth for professional and personal reasons and viewing personal accounts of birth on social media.

"I do follow a couple like natural birth things too. I am not going to get pregnant any time soon, but I do want the advice, so that's why it's interesting to me. And then, so like just looking at all of the options. Because it's like exposure and I like don't really have much experience right now, so I am getting a little bit more, but just like seeing what it actually looks (P8)"

Social support and trust on social media

For participants who did not have strong social networks, social media was a positive source:

> *"Yeah. I feel like it helps me block out the loneliness of it like I don't necessarily have to talk to anybody on social media. It's just that I know that somebody is living their life and that's going to be me." (P2)*

Generally, the participants felt that they had only limited information about others, insufficient to have an informed perspective about these individuals. Similarly, most participants felt that others they met on social media had only a fragmented picture of who they really were. This further eroded their ability to trust opinions of others. P2 discussed participating in online health forums and not connecting with the other participants:

> *"And I feel like if you can't relate to me then what's the point? You can answer my questions to some extent because you went through it and maybe your healing process was longer than mine maybe it was shorter than mine. I just feel like my healing process is taking so long and I'm just sitting here like after 17 months or still don't know what's going on I don't know if it's my stomach that's still causing me the pain… because there is nothing left down there you let me take it all. So it's like I don't understand why I still have to go to so many doctors like if I am pregnant … I am just not sure not sure about it." (P2)*

Social media as a source of inspiration in health

Just as for other areas in life, many participants looked at social media as a source of inspiration in health. Once again, this sometimes took the form of following inspirational individuals, who personified participants' ideas for health and wellness:

"I mean personally -- I mean, it's actually, I'm so inspired by people on social media like I like the idea of being very fit and people I follow I mean they all have personal trainers or are personal trainers." (P1)

At other times, inspiration was connected less to specific people, and more to specific activities. Many participants were inspired by examples of healthy living shared on social media, and felt that they could use those to improve their own lifestyles:

"It's not like, just more like an encouragement to like, okay, great. If somebody else is eating healthy like I can cook that too." (P6)

Several participants reported seeking social media posts that would inspire them to engage in healthy activities. Many subscribed to blog posts and media channels for healthy cooking, for example, looking for new recipes and new ways to eat healthfully. The participants were often drawn by simplicity of recipes that fit with their busy lifestyles and did not require extensive time commitment. Others used social media as an inspiration to try new forms of exercise. For example, P8 wished to transition from running to weightlifting but was struggling to come up with a concrete routine to try and relied on social media posts for ideas:

"Because before I was really struggling with like what am I supposed to do here at the gym? Like I'm tired of running. I don't want to just run. That's been super helpful to like give me ideas and not get burnt out of the same exact thing every time I go to the gym." (P8)
"But like when I watch those videos, at the same time like it kind of motivates me to do something because I see other people doing it and something that always like pushes me away from fitness is like I really don't know what to do. What exercises, I should do." (P18)

When talking about inspirational qualities of posts on social media, the participants often referred to images and found rich media to be inspirational. This was often the case for recipes of meals:

"And honestly just like pictures if one of them kind of looks like then I'll go with the better looking one." (P8)

For learning cooking techniques, images with instructions and short videos exposed participants to new methods, inspired them, and helped them learn how to do it.

"Sometimes I have [on social media] like farmer's market or grocery hauls and like mention cool vegetables and I'm like, I want to try that vegetable and then like, I'll look for where I can get that vegetable. And I'll learn like different like easy ways to like cook vegetables. So, like when I was younger, my mom never used the oven to cook vegetables. She always like stir-fry it. then I learned how to use the oven to cook vegetables via Instagram." (P21)

This was also the case for fitness and weight loss. Participants found the visual images and short videos useful for learning about specific exercises. Participants were also inspired by the personal weight loss and physical fitness journeys documented on social media. And for some, seeing a person who looked similar to them in these journeys further inspired them.

"So, it was like, I was just following pages of like, they had tips and tricks and it was just like a photo with, okay, it would have ten exercises on how to target something. So, like you want a small waist. That one photo will have everything. So, it was very useful in that aspect." (P18)

Participants also discussed being a health inspiration to their social media followers serendipitously or purposely. This included sharing wellness activities that they believe influenced families and friends.

"by virtue [of] having social media, you are an influencer. Even if it is private, you are influencing your friends. They find it like inspirational […] you are influencing your family, for example, to have your lifestyle or whatever. I do find like my cousins or like my parents see. Like, they got into hiking or like they are like so excited, showed me their hiking photos and it's like so cute. I am like so happy of that. They feel that that's something they can share with me like the happiness. So, I don't know if that would be the case if they didn't follow me on social media" (P3)

Discussion

In this study, we investigated attitudes, perceptions and experiences with social media overall, and, particularly, social media for personal health, among young adults. The participants in this study came from a variety of backgrounds and had different living experiences. Despite these differences, however, there were several overarching themes of findings that can provide guidance for the design of new interventions that utilize social media to help individuals improve their health. We describe these themes and their implications below.

Seeking Inspiration

Perhaps not surprisingly given their age, all participants of this study were frequent users of social media. While their engagement with social media varied in style, frequency, and intensity, one common reason the participants used social media was to seek inspiration. Often, this involved seeking out inspirational individuals who either had qualities the participants valued, or who engaged in activities the participants found exciting. Even more commonly, however, this included actively searching for new ideas that can both inspire and inform their own choices and behaviors. This varied from personal style, such as choosing new hair color and make up, to new ideas for business, and to new places to visit. Social media was also a common source of inspiration for healthy activities, specifically regarding diet and exercise. While most

participants were generally skeptical of social media as a source of reliable health information and preferred experts and credible media outlets, all participants without exception, used social media to look up new recipes and new ways to cook healthy meals. Most also relied on social media to find new exercise routines. Most participants considered both of these activities, cooking and exercise, relatively risk-free, and were happy to try new ideas, even if these ideas came from less than credible sources. There were, however, several characteristics that the participants pointed out as catching their attention. One recurring theme was simplicity, particularly in regard to meals and cooking; given their busy lifestyles that required balancing school and work, and constrained living situations, most participants gravitated towards simple recipes with few ingredients that took little time to prepare. Another important characteristic was authenticity; the participants were quick to point out that commercial aspirations were a common turn off. Instead, they valued individuals who appeared authentic and genuine in their strive to help others. Finally, in both of these domains, visual media played an important role in helping the participants identify content they could connect with.

Light-weight positive engagement

While all participants of the study had considerable experience with social media, most more readily described themselves as consumers rather than producers of new content. Furthermore, even those who regularly posted on social media appeared concerned about imposing on others. Most participants made negative comments about self-promotion and narcissism when others' posts focused excessively on themselves, for example those who frequently posted selfies. Similarly, many participants were negative about posts that appeared to seek empathy. Overall, most felt that there was enough drama in real life and in their relationships with people around them and were actively avoiding negativity on social media,

often choosing to block individuals rather than to face direct confrontation. Those who posted their own content were careful to make sure it was brief, for example, shortening descriptions of images and was worthy of sharing, such as including special, out of the ordinary experiences, locations, and meals. Most felt that there was already too much content on social media and that any additions need to be judicious and respectful of others.

Implications for Design

Combined, these two conclusions suggest several new directions for the design of health interventions for young adults that utilize social media.

First, they suggest the need for technologies that can mix virtual and in-person experiences in the context of health and wellness. There already exist many interventions that help friends and acquaintances share their fitness experiences, such as the Facebook group for runners described by one participant in our study. However, new directions for these interventions could include techniques for expanding social circles through social matching and introduction. These mechanisms were previously explored in the context of dating applications, but less so in technologies for health and wellness.

Second, new social media interventions for health could help individuals filter through the incredible volume of already available content to help identify content that matches their interests, preferences, and needs. Current social media platforms are already applying machine learning techniques to learn individuals' preferences from their browsing history. However, commercial platforms may not necessarily focus on individuals' personal interests, and instead focus on promoting sponsored content. User-driven and user-centric approaches can help to balance user interests with those of commercial engines.

Finally, new interventions could leverage the potential of visual media shared on social media to inspire individuals to engage in healthy behaviors. Many participants of this study found images posted by others to be inspirational. However, the study also showed that there may be considerable variability in what inspires different individuals and what images they find inspirational. In the third aim of this dissertation, I specifically focus on investigating the potential of machine learning methods to learn individuals' preferences for inspirational images in health.

Chapter 5: Aim 3: Explore the feasibility of using a machine learning approach to identify inspiring health-related social media images for young populations

5.1 Introduction

Nutrition interventions introduced thus far, often made the assumption that nutritional decisions are rational and controlled. As a result, social media interventions have targeted nutritional intentions such as goal setting and self-monitoring (Chau, Burgermaster, and Mamykina, 2018; Cullen, Baranowski, and Smith, 2001; Shilts, Horowitz, and Townsend, 2004; White and Skinner, 1988). However, individuals often fail to successfully translate goals into actions (Gollwitzer, 1999) and health tracking applications are frequently abandoned (Clawson et al., 2015). Other research indicates that in the absence of motivation and time to process information, nutrition choices are often automatic and based on heuristics (Cohen and Babey, 2012). Thus, in this Aim, we approach the problem from the perspective of dual process theory. The theory suggests that nutritional decision making can take two forms: rationalist approaches that are slow and entail careful consideration of choices and consequences, and fast, in-the-moment, approaches during which decisions are based on heuristics.

First, we propose that social media images are well-suited to provide short, inspirational, and informational messages that use heuristics to promote healthy lifestyle choices. The use of imagery is commonly used in health communication strategies to motivate behaviors (Cameron and Chan, 2008). These appear in social marketing campaigns that are carefully crafted by health communicators. Of late, social media is emerging as a new source of health imagery. Young adults use social media for inspirational content, to learn about new foods, and to find

instructions for learning health routines (Vaterlaus et al., 2015). The Aim 2 results further supports this idea with the finding that adolescents and young adults frequently use image-based social media for inspiration. Previous studies have explored inspirational social media content using qualitative and manual methods (Simpson and Mazzeo, 2017). However, advances in deep learning provide automated methods to examine multimedia images.

Computer vision methods take on the tasks of identifying image attributes defined as any kind of feature, component, or property of a stimulus that can be represented by an information processing system (Medin and Barsalou, 1987). Operationalizing image characteristics usually entails understanding image content at two levels: conceptual and visual (Hollink et al., 2004; Jörgensen, 1998). At the conceptual level, there can be people, objects, attributes of and relationships among them. Visual level characteristics include qualities such as colors, shapes, textures, composition and techniques. Together these can be used to infer people, objects, activities, and scenery within images. Previous methods relied on hand-crafting features using rules for classification to identify such features (Brachmann and Redies, 2017). However, the advent of convolutional neural networks has made possible state-of-the-art performance on image classification tasks automatically (Krizhevsky, Sutskever, and Hinton, 2012). Convolutional neural networks (CNNs) are a class of deep learning methods often used for computer vision tasks. Deep convolutional neural networks have multiple layers that integrate the low, medium, and high level features of images to make inferences for classification. The use of transfer learning has further facilitated the task. Transfer learning takes knowledge learned from training a machine learning algorithm in one domain and applies it to another domain. This reduces the computational resources and size of annotated datasets needed to perform accurate classifications with deep learning algorithms (Razavian et al., 2014; Yosinski et al., 2014).

Transfer learning using CNNs pre-trained on ImageNet are successfully being used in the health field with medical imaging (Bar et al., 2015; Ribeiro et al., 2017; Shin et al., 2016) and social media (Borth et al., 2013; Hsu et al., 2017; You et al., 2015; Zhao et al., 2018b).

Beyond identifying physical features within images, researchers are working to identify the affect, emotion, or sentiment evoked when viewing them (Machajdik and Hanbury, 2010; Shin and Kim, 2010; Wang and He, 2008). In health promotion, images are designed to appeal to the ”affect heuristic” where emotional reactions determine the impact on perceptions of risk and motivations to protect against them (Cameron and Chan, 2008). Similarly, models like the Behavioral Affective Associations Model explain that affective associations can influence behavior by mediating the distal effects of social cognitive factors and by directly motivating behavior (Kiviniemi, 2018). Appeals to emotion have a long history of use in the field of persuasive health messaging. Invoking fear is often used to communicate risks and negative consequences (Witte, Meyer, and Martell, 2001). More positive messaging has employed mechanisms of humor, empathy, and sexual appeal. Irony is particularly appealing to younger people (Hastings, Stead, and Webb, 2004). And lastly, role models and empowerment are examples of emotions meant to inspire (Witte, Meyer, and Martell, 2001).

The emotions of images are highly subjective and thus a challenging task for classification and retrieval. Whereas content image retrieval relies on detecting objects, emotions evoked may not be able to rely on associations with objects in images. Though visual aspects of images are evoking emotions, what specific quality is unclear and can vary from person to person. Efforts to detect emotions of images have created ontologies to link emotions to adjective-noun pairs in images to bridge the gap between visual content and affect (Borth et al., 2013). Other work has attempted to associate low level image features with emotions using

neural networks (Joshi et al., 2011). The application of these techniques of detecting sentiment for health and specifically to identifying health promotional images for nutrition and young populations is underexplored.

In this aim, I explore the feasibility of using a machine learning approach to identify inspirational social media images for young adults. Using a convolutional neural network pre-trained on ImageNet, this study attempts to classify social media images labeled as inspirational for health based on annotations from young adults. The study answers the following research question:

RQ1 Can a machine learning approach effectively predict images labeled by young adults as inspirational for health?

5.2 Methods

In this study, I explored the use of CNN transfer learning from ImageNet to health-related social media images.

Health-related Social Media Image Dataset

The dataset consists of 600 social media images labeled by young adults as inspirational for health. These image annotations were collected using Qualtrics surveys. Survey respondents were recruited from the sample of young adults aged 18-27 from Aim 2c who gave permission to be contacted for further research studies in their informed consent forms. These respondents were chosen because they reported using social media for health and wellness and submitted a list of public social media accounts with health-related images they follow. The Columbia University Medical Center Institutional Review Board approved this study.

In this research, we differentiate between inspirational and non-inspirational images for health. Each young adult participant completed a survey with 100 images from health-related social media accounts available publicly. We chose to include 100 images because of practical considerations for annotation. Although, we wanted to annotate a large number of images we also wanted to limit survey fatigue.

Image Selection Process

In the previous study Aim 2c, each participant submitted a list of health-related accounts they follow on social media. For each participant, the 100 images were selected from their own list of social media accounts. Images were selected from each account so that each account contributed a similar proportion of images to the set of 100. The appropriate number of images were selected from these accounts at random. For example, if a participant submitted 4 accounts, 25 images were selected from each account. Types of images included foods/meals; physical activity and fitness; nature/landscape/travel photos; and inspirational quotes.

Image Survey

Within the survey, participants were shown an image and were asked the following questions:

1) Do you like this image? (Yes/No)

2) Does this image inspire you to engage in healthy activities and behaviors? (Yes/No)

3) Why or why not? Please list specific things (people/objects/activities) in the image or visual qualities (colors/style/composition/quality) of the image that led you to the previous answer. (Free text)

The first two questions were asked to help the participant differentiate between liking the photo and finding it inspiring for health; we wanted to ensure participants didn't just like the image but found it inspiring. The last question was asked to better understand why the image appealed to

the young adults. Each image was given a label of inspirational+ or inspirational- based on the answer to the second question.

Convolutional Neural Net Transfer Learning

This section provides details on how transfer learning was applied to our dataset of social media images.

Convolutional Neural Network Architecture

In this research, I used ResNet as a base CNN for our machine learning classifier. Resnet is a CNN developed by Microsoft Research that first appeared in 2015 winning first place in the ImageNet Large Scale Visual Recognition Challenge competition (He et al., 2015). Its innovation lies in its use of ”identity shortcut connections” to create residual blocks that allow deeper layers than previous CNNs. Figure 5.1 shows the architectures of ResNet50 which consists of a deep convolutional neural network with small filters (3×3), grouped convolutional layers followed with no pooling in between, and an average pooling at the end of the feature detector part of the model prior to the fully connected output layer with a SoftMax activation function.

Figure 5.1: Resnet50 architecture (He et al 2015)

layer name	output size	50-layer
conv1	112x112	7x7, 64 stride 2 3x3 max pool, stride 2
conv2.x	56x56	[1x1, 64 3x3, 64 1x1, 256] x 3
conv3.x	28x28	[1x1, 128 3x3, 128 1x1, 512] x 4
conv4.x	14x14	[1x1, 256 3x3, 256 1x1, 1024] x 6
conv5.x	7x7	[1x1, 512 3x3, 512 1x1, 2048] x 3
	1x1	average pool, 1000-d fc, softmax
FLOPs		3.8×10^9

ImageNet dataset

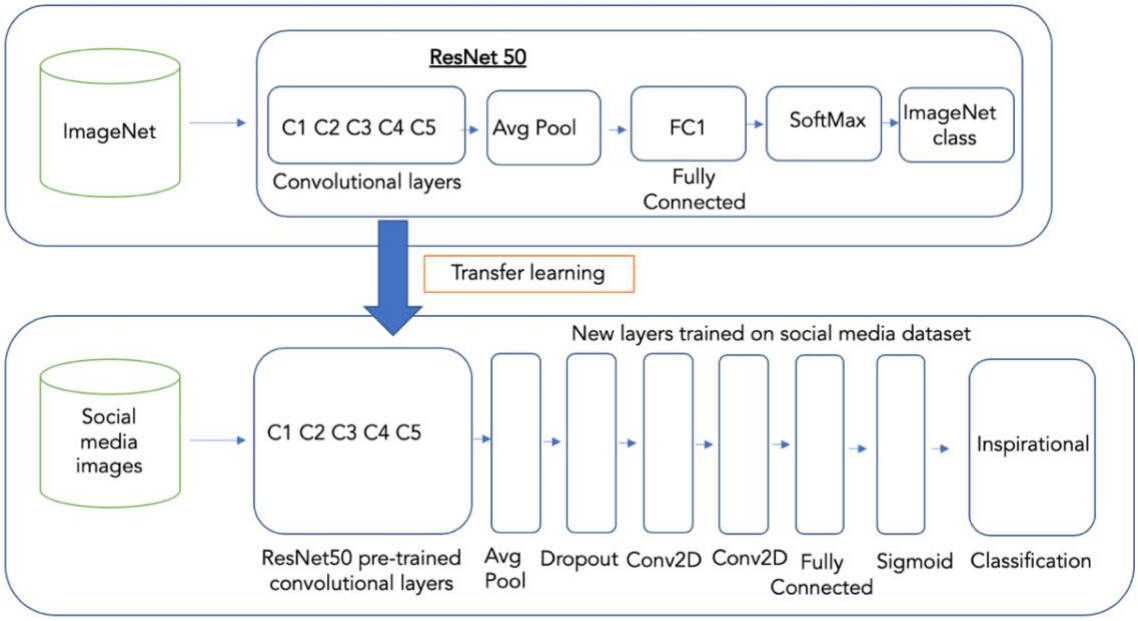
Developed by Fei-Fei Li of Stanford, ImageNet is a database of over 14 million third-party images that is widely used in the computer vision community for training deep learning algorithms (Deng et al, 2009). The images are sourced from Flickr and other social media sites. Images include objects that are labeled and organized according to the WordNet hierarchy and synonym groups called synsets (Princeton University, 2010). ImageNet contains images from over 20,000 categories or synsets of images. Although WordNet's lexical database includes nouns, adjectives, and verbs, ImageNet includes nouns only. Examples of the types of objects represented in ImageNet include animals, insects, plants, vehicles, furniture, tools, and other man-made artifacts. Specifically relevant for our task of health-related images, synsets include component included in physical activity and nutrition-related images. These include landscapes (urban and natural), foods, cookware, cutlery, and athletic equipment. Images are manually annotated with the objects they contain and with bounding boxes for localization. PyTorch makes widely available CNNs pre-trained on ImageNet.

5.3 Experiment and Results

In this study, I used ResNet50 as a fixed feature extractor and no fine-tuning as the base of a classifier to predict health-inspirational images in a health-related social media dataset (Yosinski et al., 2014). This particular method is appropriate given the small dataset size and its similarity to the ImageNet images which are also images from social media (Razavian et al., 2014). As such, ResNet50 is initialized using the parameters learned from the ImageNet ILSVRC challenge data for 1,000 classes. The last fully connected layer is removed to accommodate the change from 1,000 classes to our classification scheme of being inspirational

or not. A dropout layer is added along with two additional convolutional layers. A last fully connected linear layer was added along with a Sigmoid output classifier. Training loss is computed using binary cross entropy loss. Figure 5.2 presents this final architecture.

Figure 5.2: Full architecture using Resnet50



One classifier was trained on the global set of 600 images from all participants. The dataset includes 243 (40%) inspirational images and 357 (60%) not inspirational images. To verify the performance of the proposed method, the dataset was split into training, validation, and test sets by random selection. Therefore, we have 92 for each validation and test samples and 419 training samples.

Training was performed on batches of 4 images each, which were randomly chosen from the training data for each iteration, resized to 224 x 224 x 3, and subsequently augmented. RMS Prop with weight decay (λ=0.1) and momentum (μ=0.5) was used for the training of the models. Training was performed for 10,000 iterations with a learning rate of 0.00005. A range of learning rates were tested from 0.01 to 0.000001. A baseline classifier was created for comparison using

L1 logistic regression. The majority classifier was also calculated. The metrics of the performance comparison are precision, recall, AUC-ROC, and F1.

Table 5.1 shows the results of the evaluation of the pre-trained ResNet50 base classifier compared to the baseline L1 logistic regression. Precision, recall, ROC AUC and F1 scores performed well with the training and validation sets. However, in the test set, using the classifier with ResNet50 were all below 50%— 44%, 44%, 47%, and 41% respectively. The final accuracy calculation in the test set was 60% which is an improvement over the baseline L1 logistic regression. However, not shown in this table is the second baseline— the majority classifier with an accuracy of 60%. The ResNet 50 pretrained classifier did not perform better than this second baseline.

Table 5.1: Evaluation on Training, Test, and Validation Sets

Model	Set	Precision	Recall	ROC AUC	Accuracy	F1
Pretrained ResNet50	Train	0.56	0.57	0.70	0.72	0.63
	Validation	0.56	0.61	0.69	0.71	0.64
	Test	0.44	0.44	0.57	0.60	0.47
L1 Logistic (baseline)	Train	0.42	0.53	0.53	0.53	0.48
	Validation	0.42	0.53	0.53	0.53	0.48
	Test	0.39	0.47	0.47	0.47	0.41

Figure 5.3: Confusion Matrix for Test Set

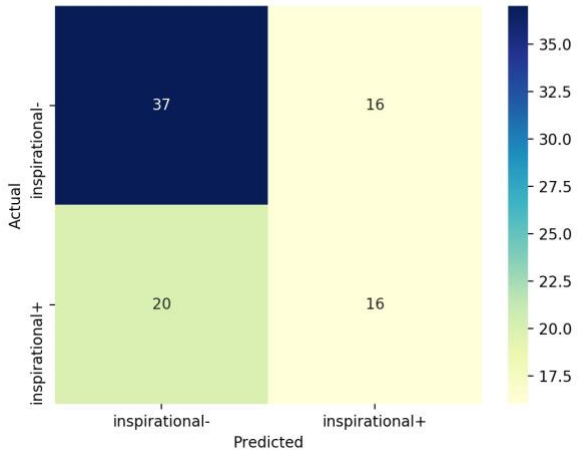


Figure 5.3 shows the confusion matrix for the test set images. The matrix shows the number of images classified as: true positives (16); true negatives (37); false positives (16); and false negatives (20).

A qualitative examination of the misclassified images shows notable differences in patterns of objects and actions visible when comparing false negatives and false positives. Within the false negatives, images contained motionless objects and people. These included physical objects (watches, sneakers, map), people standing stationary in natural surroundings (mountains, beaches, jungles, trees); and a gorilla sitting. Types of food-related images included two images of bowls of healthy food and infographics with an image of a food (beans, chicken breast, and bread) along with nutrition information. Also included were inspirational quotes of black and white text alone. With the false positive images, the majority included people engaging actively in physical activities (running, yoga, weightlifting); a close up of a person's sneakers while running; the winner's circle of a professional road race. Of the remaining images, two were of women standing stationary, one in front of a landmark the Eiffel Tower; and two were memes with images and text.

Among the images correctly classified, there were also noticeable patterns. Among the true positives, all but two of the images with people showed individuals engaged in sports (running, basketball, weightlifting, football); the remaining two were of a woman in swimsuit/athletic wear. The two other images were memes (black and white text; pop culture). Among the true negatives, only two images included physical activity (running). The remainder were landscapes, stationary people posing, animals, and insects. Several food photos included desserts (cookies and pastries), waffles, and hotdogs.

5.4 Discussion

In this study, I explored the use of transfer learning with a pre-trained ResNet50 CNN-based classifier to predict images that are health-inspirational for young adults. The experiment

showed that transfer learning may have potential to extract relevant features and indeed outperformed the baseline L1 logistic regression; however, its accuracy on the test set was not above the majority classifier baseline.

Within the experiment, the pre-trained ResNet50-based classifier showed some promise that relevant features could be identified for the classification task. Compared to the baseline L1 logistic regression, the pre-trained classifier performed better on nearly all metrics evaluated particularly with the training and validation sets. Evaluation metrics on the test set however were significantly worse suggesting the CNN did not have good generalization capabilities.

The qualitative assessment of the misclassified images showed some promise for future classifiers. In reviewing the types of images that were inappropriately classified, it appears that images that were falsely classified were similar to true cases. Moreover, the content seemed to logically fit into the categories in which they were falsely classified. Regarding images for physical activity, in both the false positives and true positives, were images of people actively engaging in sports and exercise. Similarly, images that were classified as false negatives were similar to the true negatives in that they included mostly people posing for photos. Regarding food categorizations, true negatives appeared to include less healthy foods such as desserts, sweet breakfast items, and fast food. However, the classifier misclassified several more healthful foods and nutrition-related images as not inspirational. These findings further reiterate that inspiration is a highly nuanced concept, and that further research is needed to distinguish inspirational and non-inspirational images within the same domains and with the same objects.

This study had several limitations. Most notably, the model may have been hindered by the lack of data. Our dataset included 600 images of a heterogenous nature. The images were varied in the types of people, objects, and scenery included. There were diverse types of people

in terms of gender, race/ethnicity, and body types. Objects ranged from watches to exercise equipment to home furnishings. Food in various forms were also included ranging from desserts, snacks to full meals. Although transfer learning reduces the number of images needed to train a classifier for a task, more homogenous data may be needed with such few images.

I propose that future work in this area can develop along several directions. First, it can attempt to replicate the approach taken in this aim with a larger and more homogeneous dataset. In medical imaging studies using transfer learning, studies with similarly small dataset sizes included images of one type (e.g. chest x-rays) (Bar et al., 2015). In studies predicting sentiment and likes of social media images that were similarly diverse, the training data included from 300,000 to over 1 million images (Borth et al., 2013; Hsu et al., 2017; You et al., 2015; Zhao et al., 2018b). Furthermore, future work can augment the classifier with different types of data besides images alone. In previous studies, multi-modal approaches used not only images but included other related data. These included meta-data from posts (user who posted, counts of comments/users ragged/views, dates, length of title/comments, location), social information (similarity of users who like images), and temporal information (Hsu et al., 2017; Zhao et al., 2018b). Further, these classifiers were more complex in architecture including multiple CNNs and/or other types of machine learning classifiers in conjunction with CNNs (Hsu et al., 2017; You et al., 2015; Zhao et al., 2018b).

Another potential direction for future work is to take a more personalized approach and include more information about the individuals annotating the images. Assuming health inspiration is highly subjective, more information about the person would be useful for classification. This could include demographic information about the individual and health-

related activities and food preferences. Social network information about the annotators could also be included.

Lastly, the classifier may require a greater degree of pre-training or additional classifiers included in the architecture. There exist several labeled image sentiment datasets that do not include health inspiration but may be useful for adding another level of pre-training that can recognize other sentiments.

Furthermore, there are other categories of pre-trained classifiers that may also be leveraged. Our data set included images in the categories of physical activity, food, landscapes/cityscapes, and images with text. Incorporating classifiers and/or training on data that can recognize key features within these categories may improve classification. For images with humans, there are CNN classifiers for action classification (e.g. walking, running, horseback riding), facial emotions, age, and gender. For landscapes/locations, classifiers exist for indoor/outdoor, landmarks, and land features. There are classifiers for food that can be used. And lastly, one can incorporate methods to read the text in images and leverage that information for use.

Chapter 6: Conclusions

In this final chapter, I summarize the research in this dissertation, discuss its contributions and limitations, and conclude with future work.

6.1 Summary of Work

This dissertation investigated how social media is being leveraged for nutrition behaviors and interventions among adolescents and young adults. This research uses three broad approaches by exploring: 1) their attitudes, behaviors, and contexts around healthy eating and nutrition; 2) how adolescents and young adults are using social media for health and wellness; and 3) methods for using social media within nutrition interventions targeting these groups.

Aim 1

In Aim 1, I explored how social media is currently being used in nutrition informatics interventions for adolescents and young adults. To accomplish this goal, I conducted a systematic review of nutrition interventions that used social media. I identified technological features included in the interventions and evaluated the evidence regarding their efficacy. Interventions leveraged existing social networking platforms and homegrown social media in the form of blogs, discussion boards, and messaging. Social media in the interventions were used to facilitate communications, to share content, and to support activities such as self-tracking and gamification. Additionally, the interventions had multiple components beyond social media. None assessed the efficacy of its social media component individually. However, the majority of studies had significant nutrition-related outcomes suggesting social media may be valuable for delivering interventions for adolescents and young adults.

Overall the results of this aim showed there is potential for social media to improve nutrition behaviors and outcomes among adolescents and young adults. The use of social media

is in its infancy with few researchers employing this feature. Moreover, the social media that is being included is more traditional in format and/or utilizes older, established social networks. This leaves opportunities in the informatics intervention design space for newer, more innovative social media formats. Lastly, with evidence of intervention efficacy, social media has potential to be efficacious in improving nutrition behaviors and outcomes.

Aim 2

In Aim 2, I explored adolescents' and young adults' attitudes, behaviors, contexts, and use of technology and social media for healthy eating. The goal of this aim was to develop an empirical understanding of adolescents' and young adults' lives and perspectives to inform the design of informatics interventions. I investigated these topics in three studies with two groups of adolescents and young adults: 1) those currently living with a chronic disease—pediatric cancer survivors and 2) healthy young adults. In the first sub-aim, I conducted an exploratory study to understand motivations, behaviors and barriers to healthy eating among pediatric cancer survivors. In the second sub-aim, I used an informatics intervention as a probe to understand the needs of adolescents and young adults in using technologies for healthy eating in real world settings. In the third sub-aim, I conducted a mixed methods study to understand the use of social media for health and wellness among a group of diverse, healthy young adults.

In the first sub-aim, I identified several influences and behaviors around nutrition among pediatric cancer survivors in a set of focus groups. I found that pediatric cancer survivors had an in-depth understanding of personal health. Many participants were in the process of discovering healthy eating routines; simple routines were preferred. Information from trusted sources was paramount.

In terms of behaviors, social environments shaped nutrition choices. Participants had multiple levels of influence that affected their food choices, nutrition, and health. The analysis identified intrinsic (e.g. motivation and time management) and extrinsic (limited availability) barriers to healthy eating. In terms of using technology for nutrition, none used tracking applications but social media was used as a source of inspiration and ideas. These results were used to inform the design of the informatics application in the second study.

In the second sub-aim, I conducted a pilot study with 19 pediatric cancer survivors using an informatics application—Mealyzer—over a period of five weeks. Mealyzer was a user-friendly application but, it was used inconsistently. Results on its impact on meal nutrition outcomes were mixed. Quantitative results showed potential upward trends in goal accuracy but not in goal attainment. Qualitative results from seven participants interviewed highlighted mostly positive perceptions of features. The logging and meal evaluation process led to reportedly increased reflection on nutrition. The simple dietitian feedback was effective for simple meals but not adequate for complex meals. Feedback from a professional was highly valued and cited as the best feature. However, participants wanted more interaction with the dietitian to answer remaining questions or more direct ways to understand nutrition of meals. On the contrary, the social media-like feed of user meals garnered little attention. The dietitian-selected content was inadequate in quantity and quality. And generally, participants expressed little interest in the users they did not know. Participants, however, shared meals on other social media applications. This suggests that there is an interest in social media but with participants' own networks.
In terms of behaviors, influences, and contexts, the qualitative analysis uncovered findings consistent with the first sub-aim and new ones. This group of pediatric cancer survivors reported similar health sensibilities and influences and barriers to healthy eating. Similarly, time played a

large role in nutrition decisions. The adolescents and young adults managed full schedules and time available dictated food choices. Dual process theory aptly describes this process of making fast, intuitive food decisions with little time available and making slow, reflective decisions with ample time. As a result, health tracking was not feasible for their on the go lifestyles.

In the last study in Aim 2, I examined the health-related attitudes, behaviors, and social media use among a group of 25 healthy young adults. Unlike the pediatric cancer survivors, none of the participants reported high risks for chronic diseases. Young adults had varied backgrounds in terms of socioeconomic backgrounds, race/ethnicity, education, and employment experiences. Their diverse backgrounds and experiences shaped their views on health and the choices they made in different ways. We found perspectives on personal health were highly subjective. ”Being healthy” included unique combinations of healthy eating, physical activity, rest, and mental health. Similar to the pediatric cancer survivors, these young adults led hectic lives. For nearly all of them, achieving an optimal balance was key to being healthy.

In terms of general social media usages, we found young adults used a variety of social media platforms. They used them for communicating with friends, finding information, self-promotion, affirmation of identity and inspiration. Use of a platform was dependent on the specific affordances of the platform or the network of people using it. Most consumed social media content rather than producing it. Participants viewed social media as a positive and entertaining media source seeking out authenticity in user accounts and controlling their content to ensure this.

In terms of use of social media for health, social media was not considered a source for high quality, scientific information. Young adults relied on clinicians for personal health issues and disease diagnosis. Instead, social media was often used as a source of visual inspiration to

users. Instagram and YouTube were popular platforms for seeking health inspiration. It was used to find ideas on health and wellness (cooking, exercise, beauty, and self-care) where there was few risks to following the advice. Social media was used as a source of positivity specifically as sources of humor, positive mental well-being, body image, and inspiration for health improvements. Similar to findings from the previous studies, participants followed users who inspired them with their personal style, life stories, and aesthetically pleasing content.

Overall, the results of Aim 2 showed similar cross-cutting themes. Adolescents and young adults across studies had a keen awareness of health and attempted to forge healthy lifestyles in their own personal ways. Both across and within the pediatric cancer groups and the healthy young adults, there was a diversity of individual preferences and multi-level influences on choices. Participant lived fast-paced lifestyles and wanted simple, uncomplicated ways to be healthy. Health tracking was too burdensome for adolescents and young adults. The results also showed that adolescents and young adults are keen consumers of health information on the internet. In terms of medical information, participants prized trusted professional information and evaluations over social media. Instead, social media was preferred for more lightweight health topics such as physical activity, cooking, and self-care. They preferred visual media on these topics. Adolescents and young adults used social media to share food experiences and learn from others. However, they preferred to have control over the people and types of content included.

Aim 3

In Aim 3, I explored the feasibility of using a machine learning method to identify health-inspirational images from social media for young adults. Based on the findings from Aims 1 and 2, I decided to focus specifically on visual content from social media. To accomplish this goal, I

explored the use of transfer learning using a convolutional neural network with a base CNN pretrained on ImageNet. The classifier was trained on a dataset of 600 social media images labeled by young adults as inspirational for health. A majority classifier and L1 logistic regression were used as base classifiers for comparison. The CNN outperformed the L1 logistic regression in measures of recall, ROC AUC score, F1 score, and accuracy. However it did not perform better on precision. The CNN did not outperform the majority classifier on accuracy. A qualitative examination of misclassified and accurately images found reasonable patterns of similarities.

The results of Aim 3 showed there is potential for transfer learning methods using CNNs to be able to classify social media images as inspirational for health.

6.2 Contributions

The research in this dissertation is a novel contribution to understanding the use of social media for nutrition-related behaviors and interventions for a specific demographic group---adolescents and young adults. The contribution of this research includes: 1) a comprehensive overview of the current use of social media in nutrition interventions for adolescents and young adults; 2) an empirical investigation into the nutrition-related behaviors and needs of young adults and adolescents with and without chronic diseases; 3) an empirical investigation into the current use of social media for health and wellness among healthy young adults; and 4) an evaluation of the feasibility of using a novel machine learning method to identify health inspiration within image-based social media.

Aim 1 provides a comprehensive inventory of nutrition informatics interventions with social media for adolescents and young adults. My review was the first to focus on informatics interventions for nutrition, social media, and both adolescents and young adults. My research

comprehensively identified types of social media features being used and provided evidence that social media is a promising feature in nutrition interventions for these groups.

Aim 2 provides in-depth empirical investigations into the health-related behaviors, social contexts, and use of social media and technology among adolescents and young adults. The results provided insight into the individual and social determinants of nutrition-related behaviors for adolescents and young adults with and without chronic diseases. It further elucidates the nutrition-related decision making processes of adolescents and young adults. This research also provides more granular knowledge on how young adults are using social media for health and wellness. These topics have not been investigated deeply in the biomedical informatics community.

Lastly, Aim 3 provides an evaluation of a novel machine learning method to identify health inspirational social media images. This study is the first to apply transfer learning and convolutional neural networks to examine health inspiration in social media images.

6.3 Limitations

The research in this dissertation has several limitations. First, there are limitations in the settings of this research. The studies were conducted with pediatric cancer patients at a large academic institution and adolescents and young adults living in a large, urban city. Thus, our findings may not be generalizable to other institutions or geographic areas. Second, Aim 2 studies limited by small sample sizes. For the Aim 2 quantitative analyses, statistical power was limited. For the qualitative studies, the experiences of individuals in these studies may not generalize to others in different settings. Additionally, deeper analysis by demographics was not feasible. Further with qualitative studies, the coding and analyses may be subject to bias. For the qualitative studies in Aim 2, there were multiple coders for each study. However there may be

subjectivity in researchers' interpretations of participants' responses. Lastly for Aim 3, the dataset available was small in size and no additional data sources were used. Although the use of transfer learning can overcome the limitations of small sample sizes, it nonetheless may have been sufficient to effectively train the neural network.

6.4 Future work

This dissertation research work can be expanded in several ways. First, this dissertation characterized the landscape of social media features included in nutrition interventions. Aim 1 identified potential evidence for the efficacy of social media. However, this research found that most nutrition interventions were multi-component and the efficacy of social media itself is unknown. More research is needed into understanding the efficacy of social media in nutrition interventions. Future implementation research should include an evaluation of the social media feature itself.

Second, future research can explore different types of social media for use in interventions. Aim 1 found that with few exceptions, social media interventions were limited to discussion boards and blogs. Future research can identify a broader group of social media features appropriate for implementation in interventions. For example, this research identified an interest in visual medium including images and videos that could be leveraged for behavior change.

Additionally, more research is needed to identify preferences for social media interactions. Our participants were a diverse group preferring a range of social media from visual to text-based Twitter-like to video game networking communities. Identifying the archetypes or characteristics of adolescents and young adults that prefer different types of social media is needed to better tailor interventions. Further research can examine more in-depth the specific

aspects of each medium that are appealing to aid in the design of social media for health. This research identified preferences for sharing within own social media circles versus to the public more generally. Research can explore qualitatively these aspects of preferences for health and social media.

Future research can explore design needs specific to demographic groups. The research studies in this dissertation, overall, included diverse groups of adolescents and young adults from varying socioeconomic backgrounds, ages, and race/ethnicities. However, the analyses focused on overall patterns and themes rather than by subgroups. In Aim 2c, there appeared to be differences in social media platforms usage by age and race/ethnicity which can be further explored. More focused research can be done on specific demographic groups, and what is important to understand for social media design and how much overlap there is by characteristics.

Lastly, this dissertation identified a new area of research in identifying health-related inspiration within social media images. Further research can work to identify the specific aspects of images that appeal to participants. A deeper understanding of types of health inspiration is needed to understand the linkages between the visual sentiment of an image and how it's linked to specific content or visual aspects of images that are inspirational This can be accomplished qualitatively with adolescents and young adults. This can explore universal appeal versus appeal to specific groups of individuals. Further greater disaggregation by demographic or other relevant subgroup may be necessary to fully understand the breadth of health inspiration and how an individuals' characteristics relate to the specific combinations of inspiration they choose. This information can then be leveraged for intervention development. Alternatively, more research can be done using machine learning to identify images that inspire healthy behaviors.

This research can focus specifically on nutrition. However, physical fitness and mental health were identified as areas of interest on social media that could be explored as well. This research shows potential for the use of transfer learning into identifying health inspirational images. Further research can explore incorporating more and different types of data into machine learning models.

6.5 Conclusions

Social media is a promising feature in nutrition interventions for adolescents and young adults. The goal of this dissertation was to develop a better understanding of how social media is used for nutrition interventions and to gain a better understanding of nutrition-related decision-making processes, contexts, and social media use among adolescents and young adults. The studies in this dissertation found that adolescents and young adults are engaged with social media and use it for health-related reasons. Nutrition interventions are beginning to use social media. But, there is a lot of room for designing engaging social media applications for adolescents and young adults. More specifically, using visual-based social media images, which may be more well suited for their lifestyles, may be a promising area to investigate. Deep learning methods can aid in the development of identifying images appropriate for health interventions. In conclusion, this dissertation outlines the characteristics of social media being used it interventions, the behaviors, attitudes, and contexts of nutrition decisions, how social media is being used for health, and a potential new method to explore using image-based social media for health inspiration.

Bibliography

Abbar, Sofiane, Yelena Mejova, and Ingmar Weber (2015). "You Tweet What You Eat: Studying Food Consumption Through Twitter." In: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. CHI '15. New York, NY, USA: ACM,pp. 3197–3206. ISBN: 978-1-4503-3145-6. DOI: 10.1145/2702123.2702153. URL: http://doi.acm.org/10.1145/2702123.2702153.

Ajie, Whitney N. and Karen M. Chapman-Novakofski (June 2014). "Impact of computer-mediated, obesity-related nutrition education interventions for adolescents: a systematic review." eng. In: The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine 54.6. 00004 PMID: 24534357, pp. 631–645. ISSN: 1879-1972. DOI: 10.1016/j.jadohealth.2013.12.019.

Alhabash, S., McAlister, A. R., Quilliam, E. T., Richards, J. I., & Lou, C. (2015). Alcohol's getting a bit more social: When alcohol marketing messages on Facebook increase young adults' intentions to imbibe. Mass Communication and Society, 18(3), 350-375.

Ali, Kathina et al. (June 2015). "Online Peer-to-Peer Support for Young People With Mental Health Problems: A Systematic Review." eng. In: *JMIR mental health* 2.2, e19. ISSN: 2368-7959 2368-7959. DOI: 10.2196/mental.4418.

Ali, M.M., A. Amialchuk, and F.W. Heiland (2011). "Weight-related behavior among adolescents: The role of peer effects." In: *PLoS ONE* 6.6. ISSN: 1932-6203. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L362012911.

Allman-Farinelli, Margaret et al. (2016). "A Mobile Health Lifestyle Program for Prevention of Weight Gain in Young Adults (TXT2BFiT): Nine-Month Outcomes of a Randomized Controlled Trial." eng. In: *JMIR mHealth and uHealth* 4.2, e78. ISSN: 2291-5222. DOI: 10.2196/mhealth.5768.

An, Lawrence C. et al. (2013). "A randomized trial of an avatar-hosted multiple behavior change intervention for young adult smokers." In: *J Natl Cancer Inst Monogr* 2013.47, pp. 209–215. DOI: 10.1093/jncimonographs/lgt021.

Anderson, E., Buchko, A., & J. Buchko, K. (2016). Giving negative feedback to Millennials: How can managers criticize the "most praised" generation. Management Research Review, 39, 692–705. https://doi.org/10.1108/MRR-05-2015-0118

Anderson, M and Jiang, J. (May 2018). *Teens, Social Media & Technology 2018*. en-US. URL: http://www.pewinternet.org/2018/05/31/teens-social-media- technology-2018/ (visited on 07/11/2018).

Bae, S., Chung, T., Ferreira, D., Dey, A. K., & Suffoletto, B. (2018). Mobile phone sensors and supervised machine learning to identify alcohol use events in young adults: Implications for just-

in-time adaptive interventions. Addictive Behaviors, 83, 42–47. https://doi.org/10.1016/j.addbeh.2017.11.039

Bandura, Albert (July 1998). “Health promotion from the perspective of social cognitive theory.” In: *Psychology & Health* 13.4. Publisher: Routledge _eprint: https://doi.org/10.1080/08870449808407422, pp. 623–649. ISSN: 0887-0446. DOI: 10.1080/08870449808407422. URL: https://doi.org/10.1080/08870449808407422 (visited on 04/19/2020).

Bandura, Albert (1999). “Social Cognitive Theory: An Agentic Perspective.” en. In: *Asian Journal of Social Psychology* 2.1, pp. 21–41. ISSN: 1467-839X. DOI: 10.1111/1467-839X.00024. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/1467-839X.00024 (visited on 02/14/2019).

— (Aug. 2001). “Social Cognitive Theory of Mass Communication.” In: *Media Psychology* 3.3, pp. 265–299. ISSN: 1521-3269. DOI: 10.1207/S1532785XMEP0303_03. URL: http://dx.doi.org/10.1207/S1532785XMEP0303_03 (visited on 02/17/2016).

— (2004). “Observational Learning.” English. In: *Learning and Memory*. Ed. by John H. Byrne. 2nd ed. New York, NY: Macmillan Reference USA, pp. 482–484. URL: https://link.gale.com/apps/doc/CX3407100173/GVRL?u=cuny_hunter&sid=zotero&xid=571b1693 (visited on 04/20/2020).

Bar, Y., Diamant, I., Wolf, L., Lieberman, S., Konen, E., & Greenspan, H. (2015, April). Chest pathology detection using deep learning with non-medical training. In 2015 IEEE 12th international symposium on biomedical imaging (ISBI) (pp. 294-297). IEEE.

Bedi, S., Diaz Ruvalcaba, J., Foley-Fisher, Z., Kamal, N., & Tsao, V. (2010). Health shelf: interactive nutritional labels. In CHI'10 Extended Abstracts on Human Factors in Computing Systems (pp. 4405-4410).

Best, Paul, Roger Manktelow, and Brian Taylor (June 2014). “Online communication, social media and adolescent wellbeing: A systematic narrative review.” In: *Children and Youth Services Review* 41, pp. 27–36. ISSN: 0190-7409. DOI: 10.1016/j.childyouth.2014.03.001. URL: http://www.sciencedirect.com/science/article/pii/S0190740914000693.

Bidargaddi, N., Almirall, D., Murphy, S., Nahum-Shani, I., Kovalcik, M., Pituch, T., Maaieh, H., & Strecher, V. (2018). To Prompt or Not to Prompt? A Microrandomized Trial of Time-Varying Push Notifications to Increase Proximal Engagement With a Mobile Health App. JMIR MHealth and UHealth, 6(11), e10123. https://doi.org/10.2196/10123

Bisafar, F. I., & Parker, A. G. (2016, February). Confidence & control: Examining adolescent preferences for technologies that promote wellness. In Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (pp. 160-171).

Borth, D., Ji, R., Chen, T., Breuel, T., & Chang, S. F. (2013, October). Large-scale visual sentiment ontology and detectors using adjective noun pairs. In Proceedings of the 21st ACM international conference on Multimedia (pp. 223-232).

boyd, danah (Apr. 2015). "Social Media: A Phenomenon to be Analyzed." en. In: *Social Media + Society* 1.1, p. 205630511558014. ISSN: 2056-3051, 2056-3051. DOI: 10.1177/2056305115580148. URL: http://journals.sagepub.com/doi/10.1177/2056305115580148 (visited on 06/26/2018).

Brachmann, Anselm and Christoph Redies (2017). "Computational and Experimental Approaches to Visual Aesthetics." English. In: *Frontiers in Computational Neuroscience* 11. ISSN: 1662-5188. DOI: 10.3389/fncom.2017.00102. URL: https://www.frontiersin.org/articles/10.3389/fncom.2017.00102/full (visited on 03/26/2019).

Bronfenbrenner, Urie (1979). *The Ecology of Human Development*. en. Google-Books-ID: OCmbzWka6xUC. Harvard University Press. ISBN: 978-0-674-22457-5.

Burgermaster, Marissa et al. (May 2017). "The Role of Explanations in Casual Observational Learning about Nutrition." In: ACM, pp. 4097–4145. ISBN: 978-1-4503-4655-9. DOI: 10.1145/3025453.3025874. URL: http://dl.acm.org/citation.cfm?id=3025453.3025874 (visited on 10/10/2018).

Burke, Lora E. et al. (Sept. 2015). "Current Science on Consumer Use of Mobile Health for Cardiovascular Disease Prevention." en. In: *Circulation* 132.12, pp. 1157–1213. ISSN: 00097322, 1524-4539. DOI: 10.1161/CIR.0000000000000232. URL: http://circ.ahajournals.org/content/132/12/1157 (visited on 05/29/2017).

Cafazzo, J. A., Casselman, M., Hamming, N., Katzman, D. K., & Palmert, M. R. (2012). Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. Journal of medical Internet research, 14(3), e70.

Cameron, Linda D. and Carina K. Y. Chan (2008). "Designing Health Communications: Harnessing the Power of Affect, Imagery, and Self-Regulation." en. In: *Social and Personality Psychology Compass* 2.1. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1751-9004.2007.00057.x, pp. 262–282. ISSN: 1751-9004. DOI: 10.1111/j.1751-9004.2007.00057.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1751-9004.2007.00057.x (visited on 04/26/2020).

Casazza, Krista and Michele Ciccazzo (Jan. 2007). "The method of delivery of nutrition and physical activity information may play a role in eliciting behavior changes in adolescents." In: *Eating Behaviors* 8.1, pp. 73–82. ISSN: 1471-0153. DOI: 10.1016/j.eatbeh.2006.01.007. URL: http://www.sciencedirect.com/science/article/pii/S1471015306000080 (visited on 10/27/2016).

Chan, A., Kow, R., & Cheng, J. K. (2017). Adolescents' perceptions on smartphone applications (apps) for health management. Journal of mobile technology in medicine, 6(2), 47-55.

Chassiakos, Yolanda (Linda) Reid et al. (Nov. 2016). "Children and Adolescents and Digital Media." en. In: *Pediatrics* 138.5, e20162593. ISSN: 0031-4005, 1098-4275. DOI: 10.1542/peds.2016-2593. URL: http://pediatrics.aappublications.org/content/138/5/e20162593 (visited on 06/27/2017).

Chau, Michelle M., Marissa Burgermaster, and Lena Mamykina (Dec. 2018). "The use of social media in nutrition interventions for adolescents and young adults—A systematic review." In: *International Journal of Medical Informatics* 120, pp. 77–91. ISSN: 1386-5056. DOI: 10.1016/j.ijmedinf.2018.10.001. URL: http://www.sciencedirect.com/science/article/pii/S138650561830039X (visited on 12/11/2018).

Chen, Jyu-Lin and Mary Ellen Wilkosz (2014). "Efficacy of technology-based interventions for obesity prevention in adolescents: a systematic review." eng. In: *Adolescent Health, Medicine and Therapeutics* 5, pp. 159–170. ISSN: 1179-318X. DOI: 10.2147/AHMT.S39969.

Christakis, Nicholas A. and James H. Fowler (July 2007). "The spread of obesity in a large social network over 32 years." eng. In: *The New England Journal of Medicine* 357.4, pp. 370–379. ISSN: 1533-4406. DOI: 10.1056/NEJMsa066082.

Chung, Arlene E. et al. (2016). "Tweeting to Health: A Novel mHealth Intervention Using Fitbits and Twitter to Foster Healthy Lifestyles." In: *Clin Pediatr (Phila)*. DOI: 10.1177/0009922816653385.

Chung, C. F., Agapie, E., Schroeder, J., Mishra, S., Fogarty, J., & Munson, S. A. (2017, May). When personal tracking becomes social: Examining the use of Instagram for healthy eating. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (pp. 1674-1687).

Clawson, James et al. (Sept. 2015). "No longer wearing: investigating the abandonment of personal health-tracking technologies on craigslist." In: *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. UbiComp '15. Osaka, Japan: Association for Computing Machinery, pp. 647–658. ISBN: 978-1-4503-3574-4. DOI: 10.1145/2750858.2807554. URL: https://doi.org/10.1145/2750858.2807554 (visited on 04/25/2020).

Cohen, D. A. and S. H. Babey (Sept. 2012). "Contextual influences on eating behaviours: heuristic processing and dietary choices." en. In: *Obesity Reviews* 13.9, pp. 766–779. ISSN:1467-789X. DOI: 10.1111/j.1467-789X.2012.01001.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-789X.2012.01001.x (visited on 09/18/2018).

Cordeiro, F., Bales, E., Cherry, E., & Fogarty, J. (2015, April). Rethinking the mobile food journal: Exploring opportunities for lightweight photo-based capture. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 3207-3216).

Cullen, Karen Weber, Tom Baranowski, and Stella P Smith (May 2001). "Using goal setting as a strategy for dietary behavior change." In: *Journal of the American Dietetic Association* 101.5, pp. 562–566. ISSN: 0002-8223. DOI: 10.1016/S0002-8223(01)00140-7. URL: http://www.sciencedirect.com/science/article/pii/S0002822301001407 (visited on 08/17/2018).

Cullen, Karen Weber et al. (2013). *Evaluation of a web-based program promoting healthy eating and physical activity for adolescents: Teen Choice: Food and Fitness.*

Cushing, Christopher C. and Ric G. Steele (Oct. 2010). "A meta-analytic review of eHealth interventions for pediatric health promoting and maintaining behaviors." eng. In: *Journal of Pediatric Psychology* 35.9, pp. 937–949. ISSN: 1465-735X. DOI: 10.1093/jpepsy/jsq023.

Deng, J., Dong, W., Socher, R., Li, L. J., Li, K., & Fei-Fei, L. (2009, June). Imagenet: A large-scale hierarchical image database. In 2009 IEEE conference on computer vision and pattern recognition (pp. 248-255). Ieee.

Deterding, Sebastian et al. (2011). "From Game Design Elements to Gamefulness: Defining "Gamification"." In: *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*. MindTrek '11. event-place: Tampere, Finland. New York, NY, USA: ACM, pp. 9–15. ISBN: 978-1-4503-0816-8. DOI: 10.1145/2181037.2181040. URL: http://doi.acm.org/10.1145/2181037.2181040 (visited on 02/18/2019).

Di Noia, J., I.R. Contento, and J.O. Prochaska (2008). "Computer-mediated intervention tailored on transtheoretical model stages and processes of change increases fruit and vegetable consumption among urban African-American adolescents." In: *Am. J. Health Promot.* 22.5, pp. 336–341. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L351694032.

DiFilippo, Kristen N. et al. (July 2015). "The use of mobile apps to improve nutrition outcomes: A systematic literature review." eng. In: *Journal of Telemedicine and Telecare* 21.5, pp. 243–253. ISSN: 1758-1109. DOI: 10.1177/1357633X15572203.

Diller, Lisa et al. (May 2009). "Chronic Disease in the Childhood Cancer Survivor Study Cohort: A Review of Published Findings." en. In: *Journal of Clinical Oncology* 27.14, pp. 2339–2355. ISSN: 0732-183X, 1527-7755. DOI: 10.1200/JCO.2008.21.1953. URL: http://jco.ascopubs.org/content/27/14/2339 (visited on 03/08/2015).

Downs, S. H. and N. Black (June 1998). "The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies of

health care interventions." eng. In: *Journal of Epidemiology and Community Health* 52.6, pp. 377–384. ISSN: 0143-005X.

Doyle, Angela Celio et al. (2008). "Reduction of Overweight and Eating Disorder Symptoms via the Internet in Adolescents: A Randomized Controlled Trial." In: *Journal of Adolescent Health* 43.2, pp. 172–179. DOI: 10.1016/j.jadohealth.2008.01.011. URL: http://www.sciencedirect.com/science/article/pii/S1054139X08001109.

Dumas, Audrée-Anne, Annie Lapointe, and Sophie Desroches (2018). "Users, Uses, and Effects of Social Media in Dietetic Practice: Scoping Review of the Quantitative and Qualitative Evidence." en. In: *Journal of Medical Internet Research* 20.2, e55. DOI: 10.2196/jmir.9230. URL: https://www.jmir.org/2018/2/e55/ (visited on 02/26/2018).

Dute, Denise Jantine, Wanda Jose Erika Bemelmans, and João Breda (2016). "Using Mobile Apps to Promote a Healthy Lifestyle Among Adolescents and Students: A Review of the Theoretical Basis and Lessons Learned." eng. In: *JMIR mHealth and uHealth* 4.2, e39. ISSN: 2291-5222. DOI: 10.2196/mhealth.3559.

Evans, Jonathan St. B. T. (2008). "Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition." In: *Annual Review of Psychology* 59.1, pp. 255–278. DOI: 10.1146/annurev.psych.59.103006.093629. URL: https://doi.org/10.1146/annurev.psych.59.103006.093629 (visited on 01/23/2019).

Ezendam, Nicole P. M., Johannes Brug, and Anke Oenema (Mar. 2012). "Evaluation of the Web-based computer-tailored Faintheart intervention to promote energy balance among adolescents: results from a school cluster randomized trial." eng. In: *Archives of Pediatrics & Adolescent Medicine* 166.3, pp. 248–255. ISSN: 1538-3628. DOI: 10.1001/archpediatrics.2011.204.

Forrest, Christopher B. and Anne W. Riley (Sept. 2004). "Childhood Origins Of Adult Health: A Basis For Life-Course Health Policy." en. In: *Health Affairs* 23.5, pp. 155–164. ISSN: 0278-2715, 1544-5208. DOI: 10.1377/hlthaff.23.5.155. URL: http://content.healthaffairs.org/content/23/5/155 (visited on 07/01/2017).

Fortin, B. and M. Yazbeck (2015). "Peer effects, fast food consumption and adolescent weight gain." In: *Journal of Health Economics* 42.(Fortin B., Bernard.Fortin@ecn.ulaval.ca) CIRPÉE, IZA, CIRANO and Department of Economics, Universitý Laval, Canada, pp. 125–138. ISSN: 1879-1646. URL: http://www.embase.com/search/results? sub action=viewrecord&from=export&id=L604055838.

Free, Caroline et al. (Jan. 2013). "The Effectiveness of Mobile-Health Technology-Based Health Behaviour Change or Disease Management Interventions for Health Care Consumers: A Systematic Review." In: *PLoS Med* 10.1, e1001362. DOI: 10.1371/journal.pmed.1001362. URL: http://dx.doi.org/10.1371/journal.pmed.1001362 (visited on 11/12/2015).

Garvey, Katharine C. et al. (2013). “HEALTH CARE TRANSITION IN YOUNG ADULTS WITH TYPE 1 DIABETES: BARRIERS TO TIMELY ESTABLISHMENT OF ADULT DIABETES CARE.” In: *Endocrine practice : official journal of the American College of Endocrinology and the American Association of Clinical Endocrinologists* 19.6, pp. 946–952. ISSN: 1530-891X. DOI: 10.4158/EP13109.OR. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4034180/.

Gauvain, Mary and Michael Cole (2005). *Readings on the Development of Children*. en. Google-Books-ID: 0VIROZKuKNsC. Macmillan. ISBN: 978-0-7167-0961-9.

Gerrard, Meg et al. (Mar. 2008). “A dual-process approach to health risk decision making: The prototype willingness model.” In: *Developmental Review*. Current Directions in Risk and Decision Making 28.1, pp. 29–61. ISSN: 0273-2297. DOI: 10.1016/j.dr.2007.10.001. URL: http://www.sciencedirect.com/science/article/pii/S0273229707000512 (visited on 02/20/2019).

Glanz, K., Basil, M., Maibach, E., Goldberg, J., & Snyder, D. (1998). Why Americans Eat What They Do: Taste, Nutrition, Cost, Convenience, and Weight Control Concerns as Influences on Food Consumption. Journal of the American Dietetic Association, 98(10), 1118–1126. https://doi.org/10.1016/S0002-8223(98)00260-0

Godino, Job G. et al. (2016). “Using social and mobile tools for weight loss in overweight and obese young adults (Project SMART): a 2 year, parallel-group, randomised, controlled trial.” In: *Lancet Diabetes Endocrinol*. DOI: 10.1016/S2213-8587(16)30105-X.

Goldberg, R. L. (2013). No Such Thing as a Free Lunch: Paternalism, Poverty, and Food Justice. Stan. L. & Pol'y Rev., 24, 35.

Gollwitzer, Peter M. (1999). “Implementation intentions: Strong effects of simple plans.” en. In: *American Psychologist*. DOI: 10.1037/0003-066X.54.7.493. URL: /fulltext/1999-05760-004.html (visited on 12/27/2018).

Hackman, Christine L and Adam P Knowlden (June 2014). “Theory of reasoned action and theory of planned behavior-based dietary interventions in adolescents and young adults: a systematic review.” In: *Adolescent Health, Medicine and Therapeutics* 5, pp. 101–114. ISSN: 1179-318X. DOI: 10.2147/AHMT.S56207. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4057331/ (visited on 03/09/2015).

Haerens, Leen et al. (2006). “Evaluation of a 2-year physical activity and healthy eating intervention in middle school children.” In: *Health Educ. Res.* 21.6, pp. 911–921. DOI: 10.1093/her/cyl115. URL: http://her.oxfordjournals.org/content/21/6/911.

Hamm, Michele P. et al. (2014). “A systematic review of the use and effectiveness of social media in child health.” eng. In: *BMC pediatrics* 14, p. 138. ISSN: 1471-2431. DOI: 10.1186/1471-2431-14-138.

He, Kaiming et al. (Dec. 2015). “Deep Residual Learning for Image Recognition.” In: *arXiv:1512.03385 [cs]*. arXiv: 1512.03385. URL: http://arxiv.org/abs/1512.03385 (visited on 04/30/2020).

Hebden, L. et al. (2014). “A mobile health intervention for weight management among young adults: a pilot randomised controlled trial.” In: *J Hum Nutr Diet* 27.4, pp. 322–332. DOI: 10.1111/jhn.12155.

Heimlich, Russell (Dec. 2011). *Using Social Media to Keep in Touch*. en-US. URL: http://www.pewresearch.org/fact-tank/2011/12/22/using-social-media-to- keep-in-touch/ (visited on 07/11/2018).

Higgins, J. A. et al. (Aug. 2009). “Validation of photographic food records in children: are pictures really worth a thousand words?” en. In: *European Journal of Clinical Nutrition* 63.8, pp. 1025–1033. ISSN: 1476-5640. DOI: 10.1038/ejcn.2009.12. URL: https://www.nature.com/articles/ejcn200912 (visited on 06/25/2018).

Hollink, L., Schreiber, A. T., Wielinga, B. J., & Worring, M. (2004). Classification of user image descriptions. International Journal of Human-Computer Studies, 61(5), 601-626.

Holmberg, Christopher et al. (Apr. 2016). “Adolescents’ presentation of food in social media: An explorative study.” In: *Appetite* 99, pp. 121–129. ISSN: 0195-6663. DOI: 10.1016/j.appet.2016.01.009. URL: http://www.sciencedirect.com/science/article/pii/S0195666316300083 (visited on 10/07/2016).

Houlihan, S. (Mar. 2018). “Dual-process models of health-related behaviour and cognition: a review of theory.” In: *Public Health* 156, pp. 52–59. ISSN: 0033-3506. DOI: 10.1016/j.puhe.2017.11.002. URL: http://www.sciencedirect.com/science/article/pii/S0033350617303682 (visited on 01/23/2019).

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. Qualitative health research, 15(9), 1277-1288.

Hsu, Chih-Chung et al. (Oct. 2017). “Social Media Prediction Based on Residual Learning and Random Forest.” In: *Proceedings of the 25th ACM international conference on Multimedia*. MM ’17. Mountain View, California, USA: Association for Computing Machinery, pp. 1865–1870. ISBN: 978-1-4503-4906-2. DOI: 10.1145/3123266.3127894. URL: https://doi.org/10.1145/3123266.3127894 (visited on 05/01/2020).

Hutchesson, Melinda J. et al. (June 2016). “Be Positive Be Healthe: Development and Implementation of a Targeted e-Health Weight Loss Program for Young Women.” eng. In: *Telemedicine Journal and E-Health: The Official Journal of the American Telemedicine Association* 22.6, pp. 519–528. ISSN: 1556-3669. DOI: 10.1089/tmj.2015.0085.

Institute of Medicine. (2014). *Investing in the Health and Well-Being of Young Adults*. DOI: 10.17226/18869. URL: https://www.nap.edu/read/18869/chapter/2 (visited on 06/23/2017).

Jones, Megan et al. (2014). "Healthy weight regulation and eating disorder prevention in high school students: a universal and targeted Web-based intervention." In: *J Med Internet Res* 16.2, e57. DOI: 10.2196/jmir.2995.

Jörgensen, Corinne (Mar. 1998). "Attributes of images in describing tasks." In: *Information Processing & Management* 34.2, pp. 161–174. ISSN: 0306-4573. DOI: 10.1016/S0306-4573(97)00077-0. URL: http://www.sciencedirect.com/science/article/pii/S0306457397000770 (visited on 06/30/2019).

Joshi, Dhiraj et al. (Sept. 2011). "Aesthetics and Emotions in Images." In: *IEEE Signal Processing Magazine* 28.5. Conference Name: IEEE Signal Processing Magazine, pp. 94–115. ISSN: 1558-0792. DOI: 10.1109/MSP.2011.941851.

Kann, Laura (2016). "Youth Risk Behavior Surveillance — United States, 2015." In: *MMWR. Surveillance Summaries* 65. ISSN: 1546-07381545-8636. DOI: 10.15585/mmwr.ss6506a1. URL: http://www.cdc.gov/mmwr/volumes/65/ss/ss6506a1.htm (visited on 06/21/2017).

Karapanos, Evangelos (June 2015). "Sustaining user engagement with behavior-change tools." en. In: *interactions* 22.4, pp. 48–52. ISSN: 10725520. DOI: 10.1145/2775388. URL: http://dl.acm.org/citation.cfm?doid=2797212.2775388 (visited on 04/16/2020).

Kavey, Rae-Ellen W. et al. (Mar. 2003). "American Heart Association Guidelines for Primary Prevention of Atherosclerotic Cardiovascular Disease Beginning in Childhood." en. In: *Circulation* 107.11, pp. 1562–1566. ISSN: 0009-7322, 1524-4539. DOI: 10.1161/01.CIR.0000061521.15730.6E. URL: http://circ.ahajournals.org/content/107/11/1562 (visited on 05/29/2017).

Kerr, Deborah A et al. (2016). *The connecting health and technology study: A 6-month randomized controlled trial to improve nutrition behaviours using a mobile food record and text messaging support in young adults.*

Khanana, Kornchulee and Effie L.-C. Law (2013). "Designing Children's Digital Games on Nutrition with Playability Heuristics." In: *CHI '13 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '13. New York, NY, USA: ACM, pp. 1071–1076. ISBN: 978-1-4503-1952-2. DOI: 10.1145/2468356.2468548. URL: http://doi.acm.org/10.1145/2468356.2468548 (visited on 12/23/2014).

Krieger, Nancy (Aug. 2001). "Theories for social epidemiology in the 21st century: an ecosocial perspective." en. In: *International Journal of Epidemiology* 30.4, pp. 668–677. ISSN: 0300-5771, 1464-3685. DOI: 10.1093/ije/30.4.668. URL: http://ije.oxfordjournals.org/content/30/4/668 (visited on 11/05/2014).

Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E Hinton (2012). "ImageNet Classification with Deep Convolutional Neural Networks." In: *Advances in Neural Information Processing Systems 25*. Ed. by F. Pereira et al. Curran Associates, Inc., pp. 1097–1105. URL: http://papers.nips.cc/paper/4824-imagenet-classification-with-deep- convolutional-neural-networks.pdf (visited on 03/08/2019).

Kulik, Noel L. et al. (2014). "Peer support enhanced social support in adolescent females during weight loss." In: *Am J Health Behav* 38.5, pp. 789–800. DOI: 10.5993/AJHB.38.5.16.

Lana, Alberto et al. (2013). "Study protocol of a randomized controlled trial to improve cancer prevention behaviors in adolescents and adults using a web-based intervention supplemented with SMS." In: *BMC Public Health* 13, p. 357. DOI: 10.1186/1471-2458-13-357.

Laranjo, Liliana et al. (2014). "The influence of social networking sites on health behavior change: a systematic review and meta-analysis." In: *Journal of the American Medical Informatics Association : JAMIA*, amiajnl–2014. DOI: 10.1136/amiajnl-2014-002841. URL: http://jamia.bmj.com/content/early/2014/07/08/amiajnl-2014-002841.full.

Lau, Patrick W. C. et al. (2011). "A systematic review of information and communication technology-based interventions for promoting physical activity behavior change in children and adolescents." eng. In: *Journal of Medical Internet Research* 13.3, e48. ISSN: 1438-8871. DOI: 10.2196/jmir.1533.

Lau, Richard R., Marilyn Jacobs Quadrel, and Karen A. Hartman (1990). "Development and Change of Young Adults' Preventive Health Beliefs and Behavior: Influence from Parents and Peers." In: *Journal of Health and Social Behavior* 31.3, pp. 240–259. ISSN: 0022-1465. DOI: 10.2307/2136890. URL: http://www.jstor.org/stable/2136890.

Lee-Kwan, Seung Hee (2017). "Disparities in State-Specific Adult Fruit and Vegetable Consumption — United States, 2015." en-us. In: *MMWR. Morbidity and Mortality Weekly Report* 66. ISSN: 0149-21951545-861X. DOI: 10.15585/mmwr.mm6645a1. URL: https://www.cdc.gov/mmwr/volumes/66/wr/mm6645a1.htm (visited on 02/06/2019).

Leme, Ana Carolina Barco and Sonia Tucunduva Philippi (2015). "The "Healthy Habits, Healthy Girls" randomized controlled trial for girls: study design, protocol, and baseline results." In: *Cad Saude Publica* 31.7, pp. 1381–1394. DOI: 10.1590/0102-311X00136014.

Lenhart, Amanda (Apr. 2015a). *Teens, Social Media & Technology Overview 2015*. Tech. rep. URL: http://www.pewinternet.org/2015/04/09/teens-social-media- technology-2015/ (visited on 06/30/2017).

— (Aug. 2015b). *Teens, Technology and Friendships*. Tech. rep. URL: http://www.pewinternet.org/2015/08/06/teens-technology-and-friendships/ (visited on 06/27/2017).

Lenhart, Amanda et al. (Feb. 2010). *Social Media and Young Adults*. Tech. rep. URL: http://www.pewinternet.org/2010/02/03/social-media-and-young-adults/ (visited on 06/27/2017).

Lenz, B. (Dec. 2001). "The transition from adolescence to young adulthood: a theoretical perspective." eng. In: *The Journal of School Nursing: The Official Publication of the National Association of School Nurses* 17.6, pp. 300–306. ISSN: 1059-8405. DOI: 10.1177/10598405010170060401.

Li, I., Dey, A., & Forlizzi, J. (2010, April). A stage-based model of personal informatics systems. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 557-566).

Liberato, S. C., Bailie, R., & Brimblecombe, J. (2014). Nutrition interventions at point-of-sale to encourage healthier food purchasing: a systematic review. BMC public health, 14(1), 1-14.

Linehan, Conor et al. (2010). "Tagliatelle: Social Tagging to Encourage Healthier Eating." In: *CHI '10 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '10. New York, NY, USA: ACM, pp. 3331–3336. ISBN: 978-1-60558-930-5. DOI: 10.1145/1753846.1753980. URL: http://doi.acm.org/10.1145/1753846.1753980.

Lipshultz, Steven E. et al. (2015). "Cardiovascular Disease in Adult Survivors of Childhood Cancer." In: *Annual Review of Medicine* 66.1, pp. 161–176. DOI: 10.1146/annurev-med-070213-054849. URL: http://dx.doi.org/10.1146/annurev-med-070213-054849 (visited on 03/08/2015).

Locke, Edwin A. and Gary P. Latham (2002). "Building a practically useful theory of goal setting and task motivation: A 35-year odyssey." In: *American Psychologist* 57.9, pp. 705–717. ISSN: 1935-990X(Electronic),0003-066X(Print). DOI: 10.1037/0003-066X.57.9.705.

Logsdon, M. Cynthia et al. (Nov. 2014). "Preferred Health Resources and Use of Social Media to Obtain Health and Depression Information by Adolescent Mothers." en. In: *Journal of Child and Adolescent Psychiatric Nursing* 27.4, pp. 163–168. ISSN: 1744-6171. DOI: 10.1111/jcap.12083. URL: http://onlinelibrary.wiley.com/doi/10.1111/jcap.12083/abstract.

Long, JoAnn D. and Kathleen R. Stevens (June 2004). "Using Technology to Promote Self-Efficacy for Healthy Eating in Adolescents." en. In: *Journal of Nursing Scholarship* 36.2. 00090, pp. 134–139. ISSN: 1547-5069. DOI: 10.1111/j.1547-5069.2004.04026.x. URL: http://onlinelibrary.wiley.com/doi/10.1111/j.1547- 5069.2004.04026.x/abstract (visited on 09/25/2014).

Lytle, Leslie A. et al. (Jan. 2014). "Designing a Weight Gain Prevention Trial for Young Adults: The CHOICES Study." eng. In: *American Journal of Health Education* 45.2, pp. 67–75. ISSN: 1932-5037. DOI: 10.1080/19325037.2013.875962.

Machajdik, J., & Hanbury, A. (2010, October). Affective image classification using features inspired by psychology and art theory. In Proceedings of the 18th ACM international conference on Multimedia (pp. 83-92).

Maher, Carol A. et al. (2014). "Are health behavior change interventions that use online social networks effective? A systematic review." eng. In: *Journal of Medical Internet Research* 16.2, e40. ISSN: 1438-8871. DOI: 10.2196/jmir.2952.

Mamykina, Lena et al. (2016). "Learning From the Crowd: Observational Learning in Crowdsourcing Communities." In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, pp. 2635–2644. ISBN: 978-1-4503-3362-7. DOI: 10.1145/2858036.2858560. URL: http://doi.acm.org/10.1145/2858036.2858560.

Mangunkusumo, Resiti T. et al. (Mar. 2007). "School-based internet-tailored fruit and vegetable education combined with brief counselling increases children's awareness of intake levels." eng. In: *Public Health Nutrition* 10.3, pp. 273–279. ISSN: 1368-9800. DOI: 10.1017/S1368980007246671.

Mansour, Anna et al. (2009). "MunchCrunch: A Game to Learn Healthy-eating Heuristics." In: *Proceedings of the 8th International Conference on Interaction Design and Children*. IDC '09. New York, NY, USA: ACM, pp. 166–169. ISBN: 978-1-60558-395-2. DOI: 10.1145/1551788.1551818. URL: http://doi.acm.org/10.1145/1551788.1551818 (visited on 11/05/2014).

Martin, C. K. et al. (2014) "Measuring food intake with digital photography." en. In: *Journal of Human Nutrition and Dietetics* 27.s1 (), pp. 72–81. ISSN: 1365-277X. DOI: 10.1111/jhn.12014. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/jhn.12014.

Medin, D. L., & Barsalou, L. W. (1987). Categorization processes and categorical perception. In S. Harnad (Ed.), Categorical perception: The groundwork of cognition (p. 455–490). Cambridge University Press.

Mejova, Yelena et al. (2015). "#FoodPorn: Obesity Patterns in Culinary Interactions." In: *Proceedings of the 5th International Conference on Digital Health 2015*. DH '15. New York, NY, USA: ACM, pp. 51–58. ISBN: 978-1-4503-3492-1. DOI: 10.1145/2750511.2750524. URL: http://doi.acm.org/10.1145/2750511.2750524.

Merolli, Mark, Kathleen Gray, and Fernando Martin-Sanchez (Dec. 2013). "Health outcomes and related effects of using social media in chronic disease management: a literature review and analysis of affordances." eng. In: *Journal of Biomedical Informatics* 46.6, pp. 957–969. ISSN: 1532-0480. DOI: 10.1016/j.jbi.2013.04.010.

Michie, Susan et al. (2009). "Effective techniques in healthy eating and physical activity interventions: A meta-regression." In: *Health Psychology* 28.6. Place: US Publisher: American

Psychological Association, pp. 690–701. ISSN: 1930-7810(Electronic),0278-6133(Print). DOI: 10.1037/a0016136.

Mikkilä, V. et al. (June 2005). "Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study." eng. In: *The British Journal of Nutrition* 93.6, pp. 923–931. ISSN: 0007-1145.

Moher, David et al. (2015). "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement." In: *Systematic Reviews* 4, p. 1. ISSN: 2046-4053. DOI: 10.1186/2046-4053-4-1. URL: http://dx.doi.org/10.1186/2046-4053-4-1 (visited on 06/13/2016).

Moorhead, S Anne et al. (Apr. 2013). "A New Dimension of Health Care: Systematic Review of the Uses, Benefits, and Limitations of Social Media for Health Communication." In: *Journal of Medical Internet Research* 15.4. ISSN: 1439-4456. DOI: 10.2196/jmir.1933. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3636326/.

Moreno, Megan A. et al. (June 2011). "Feeling bad on Facebook: depression disclosures by college students on a social networking site." eng. In: *Depression and Anxiety* 28.6, pp. 447–455. ISSN: 1520-6394. DOI: 10.1002/da.20805.

Napolitano, M.A. et al. (2013). "Using Facebook and text messaging to deliver a weight loss program to college students." In: *Obesity* 21.1, pp. 25–31. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L52016613.

National Cancer Institute (2014). *A Snapshot of Adolescent and Young Adult Cancers*. URL: http://www.cancer.gov/researchandfunding/snapshots/adolescent-young- adult (visited on 03/11/2015).

Nawi, A.M. and F.I.C. Jamaludin (2015). "Effect of internet-based intervention on obesity among adolescents in Kuala Lumpur: A school-based cluster randomised trial." In: *Malays. J. Med. Sci.* 22.4, pp. 47–56. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L605093760.

Neumark-Sztainer, Dianne et al. (Aug. 1999). "Factors Influencing Food Choices of Adolescents: Findings from Focus-Group Discussions with Adolescents." In: *Journal of the American Dietetic Association* 99.8, pp. 929–937. ISSN: 0002-8223. DOI: 10.1016/S0002-8223(99)00222-9.
URL:http://www.sciencedirect.com/science/article/pii/S0002822399002229 (visited on 02/11/2019).

Niemeier, Heather M. et al. (Dec. 2006). "Fast food consumption and breakfast skipping: predictors of weight gain from adolescence to adulthood in a nationally representative sample." ENG. In: *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine* 39.6, pp. 842–849. ISSN: 1879-1972. DOI: 10.1016/j.jadohealth.2006.07.001.

Noronha, J., Hysen, E., Zhang, H., & Gajos, K. Z. (2011, October). Platemate: crowdsourcing nutritional analysis from food photographs. In Proceedings of the 24th annual ACM symposium on User interface software and technology (pp. 1-12).

Nour, Monica et al. (May 2017). "A Narrative Review of Social Media and Game-Based Nutrition Interventions Targeted at Young Adults." In: *Journal of the Academy of Nutrition and Dietetics* 117.5, 735–752.e10. ISSN: 2212-2672. DOI: 10.1016/j.jand.2016.12.014. URL: http://www.sciencedirect.com/science/article/pii/S2212267216315490.

O'Keeffe, Gwenn Schurgin, Kathleen Clarke-Pearson, and Council on Communications and Media (Apr. 2011). "The Impact of Social Media on Children, Adolescents, and Families." en. In: *Pediatrics* 127.4, pp. 800–804. ISSN: 0031-4005, 1098-4275. DOI: 10.1542/peds.2011-0054. URL: http://pediatrics.aappublications.org/content/127/4/800 (visited on 06/30/2017).

Oeffinger, K. C., Mertens, A. C., Sklar, C. A., Kawashima, T., Hudson, M. M., Meadows, A. T., ... & Schwartz, C. L. (2006). Chronic health conditions in adult survivors of childhood cancer. New England Journal of Medicine, 355(15), 1572-1582.

Ory, M. G., P. J. Jordan, and T. Bazzarre (Oct. 2002). "The Behavior Change Consortium: setting the stage for a new century of health behavior-change research." en. In: *Health Education Research* 17.5. Publisher: Oxford Academic, pp. 500–511. ISSN: 0268-1153. DOI: 10.1093/her/17.5.500. URL: https://academic.oup.com/her/article/17/5/500/609445 (visited on 04/18/2020).

Park, Bu Kyung and Christina Calamaro (2013). "A Systematic Review of Social Networking Sites: Innovative Platforms for Health Research Targeting Adolescents and Young Adults." In: *Journal of Nursing Scholarship* 45.3, pp. 256–264. DOI: 10.1111/jnu.12032. URL: http://onlinelibrary.wiley.com/doi/10.1111/jnu.12032/abstract.

Park, Bu Kyung, Eun-Shim Nahm, and Valerie E. Rogers (2016). "Development of a Teen-Friendly Health Education Program on Facebook: Lessons Learned." In: *J Pediatr Health Care* 30.3, pp. 197–207. DOI: 10.1016/j.pedhc.2015.06.011.

Parker, Andrea Grimes et al. (2013). "I Am What I Eat: Identity & Critical Thinking in an Online Health Forum for Kids." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '13. New York, NY, USA: ACM, pp. 2437–2446. ISBN: 978-1-4503-1899-0. DOI: 10.1145/2470654.2481338. URL: http://doi.acm.org/10.1145/2470654.2481338 (visited on 10/28/2016).

Parker, A. G., McClendon, I., Grevet, C., Ayo, V., Chung, W., Johnson, V., & Mynatt, E. D. (2013, April). I am what i eat: identity & critical thinking in an online health forum for kids. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2437-2446).

Patrick, Kevin et al. (May 2013). “Outcomes of a 12-Month Technology-Based Intervention to Promote Weight Loss in Adolescents at Risk for Type 2 Diabetes.” en. In: *Journal of Diabetes Science and Technology* 7.3, pp. 759–770. ISSN: 1932-2968, 1932-2968. DOI:10.1177/193229681300700322. URL: http://dst.sagepub.com/content/7/3/759 (visited on 10/28/2016).

Petty, Richard E., Jamie Barden, and S. Christian Wheeler (2009). “The Elaboration Likelihood Model of persuasion: Developing health promotions for sustained behavioral change.” In: *Emerging theories in health promotion practice and research, 2nd ed*. San Francisco, CA, US: Jossey-Bass, pp. 185–214. ISBN: 978-0-470-17913-0.

Petty, Richard E. and John T. Cacioppo (Jan. 1986). “The Elaboration Likelihood Model of Persuasion.” In: *Advances in Experimental Social Psychology*. Ed. by Leonard Berkowitz. Vol. 19. Academic Press, pp. 123–205. DOI: 10.1016/S0065-2601(08)60214-2. URL: http://www.sciencedirect.com/science/article/pii/S0065260108602142.

Pew Research Center. (2019a). *Demographics of Mobile Device Ownership and Adoption in the United States*. en-US. URL: http://www.pewinternet.org/fact-sheet/mobile/ (visited on 02/18/2019).

— (2019b). *Demographics of Social Media Users and Adoption in the United States*. en-US. URL: http://www.pewinternet.org/fact-sheet/social-media/ (visited on 02/18/2019).

— (May 2018). *Teens, Social Media & Technology 2018*. en-US. URL: http://www.pewinternet.org/2018/05/31/teens-social-media-technology- 2018/ (visited on 02/18/2019).

Picard, Rosalind W. (July 2003). “Affective computing: challenges.” en. In: *International Journal of Human-Computer Studies*. Applications of Affective Computing in Human-Computer Interaction 59.1, pp. 55–64. ISSN: 1071-5819. DOI: 10.1016/S1071-5819(03)00052-1. URL: http://www.sciencedirect.com/science/article/pii/S1071581903000521 (visited on 02/11/2020).

Plotnikoff, Ronald C. et al. (2015). “Effectiveness of interventions targeting physical activity, nutrition and healthy weight for university and college students: a systematic review and meta-analysis.” eng. In: *The International Journal of Behavioral Nutrition and Physical Activity* 12, p. 45. ISSN: 1479-5868. DOI: 10.1186/s12966-015-0203-7.

Portes, Alejandro (1998). “Social Capital: Its Origins and Applications in Modern Sociology.” In: *Annual Review of Sociology* 24, pp. 1–24. DOI: 10.1146/annurev.soc.24.1.1.

Potapov, K., Lee, V. R., Vasalou, A., & Marshall, P. (2019). Youth Concerns and Responses to Self-Tracking Tools and Personal Informatics Systems. In Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-6).

Princeton University. (2010) "About WordNet." WordNet. Princeton University.

Quelly, Susan B., Anne E. Norris, and Jessica L. DiPietro (Jan. 2016). “Impact of mobile apps to combat obesity in children and adolescents: A systematic literature review.” eng. In: *Journal for specialists in pediatric nursing: JSPN* 21.1, pp. 5–17. ISSN: 1744-6155. DOI: 10.1111/jspn.12134.

Razavian, Ali Sharif et al. (Mar. 2014). “CNN Features off-the-shelf: an Astounding Baseline for Recognition.” en. In: URL: https://arxiv.org/abs/1403.6382v3 (visited on 04/30/2020).

Reitberger, W. H., Spreicer, W., & Fitzpatrick, G. (2014, April). Nutriflect: reflecting collective shopping behavior and nutrition. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3309-3318).

Ribeiro, Eduardo et al. (Apr. 2017). “Exploring texture Transfer Learning for Colonic Polyp Classification via Convolutional Neural Networks.” In: *2017 IEEE 14th International Symposium on Biomedical Imaging (ISBI 2017)*. ISSN: 1945-8452, pp. 1044–1048. DOI: 10.1109/ISBI.2017.7950695.

Rock, C. L., Doyle, C., Demark-Wahnefried, W., Meyerhardt, J., Courneya, K. S., Schwartz, A. L., ... & Byers, T. (2012). Nutrition and physical activity guidelines for cancer survivors. CA: a cancer journal for clinicians, 62(4), 242-274.

Salam, Rehana A. et al. (Oct. 2016). “Adolescent Health Interventions: Conclusions, Evidence Gaps, and Research Priorities.” In: *The Journal of Adolescent Health* 59.4 Suppl, S88–S92. ISSN: 1054-139X. DOI: 10.1016/j.jadohealth.2016.05.006. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC5026678/.

Sansom-Daly, Ursula M. et al. (2012). “A systematic review of psychological interventions for adolescents and young adults living with chronic illness.” en. In: *Health Psychology* 31.3, pp. 380–393. ISSN: 1930-7810, 0278-6133. DOI: 10.1037/a0025977. URL: http://doi.apa.org/getdoi.cfm?doi=10.1037/a0025977.

Sawyer, Susan M. et al. (Apr. 2007). “Adolescents with a chronic condition: challenges living, challenges treating.” English. In: *The Lancet* 369.9571, pp. 1481–1489. ISSN: 0140-6736, 1474-547X. DOI: 10.1016/S0140-6736(07)60370-5. URL:https://www.thelancet.com/journals/lancet/article/PIIS0140- 6736(07)60370-5/abstract (visited on 02/11/2019).

Schaefbauer, C. L., Khan, D. U., Le, A., Sczechowski, G., & Siek, K. A. (2015, February). Snack buddy: supporting healthy snacking in low socioeconomic status families. In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (pp. 1045-1057).

Schembre, S. M., Liao, Y., Robertson, M. C., Dunton, G. F., Kerr, J., Haffey, M. E., ... & Hicklen, R. S. (2018). Just-in-time feedback in diet and physical activity interventions: systematic review and practical design framework. Journal of medical Internet research, 20(3), e106.

Sharma, Sanket S. and Munmun De Choudhury (2015). “Measuring and Characterizing Nutritional Information of Food and Ingestion Content in Instagram.” In: *Proceedings of the 24th International Conference on World Wide Web*. WWW ’15 Companion. New York, NY, USA: ACM, pp. 115–116. ISBN: 978-1-4503-3473-0. DOI: 10.1145/2740908.2742754. URL: http://doi.acm.org/10.1145/2740908.2742754 (visited on 10/07/2016).

Shaw, Julie M. et al. (Jan. 2015). “Social media used as a health intervention in adolescent health: A systematic review of the literature.” en. In: *Digital Health* 1, p. 2055207615588395. ISSN: 2055-2076. DOI: 10.1177/2055207615588395. URL: http://dhj.sagepub.com/content/1/2055207615588395 (visited on 08/04/2016).

Shay, Christina M. et al. (Apr. 2013). “Status of cardiovascular health in US adolescents: prevalence estimates from the National Health and Nutrition Examination Surveys (NHANES) 2005-2010.” eng. In: *Circulation* 127.13, pp. 1369–1376. ISSN: 1524-4539. DOI: 10.1161/CIRCULATIONAHA.113.001559.

Shilts, Mical Kay, Marcel Horowitz, and Marilyn S. Townsend (Nov. 2004). “Goal Setting as a Strategy for Dietary and Physical Activity Behavior Change: A Review of the Literature.” en. In: *American Journal of Health Promotion* 19.2, pp. 81–93. ISSN: 0890-1171. DOI: 10.4278/0890-1171-19.2.81. URL: https://doi.org/10.4278/0890-1171-19.2.81 (visited on 08/17/2018).

Shin, Y., & Kim, E. Y. (2010, July). Affective prediction in photographic images using probabilistic affective model. In Proceedings of the ACM International Conference on Image and Video Retrieval (pp. 390-397).

Shin, H. C., Roth, H. R., Gao, M., Lu, L., Xu, Z., Nogues, I., ... & Summers, R. M. (2016). Deep convolutional neural networks for computer-aided detection: CNN architectures, dataset characteristics and transfer learning. IEEE transactions on medical imaging, 35(5), 1285-1298.

Simpson, Courtney C. and Suzanne E. Mazzeo (2017). “Skinny Is Not Enough: A Content Analysis of Fitspiration on Pinterest.” eng. In: *Health Communication* 32.5, pp. 560–567. ISSN: 1532-7027. DOI: 10.1080/10410236.2016.1140273.

Smith, A., & Anderson, M. (2018). Social media use in 2018. Pew research center, 1, 1-4.

Smith, J.J. et al. (2014). “Smart-phone obesity prevention trial for adolescent boys in low-income communities: The ATLAS RCT.” In: *Pediatrics* 134.3, e723–e731. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L600059635.

Sorgi, Ashley et al. (Aug. 2015). *Lifestyle and Behavior in Young Adulthood: The National Longitudinal Study of Adolescent to Adult Health*. Research Brief 2. Chapel Hill, North Carolina: Carolina Population Center, The University of North Carolina at Chapel Hill. URL: http://www.cpc.unc.edu/projects/addhealth/news/copy2_of_ResearchBrieffinaldraft_2015_8_19.pdf.

Strong, K. A., Parks, S. L., Anderson, E., Winett, R., & Davy, B. M. (2008). Weight gain prevention: identifying theory-based targets for health behavior change in young adults. Journal of the American Dietetic Association, 108(10), 1708-1715.

Svetkey, L.P. et al. (2015). "Cell phone intervention for you (CITY): A randomized, controlled trial of behavioral weight loss intervention for young adults using mobile technology." In: *Obesity* 23.11, pp. 2133–2141. URL: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L606756019.

Syed-Abdul, Shabbir et al. (Feb. 2013). "Misleading health-related information promoted through video-based social media: anorexia on YouTube." eng. In: *Journal of Medical Internet Research* 15.2, e30. ISSN: 1438-8871. DOI: 10.2196/jmir.2237.

Thrash, Todd M. and Andrew J. Elliot (2003). "Inspiration as a psychological construct." In: *Journal of Personality and Social Psychology* 84.4, pp. 871–889. ISSN: 1939-1315(Electronic),0022-3514(Print). DOI: 10.1037/0022-3514.84.4.871.

— (2004). "Inspiration: Core Characteristics, Component Processes, Antecedents, and Function." In: *Journal of Personality and Social Psychology* 87.6, pp. 957–973. ISSN: 1939-1315(Electronic),0022-3514(Print). DOI: 10.1037/0022-3514.87.6.957.

Turner-McGrievy, G. M., Helander, E. E., Kaipainen, K., Perez-Macias, J. M., & Korhonen, I. (2015). The use of crowdsourcing for dietary self-monitoring: crowdsourced ratings of food pictures are comparable to ratings by trained observers. Journal of the American Medical Informatics Association, 22(e1), e112-e119.

Vaterlaus, J. Mitchell et al. (Apr. 2015). "#Gettinghealthy: The perceived influence of social media on young adult health behaviors." In: *Computers in Human Behavior* 45, pp. 151–157. ISSN: 0747-5632. DOI: 10.1016/j.chb.2014.12.013. URL: http://www.sciencedirect.com/science/article/pii/S0747563214007286.

Velden, Maja van der and Khaled El Emam (Jan. 2013). ""Not all my friends need to know": a qualitative study of teenage patients, privacy, and social media." In: *Journal of the American Medical Informatics Association* 20.1, pp. 16–24. ISSN: 1067-5027. DOI: 10.1136/amiajnl-2012-000949. URL: https://academic.oup.com/jamia/article/20/1/16/2909199/Not-all-my- friends-need-to-know-a-qualitative (visited on 07/03/2017).

Wang, Qing et al. (2016). "Diet and Physical Activity Apps: Perceived Effectiveness by App Users." eng. In: *JMIR mHealth and uHealth* 4.2, e33. ISSN: 2291-5222. DOI: 10.2196/mhealth.5114.

Wang, Weining and Qianhua He (Oct. 2008). "A survey on emotional semantic image retrieval." In: *2008 15th IEEE International Conference on Image Processing*. ISSN: 2381-8549, pp. 117–120. DOI: 10.1109/ICIP.2008.4711705.

Webb, Marianne et al. (2015). “Designing a Health Screening Tool to Help Young People Communicate with Their General Practitioner.” In: *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction*. OzCHI ’15. event-place: Parkville, VIC, Australia. New York, NY, USA: ACM, pp. 124–133. ISBN: 978-1-4503-3673-4. DOI: 10.1145/2838739.2838756. URL: http://doi.acm.org/10.1145/2838739.2838756 (visited on 09/20/2019).

White, Adrienne A. and Jean D. Skinner (Dec. 1988). “Can goal setting as a component of nutrition education effect behavior change among adolescents?” In: *Journal of Nutrition Education* 20.6, pp. 327–335. ISSN: 0022-3182. DOI: 10.1016/S0022-3182(88)80016-5. URL: http://www.sciencedirect.com/science/article/pii/S0022318288800165 (visited on 08/17/2018).

Whittemore, Robin, Sangchoon Jeon, and Margaret Grey (Apr. 2013). “An Internet Obesity Prevention Program for Adolescents.” In: *The Journal of adolescent health : official publication of the Society for Adolescent Medicine* 52.4, pp. 439–447. ISSN: 1054-139X. DOI: 10.1016/j.jadohealth.2012.07.014. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3608746/ (visited on 05/13/2015).

WHO. (2017). *WHO | Adolescent health*. URL: http://www.who.int/topics/adolescent_health/en/ (visited on 06/21/2017).

Wickham, Catherine A. and Elena T. Carbone (June 2015). “Who’s calling for weight loss? A systematic review of mobile phone weight loss programs for adolescents.” eng. In: *Nutrition Reviews* 73.6, pp. 386–398. ISSN: 1753-4887. DOI: 10.1093/nutrit/nuu018.

Williams, Gillian et al. (Feb. 2014). “Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials.” en. In: *BMJ Open* 4.2, e003926. ISSN: 2044-6055, DOI: 10.1136/bmjopen-2013-003926. URL: http://bmjopen.bmj.com/content/4/2/e003926 (visited on 04/11/2016).

Williamson, Donald A. et al. (2006). “Two-Year Internet-Based Randomized Controlled Trial for Weight Loss in African-American Girls.” In: *Obesity* 14.7, pp. 1231–1243. DOI: 10.1038/oby.2006.140. URL: http://onlinelibrary.wiley.com/doi/10.1038/oby.2006.140/abstract.

Witte, Kim, Gary Meyer, and Dennis Martell (Apr. 2001). *Effective Health Risk Messages: A Step-By-Step Guide*. en. Google-Books-ID: jDM5DQAAQBAJ. SAGE. ISBN: 978-0-7619-1509-6.

Worsley, Anthony (2002). “Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour?” en. In: *Asia Pacific Journal of Clinical Nutrition* 11.s3, S579–S585. ISSN: 1440-6047. DOI: 10.1046/j.1440-6047.11.supp3.7.x. URL: https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1440-6047.11.supp3.7.x (visited on 08/21/2018).

Wouters, Eveline J. et al. (Aug. 2010). “Peer influence on snacking behavior in adolescence.” In: *Appetite* 55.1, pp. 11–17. ISSN: 0195-6663. DOI: 10.1016/j.appet.2010.03.002. URL: http://www.sciencedirect.com/science/article/pii/S0195666310000759 (visited on 02/13/2019).

Wouters, E. J., & Geenen, R. (2013). The influence of friendship groups and media on eating behavior and physical activity in adolescents. International Journal of Child and Adolescent Health, 6(3), 249.

Yi-Frazier, Joyce P. et al. (2015). “Using Instagram as a Modified Application of Photovoice for Storytelling and Sharing in Adolescents With Type 1 Diabetes.” In: *Qualitative Health Research* 25.10, 1372–1382 11p. DOI: 10.1177/1049732315583282.

Yonker, Lael M. et al. (2015). “”Friending” teens: systematic review of social media in adolescent and young adult health care.” eng. In: *Journal of Medical Internet Research* 17.1, e4. ISSN: 1438-8871. DOI: /jmir.3692.

Yosinski, Jason et al. (Nov. 2014). “How transferable are features in deep neural networks?” en. In: URL: https://arxiv.org/abs/1411.1792v1 (visited on 04/30/2020).

You, Q., Luo, J., Jin, H., & Yang, J. (2015, February). Robust image sentiment analysis using progressively trained and domain transferred deep networks. In Twenty-ninth AAAI conference on artificial intelligence.

Zhao, Sicheng et al. (July 2018a). “Affective image content analysis: a comprehensive survey.” In: *Proceedings of the 27th International Joint Conference on Artificial Intelligence*. IJCAI’18. Stockholm, Sweden: AAAI Press, pp. 5534–5541. ISBN: 978-0-9992411-2-7. (Visited on 02/11/2020).

Zhao, Sicheng et al. (Oct. 2018b). “Predicting Personalized Image Emotion Perceptions in Social Networks.” In: *IEEE Transactions on Affective Computing* 9.4, pp. 526–540. ISSN: 2371-9850. DOI: 10.1109/TAFFC.2016.2628787.

Appendix A

A.1 Search Strategy

PubMed

#1 adolescent[Title/Abstract] OR adolescents[Title/Abstract] OR adolescence[Title/Abstract] OR youth[Title/Abstract] OR youth-based[Title/Abstract] OR teen[Title/Abstract] OR teens[Title/Abstract] OR teenager[Title/Abstract] OR teenagers[Title/Abstract] OR pediatric[Title/Abstract] OR college[Title/Abstract] OR student[Title/Abstract] OR students[Title/Abstract] OR ”young adults”[Title/Abstract] OR ”young adult”[Title/Abstract]

#2 diet[Title/Abstract] OR diets[Title/Abstract] OR dietary[Title/Abstract] OR nutrition[Title/Abstract] OR nutritional[Title/Abstract] OR food[Title/Abstract] OR foods[Title/Abstract] OR drinks[Title/Abstract] OR eat[Title/Abstract] OR eats[Title/Abstract] OR eating[Title/Abstract] OR beverage[Title/Abstract] OR beverages[Title/Abstract] OR meal[Title/Abstract] OR meals[Title/Abstract] OR recipe[Title/Abstract] OR recipes[Title/Abstract] OR ”weight loss”[Title/Abstract] OR cooking[Title/Abstract]

#3 app[Title/Abstract] OR apps[Title/Abstract] OR ”cellular phone”[Title/Abstract] OR ”cellular phones” or computer-tailored[Title/Abstract] OR email[Title/Abstract] OR ”health information technology”[Title/Abstract] OR informatics[Title/Abstract] OR internet[Title/Abstract] OR internet-based[Title/Abstract] OR online[Title/Abstract] OR mhealth[Title/Abstract] OR mobile[Title/Abstract] OR ”smart phone”[Title/Abstract] OR smartphone*[Title/Abstract] OR SMS[Title/Abstract] OR technology[Title/Abstract] OR technology-based[Title/Abstract] OR telemedicine[Title/Abstract] OR ”text message”[Title/Abstract] OR ”text messages”[Title/Abstract] OR web-based[Title/Abstract] OR ”short message

service”[Title/Abstract] OR ”multimedia message service”[Title/Abstract] OR computer*[Title/Abstract] OR web-delivered[Title/Abstract] OR technolog*[Title/Abstract] OR electronic*[Title/Abstract] OR netnography[Title/Abstract] OR ”Text messaging”[Title/Abstract] OR ”Web-based learning”[Title/Abstract] OR blogging[Title/Abstract] OR ”social media”[Title/Abstract] OR ”social network*”[Title/Abstract] OR myspace[Title/Abstract] OR twitter*[Title/Abstract] OR Facebook*[Title/Abstract] OR instagram[Title/Abstract] OR ”online discussion”[Title/Abstract]

#4 1 and 2 and 3

#5 adolescent OR Young adult OR Students[MeSH Terms]

#6 Diet OR Food Habits OR Weight loss OR Weight Reduction Programs OR Food OR Beverages OR Menu planning[MeSH Terms]

#7 Internet OR ”Cell Phones” OR ”Electronic Mail” OR ”Telemedicine” OR ”Computers, Handheld” OR ”Mobile Applications” OR Telemedicine OR ”Text Messaging” OR ”social media” OR informatics OR ”Social networking”[MeSH Terms]

#8 5 and 6 and 7 #9 4 or 8

#10 9 and (social or peer)

#11 10 limited to ”last 10 years”[PDat] AND English[lang]

EMBASE

#1 app:ab,ti OR apps:ab,ti OR ’cellular phone’:ab,ti OR ’cellular phones’:ab,ti OR ’computer tailored’:ab,ti OR email:ab,ti OR ’health information technology’:ab,ti OR informatics:ab,ti OR internet:ab,ti OR ’internet based’:ab,ti OR online:ab,ti OR mhealth:ab,ti OR mobile:ab,ti OR ’smart phone’:ab,ti OR smartphone*:ab,ti OR sms:ab,ti OR technology:ab,ti OR ’technology based’:ab,ti OR telemedicine:ab,ti OR ’text message’:ab,ti OR ’text messages’:ab,ti OR ’web

based’:ab,ti OR ’short message service’:ab,ti OR ’multimedia message service’:ab,ti OR computer*:ab,ti OR ’web delivered’:ab,ti OR technolog*:ab,ti OR electronic*:ab,ti OR netnography:ab,ti OR ’text messaging’:ab,ti OR ’web-based learning’:ab,ti OR blogging:ab,ti OR

’social media’:ab,ti OR ’social network*’:ab,ti OR myspace:ab,ti OR twitter*:ab,ti OR Facebook*:ab,ti OR instagram:ab,ti OR ’online discussion’:ab,ti

#2 diet:ab,ti OR diets:ab,ti OR dietary:ab,ti OR nutrition:ab,ti OR nutritional:ab,ti OR food:ab,ti OR foods:ab,ti OR drinks:ab,ti OR eat:ab,ti OR eats:ab,ti OR eating:ab,ti OR beverage:ab,ti OR beverages:ab,ti OR meal:ab,ti OR meals:ab,ti OR recipe:ab,ti OR recipes:ab,ti OR ’weight loss’:ab,ti OR cooking:ab,ti

#3 adolescent:ab,ti OR adolescents:ab,ti OR adolescence:ab,ti OR youth:ab,ti OR ’youth based’:ab,ti OR teen:ab,ti OR teens:ab,ti ORteenager:ab,ti OR teenagers:ab,ti OR pediatric:ab,ti OR college:ab,ti OR student:ab,ti OR students:ab,ti OR ’young adults’:ab,ti OR ’young adult’:ab,ti

#4 1 and 2 and 3

#5 ’adolescent’/exp OR ’adolescent’ OR ’teenager’ OR ’young adult’/exp OR ’adult, young’ OR ’young adult’

#6 ’mobile app’/exp OR ’computer’/exp OR ’internet’/exp OR ’smartphone’/exp OR ’social media’/exp OR ’social networking’/exp OR ’text messaging’/exp OR ’discussion group’

#7 ’eating’/exp OR ’recipe’/exp OR ’diet’/exp OR ’nutrition’/exp

#8 5 and 6 and 7

#9 4 or 8

#10 9 and (social or peer)

#11 10 limited to limited to English, 2006-2016, articles, articles in press, and conference papers

CINAHL

#1 adolescent OR adolescents OR adolescence OR youth OR youth-based OR teen OR teens OR teenager OR teenagers OR pediatric OR college OR student OR students OR ”young adults” OR ”young adult”

#2 diet OR diets OR dietary OR nutrition OR nutritional OR food OR foods OR drinks OR eat OR eats OR eating OR beverage OR beverages OR meal OR meals OR recipe OR recipes OR ”weight loss” OR cooking

#3 app OR apps OR ”cellular phone” OR ”cellular phones” OR computer-tailored OR email OR ”health information technology” OR informatics OR internet OR internet-based OR online OR mhealth OR mobile OR ”smart phone” OR smartphone* OR SMS OR technology OR technology-based OR telemedicine OR ”text message” OR ”text messages” OR web-based OR ”short message service” OR ”multimedia message service” OR computer* OR web-delivered OR technolog* OR electronic* OR netnography OR ”Text messaging” OR ”Web-based learning” OR blogging OR ”social media” OR ”social network*” OR myspace OR twitter* OR Facebook* OR instagram OR ”online discussion”

#4 1 and 2 and 3 in abstract and title

#5 4 limited to English, academic journals, 2006-2016, exclude Medline

PsycINFO

#1 adolescent OR adolescents OR adolescence OR youth OR youth-based OR teen OR teens OR teenager OR teenagers OR pediatric OR college OR student OR students OR ”young adults” OR ”young adult”

#2 diet OR diets OR dietary OR nutrition OR nutritional OR food OR foods OR drinks OR eat OR eats OR eating OR beverage OR beverages OR meal OR meals OR recipe OR recipes OR ”weight loss” OR cooking

#3 app OR apps OR ”cellular phone” OR ”cellular phones” OR computer-tailored OR email OR ”health information technology” OR informatics OR internet OR internet-based OR online OR mhealth OR mobile OR ”smart phone” OR smartphone* OR SMS OR technology OR technology-based OR telemedicine OR ”text message” OR ”text messages” OR web-based OR ”short message service” OR ”multimedia message service” OR computer* OR web-delivered OR technolog* OR electronic* OR netnography OR ”Text messaging” OR ”Web-based learning” OR blogging OR ”social media” OR ”social network*” OR myspace OR twitter* OR Facebook* OR instagram OR ”online discussion”

#4 1 and 2 and 3 in abstract and title

ACM Digital library

#1 adolescent OR adolescents OR adolescence OR youth OR youth-based OR teen OR teens OR teenager OR teenagers OR pediatric OR college OR student OR students OR ”young adults” OR ”young adult”

#2 diet OR diets OR dietary OR nutrition OR nutritional OR food OR foods OR drinks OR eat OR eats OR eating OR beverage OR beverages OR meal OR meals OR recipe OR recipes OR ”weight loss” OR cooking

#3 1 and 2 in abstract

#4 3 and (social or peer or peers)

A.2 Downs Black Checklist

	Study (Last name, publication year)															
Checklist for measuring study quality	**Allman-Farinelli 2016**	**An 2013**	**Chung 2016**	**Doyle 2008**	**Godino 2016**	**Hutchesson 2016**	**Jones 2014**	**Kulik 2015**	**Lana 2014**	**Laska 2016**	**Leme 2016**	**Napolitano 2014**	**Nawi 2015**	**Smith 2014**	**Svetkey 2015**	**Whittemore 2013**
Total Score (out of 31)	22	16	8	13	20	14	13	17	17	20	20	17	11	21	21	18
Total Percentage	1	1	0	0	1	1	0	1	1	1	1	1	0	1	1	1
Reporting																
1. Is the hypothesis/aim/objective of the study clearly described?	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1
2. Are the main outcomes to be measured clearly described in the Intro or Methods section?	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1
3. Are the characteristics of the patients included in the study clearly described?	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
4. Are the interventions of interest clearly described?	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
5. Are the distributions of principal confounders in each group of subjects to be compared clearly described?	1	1	0	1	1	1	1	0	1	1	0	1	1	0	1	1

6. Are the main findings of the study clearly described?	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
7. Does the study provide estimates of the random variability in the data for the main outcomes?	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1
8. Have all the important adverse events that may have been a consequence been reported?	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
9. Have the characteristics of patients lost to follow-up been described?	1	0	0	0	0	1	0	1	1	1	1	1	0	1	1	1
10. Have actual probability values been reported for the main outcomes except where the probability was less than 0.001?	1	1	0	1	1	1	1	1	0	1	1	0	1	1	1	1
External Validity																
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	1	1	1	1	1	0	0	0	1	1	1	1	0	1	0	0
12. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?	na	na	na	na	na	na	na	0	0	0	1	0	na	1	na	na
Internal Validity - bias																
14. Was an attempt made to blind study participants to the intervention they have received?	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
15. Was an attempt made to blind those measuring the main outcomes of the intervention?	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0
16. If the results of the study were based on "data dredging" was this made clear?	na	1	0	na	1	na	na	0	1	0	1	0	na	1	na	na
17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?	1	0	0	na	1	na	na	1	1	1	1	1	0	1	1	1
18. Were the statistical tests used to assess the main outcomes appropriate?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19. Was compliance with the intervention(s) reliable?	1	1	1	0	0	0	1	1	0	0	0	1	0	0	1	1

20. Were the main outcome measures used accurate (valid and reliable)?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Internal Validity - confounding																
21. Were the patients in different intervention groups or were the cases and controls recruited from the same population?	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1
22. Were study subjects in different intervention groups or were the cases and controls recruited over the same period of time?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23. Were study subjects randomized to intervention groups?	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1
24. Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?	1	0	0	0	1	na	0	0	0	1	0	0	0	0	0	0
25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	1	0	0	1	1	0	0	0	1	1	1	0	0	1	1	1
26. Were losses of patients to follow-up taken into account?	1	0	0	0	1	1	0	1	1	1	1	1	0	1	1	1
Power																

27. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?	0	0	0	0	1	0	0	0	0	0	0	0	1	2	1	0

Appendix B

B.1 Interview Guide for Focus Group

GIG Kids Nutrition Focus Group Guide

Hello, my name is XYZ, I am a researcher here at Columbia University. I design computing applications that help people to live healthier lives. (more background on me)

1. Introductions

Why don't we start with a round of introductions, could you please say a few words about yourself: your name, where you go to school, and may be one interesting fact about you.

Today we are here to talk about food and eating. And let's start with something fun.

2. General attitudes towards food and eating

- What are your favorite places to eat?
- What are some other places where you get meals? - What are your favorite foods?
- Where do you usually get to eat them?
- What are your least favorite foods?
- Where do you have to eat those?

- Likes, dislikes
- What they know - General attitude

If you have been here before than you probably had some people here talk to you about what is healthy and what is not healthy and foods that you should eat a lot of and also foods that you should really try to stay away from. Let's talk more about that.

Themes to explore:

3. Understanding of healthy eating

- What are some of the healthy foods that you like or at least ok with?
- What are some of the healthy foods that you know you should eat but are not

going to no matter what?
- What are some of the foods you think are not very good for you? Why do you

think they are not good?

- Likes, dislikes
- What they know - General attitude

Ok, so we talked about what healthy foods you know and like, and what some of the foods that you should only eat sometimes. Let's talk more about how easy it is to eat healthy.

Themes to explore:

4. Attitudes and barriers to healthy eating

- Where do you usually get to eat healthy foods?

- When you eat out, do you usually choose healthy foods or not so much? - When you eat at home, what kinds of things do you get to eat?
- Is it easy to find healthy choices? (if not, what makes it difficult?)

- Peer pressure
- Access issues (availability, cost)
- Cultural and social barriers (habits, what's available at home) - General lack of choices

Ok, we just talked about some of the reasons why eating healthy may not be as easy. Can we now think about what would make it easier? What do you think would help you?

B.2 Mealyzer endline questionnaire and interview guide

COLUMBIA UNIVERSITY
MEDICAL CENTER

Mealyzer-Youth Pilot Study
Endline Questionnaire & Semi-Structured Interview
Columbia University Medical Center
2016

Individual Questionnaire for Adolescents aged 13-25

BACKGROUND INFORMATION

Respondent Information
Respondent serial number …….. ☐☐
Respondent name
Respondent address
Interview Information

Name of the interviewer	
Date of the interview Month Day Year ☐☐ ☐☐ ☐☐☐☐	Result of interview* ☐
*Visited result codes : 1. Interview completed 2. Partially completed 3. Refused 4. Others (specify)_____	
Time Started ☐☐hr☐☐min Time Completed ☐☐hr☐☐min.	
Edited and coded by (Official use only) : Name …….Signature :…….. Date:……..	

BACKGROUND CHARACTERISTICS

No	Question	Response	Code	Skip
101.	How old are you? (Please write in completed years)	Years☐☐		
102.	What is your date of birth?	☐☐ ☐☐ ☐☐☐☐ Day Month Year Don't know ……	 98	
103.	What is your highest completed class/grade?	☐☐ 00= No education 01-12 = For Grades 1 – Grade 12 14= Some associates college 15 = Associate's degree 16 = Some bachelors college 17 = Bachelor's degree 18= Some graduate school 19 = Graduate degree 20= Professional degree 98=Don't know 99= Not applicable		

104.	Are you currently attending or enrolled in school?	Yes No	01 02	

SEMI-STRUCTURED INTERVIEW GUIDE

Interview questions (Probes below questions):

General health questions

1. Tell my why you decided to participate in our study.
2. What did you hope to learn by using the Mealyzer application?
    a. What aspects of your health were you interested in learning about?
    b. Did you have a health issue? Were you trying to get healthier? Were you just curious?
3. Have you ever used other mobile health application to track your health?

Impressions of the application and features

4. What are your thoughts on the Mealyzer application? Did you like it? Did you not like it?
5. What was your experience using the application?
    a. How long did you use the application? Did you find it fun? Boring?
    b. What was challenging? What was easy?
6. What features did you find useful or not useful? What features do you wish it had?
7. What features did you use most frequently?
8. How did you feel about logging your meals every day?
    a. What made it easy? What made it difficult?
9. How did you feel about sharing your meal photos?
10. How did you feel about having your meals evaluated by a registered dietician?

Learning about nutrition

11. What features were most helpful in helping to learn about nutrition?
12. What did you think about the nutritionist feedback feature?
13. How did the feedback from a registered dietician affect how you used the application?
    a. Did it change how you conducted your goal assessments?
14. Did you realize other users' were also using the Mealyzer application? Did you learn anything from other users' meals?
15. How did using this application affect how you feel about managing your diet and nutrition?

Thank you very much. This is the end of the interview.

Appendix C

C.1 Interview Guide

IRB protocol # AAAR9199

Attachment 5: Semi-structured Interview Guide

Thank you for agreeing to participate in our research study! In this study we are interested in how young adults such as yourself use social media for health and wellness. We invited you because you said you were using social media for wellness. We want to hear your thoughts on health, what types of activities you participate in related to it, and how you incorporate technology and social media into these activities. Let's get started ...

Interview questions (Probes below questions):

Introduction questions

1. Where are you from? (*If from outside of NY*) Why did you move here?
2. Where do you live now? Who do live with?
3. Are you in school? What is your year and major?
4. Do you have a job? Where do you work?

General health and wellness questions

5. Could you describe a typical day for yourself? Where do you spend most of your day? When, what, and where do you eat? Do you exercise or play sports? What other activities do you participate in?
6. People often have different ideas about what it means to be healthy and what health and wellness is for them...
    1. What does being healthy mean for you in your life?
    2. What parts of health and wellness are most important to you?
    3. How often do you think about these things?
7. What are the regular things you do to be healthy? What are things you'd ideally do for your health?

Health and wellness information

8. Can you tell me about a time when you wanted to do something healthy for yourself and tried to find information online about it?
9. Do you ever look for health and wellness information online? Where do you look for it? What are your favorite sources? What kind of information do you look for? Is this something you do regularly?

Communication about health and wellness

10. Do you ever talk with other people about health and wellness?

    1. Who? (see how they respond)
    2. Where? Online or in person? In social groups?
    3. What do you talk about?

11. Can you give an example of a time when someone you know (not a clinician) helped you with more information on a health issue? Who were they? How did they help (actions, info, etc)?

General social media questions

12. Thinking about your day yesterday, did you use any social media?

    1. What did you do? (e.g. read, post, follow, view video)
    2. What applications did you use? What type of social media was it (E.g. videos, photos, chat, etc)?
    3. Did you look at anyone else's accounts? Whose accounts did you look at? E.g. friends/family, celebrities, politicians, scientists, influencers?
    4. Did you use social media to communicate with anyone? Who (people you know, don't know)? What did you talk about?

13. How do you use social media on a regular basis?

    1. What social media platforms do you use and what do you use each of them for?
    2. How often do you use social media?
    3. Does this change over time... if so, how?

14. Are you a part of any social media groups?

    4. What groups?
    5. How large is the group?
    6. Do you know anyone in the group?
    7. Are there moderators in the group? How do you interact with them?
    8. How do you interact with each of these groups?

Social media following

15. Do you follow others on social media? Who? How many? Why?
16. What types of accounts do you follow? For example, friends, family, celebrities, companies, etc. Can you tell me why you follow each type of group?
17. Who are your favorite people or accounts that you follow?
18. Do you ever interact with the people you follow (if not, why not?)?
19. Have you ever unfollowed anyone? Why?

20. Do other people follow you? Is it important to you? Do you know who follows you? Do you ever interact with them?

Using social media for health and wellness

Let's talk about using social media for health and wellness...

21. Can you give an example of a time you used social media for health and wellness?

    1. Were you looking for information or were you browsing?
    2. Do you do this often or was this a one-time thing?

22. How do you generally use social media for health and wellness?

    1. What do you use it for?
    2. How often? Is that how it's been always or has it changed over time?

23. Do you follow anyone who posts about health and wellness?

    1. What are your favorite accounts (specific sites/accounts)?
    2. What do you like looking at (videos, photos) for health and wellness? Why?
    3. How do you know these people? Are they friends/family, celebrities, influencers?
    4. How did you find these accounts?
    5. What sources do you not like? Why?

24. Are you a member of any social media groups related to health and wellness? E.g. friend/family chats groups; exercise/cooking groups; online health forums; teams; classes
    1. What groups?
    2. Why did you join the groups?
    3. How did you find these groups?
    4. How large is the group?
    5. Do you know anyone in the group?
    6. Are there moderators in the group? How do you interact with them?
    7. What do you do in the groups? E.g. read/post content publicly/privately, talk to others.
    8. What do you like about these groups? What would you change?
25. Can you tell me about a time when you saw something on social media that was related to health and wellness that was...
    1. Use cases
       a. Useful
    2. Controversial or not true
    3. When you saw something on social media that made you change a health behavior. What behavior did you change?
    2. What did you see on social media?

3. Who created the social media content? What did you know about them?
4. How much did you trust this content?

26. Can you tell me about a time you posted something health and wellness related on social media?

1. Why did you post about it (e.g. giving advice, asking a question, getting a recommendation, post a review ab medical provider)?
2. Did anyone react to it? Who were they? What were their reactions?
3. Typically, when you post on social media, do you expect people to react?

27. Do you ever talk with other people about the health and wellness content you see?

4. Who?
5. What type of media was it?
6. Did you use social media to communicate with them? How (e.g. chatting, posting, sharing, etc)?

Trust in social media

28. We talked about who you follow on social media, would you say that you trust the information they post? Is it one of the considerations for choosing who to follow?

29. How much trust do you usually have in health information of social media? How do you decide what information to trust?

30. How does your level of trust compare between social media and other sources of information on health and wellness?

Thank you very much. This is the end of the interview.

C.2 Survey

COLUMBIA UNIVERSITY
IRVING MEDICAL CENTER

Young Adults Social Media Study
Columbia University Irving Medical Center
2018

Individual Survey Questionnaire for Young Adults aged 18-27

BACKGROUND INFORMATION

Respondent Information	
Respondent serial number …….. ☐☐	
Interview Information	
Name of the interviewer	
Date of the interview Month Day Year	Result of interview*
☐☐ ☐☐ ☐☐☐☐	☐

* Result codes :

1. Completed 2. Partially completed 3. Refused 4. Other (specify)_____

No	Question	Circle or Write in Response	
	DEMOGRAPHIC INFORMATION		
105.	What is your age? (Please write in completed years)	Years☐☐	
106.	What is your race/ethnicity?		
107.	Are you Hispanic?	01 = Yes 02 = No	
108.	Are you currently in school?	01 = Yes 02 = No	
109.	What is your current or highest completed class/grade? (circle all that apply)	00 = No education 01-11 = For Grades 1 – Grade 11, **Write in grade _____** 12 = High school diploma 13 = Some associates college	

		14 = Associate degree 15 = Some bachelor college 16 = Bachelor degree 17 = Some graduate school 18 = Graduate degree 19 = Professional degree	
110.	What is your mother's highest education level completed?	00 = No education 01-11 = For Grades 1 – Grade 11 **Write in grade _____** 12 = High school diploma 13 = Associate degree 14 = Bachelor degree 15 = Graduate degree 16 = Professional degree	

		99 = Don't know	
111.	What is your father's highest education level completed?	00 = No education 01-11 = For Grades 1 – Grade 11 **Write in grade _____** 12 = High school diploma 13 = Associate degree 14 = Bachelor degree 15 = Graduate degree 16 = Professional degree 99 = Don't know	
INTERNET ACCESS			
112.	Do you own a computer (desktop or laptop)?	01 = Yes 02= No	
113.	Do you own a tablet computer (iPad, Samsung Galaxy Tab, Amazon Fire, etc.)?	01 = Yes 02= No	

114.	Do you have access to the internet at home?	01 = Yes 02= No	
115.	Do you own a mobile phone (has ability to make phone calls)?	01 = Yes 02= No	
116.	Do you own a smart phone (has internet capabilities)?	01 = Yes 02= No	

SOCIAL MEDIA

Social media includes websites and applications that enable content creation, sharing, and participation in social networking. This includes social networking sites/apps, microblogging, photo sharing, video sharing, and chatting apps.

117.	Do you use social media?	01 = Yes 02= No	
118.	How often do you use social media?	01 = Several times a day 02 = About once a day 03 = A few times a week 04 = Every few weeks 05 = Less often 06 = Never 07 = Don't know	
119.	What are the top 3 social media apps/websites that you use?	1. 2. 3.	
120.	Which of the following social media platforms do you use?	01 = Facebook 02= Instagram 03 = SnapChat 04 = WhatsApp 05 = Tumblr	

		06 = YouTube 07 = Twitter 08= Pinterest 09 = Kik 10 = WeChat 11 = KakaoTalk 12 = Viber 13 = Line 14 = GroupMe 15= Google Hangouts 16 = Google Duo 17 = LiveMe 18 = IMO 19 = TextFree 20 = Yarn 21 = WishBone 22 = musical.ly 23= Discord 24 = Whisper Write in others you like to use:	

121.	What reasons do you use social media?	01 = Staying in touch with friends 02 = Staying in touch with family 03 = Connecting with old friends you've lost touch with 04 = Connecting with others who have shared interests (e.g. health, hobbies, politics/activism) 05 = Making new friends 06 = Finding potential romantic or dating partners 07 = Reading general news and political articles 08 = Reading articles on health 09 = Reading pop culture articles (art, TV, celebrities, fashion, music, etc) 10 = Reading opinions/comments from celebrities, athletes 11 = Reading opinions/comments from politicians 12 = Reading opinions/comments from social media personalities and influencers 13 = Reading random articles and memes 14= Finding local events 15 = Finding local shopping 16 = Self promotion 17 = Activism (Political, social, etc)	

		18 = Other Write in other reasons:	
122.	What health and wellness topics are you interested in?	01 = Nutrition/Food 02 = Fitness/Exercise 03 = Weight loss 04 = Weight/muscle gain 05 = General preventative health / Wellness 06 = Chronic disease management 07 = Sexual/reproductive health 08 = Mental health 09 = Substance abuse 10 = Beauty/skincare 11 = Stress management 12 = Life hacks/tips/organization 13 = Other Write in topics:	
123.	What health and wellness topics do you view on social media?	01 = Nutrition/Food 02 = Fitness/Exercise 03 = Weight loss	

		04 = Weight/muscle gain 05 = General preventative health 06 = Chronic disease management 07 = Sexual/reproductive health 08 = Mental health 09 = Substance abuse 10 = Beauty/skincare 11 = Stress management 12 = Life hacks/tips/organization 13 = Other Write in topics:	
124.	Name your favorite health and wellness social media accounts		
125.	Where do you find information about health online?	01 = Friends 02 = Family 03 = General news websites (Yahoo, Google, CNN, FoxNews, NYTimes, NBC, etc)	

		04 = Physician/Hospital websites 05 = University websites (.edu) 06 = For profit Medical websites (WebMD, .com) 07 = Government websites (.gov) 08 = Non-governmental health organizations websites (WHO, Planned Parenthood, .org, etc) 09 = Religious websites 10 = Online encyclopedias (Wikipedia, etc) 11 = Personal websites/blogs (not family or friends) 12 = Microblogging (Twitter, Tumblr) 13 = Online communities/message boards (Reddit, Health communities) 14 = Question and answer websites (Quora, Yahoo Answers, Stack Exchange) 15 = Photo sharing apps/sites (Instagram) 16 = Video sharing apps/sites (YouTube, etc) Write in other types:	

126.	What types of food and nutrition content do you view on social media?	01 = Articles on nutrition 02 = Recipes 03 = Cooking/Recipe videos 04 = General food experience videos 05 = Nutrition videos 06 = Photos of foods (foods alone or people eating food) 07 = Social media accounts for food or chefs or influencers 08 = Others Write in: 09 = None	
127.	What general level of trust do you have in health and wellness information you find online?	01 = Strongly trust 02 = Trust 03= Neutral 04 = Distrust 05 = Strongly distrust	

128. How much do you trust the following sources of health and wellness information?

Mark an X below each category

	Strongly trust	Trust	Neutral	Distrust	Strongly distrust
Friends					
Family					
General news websites (Yahoo, Google, CNN, FoxNews, NYTimes, NBC, etc)					
Physician/Hospital websites					
University websites (.edu)					
For profit Medical websites (WebMD, .com)					
Government websites (.gov)					
Non-governmental health organizations websites (WHO, Planned Parenthood, .org, etc)					
Religious websites					
Wikipedia					

Personal websites/blogs (not family or friends)						
Microblogging (Twitter, Tumblr)						
Online communities/message boards (Reddit, Health communities)						
Question and answer websites (Quora, Yahoo Answers, Stack Exchange)						
Photo sharing apps/sites (Instagram)						
Instructional/How-to video sharing						
Informational video sharing						