POLICY IMPLICATIONS OF SMARTPHONE USAGE AND HOLISTIC WELLBEING AMONG YOUTH IN URBAN SASKATCHEWAN: A SMART PLATFORM STUDY

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Abstract

Background: Screen time on multiple digital devices has become an integral part of population behavior. Globally, populations have access to a variety of digital devices and engage in high levels of screen time activities starting in early childhood. It is well established that increased levels of screen time-based sedentary behaviours have significant negative impacts on health, however, the relationship between screen time behaviours, types of devices, and holistic wellbeing remains complicated and not well understood. In particular, smartphone technology has become increasingly popular and almost all age cohorts engage in smartphone usage for a wide variety of activities.

Objectives: This study aims to investigate the relationship between screen time accumulated on smartphones and holistic wellbeing among youth and young adults (13 to 21 years) in Saskatchewan urban centres. This thesis will address the following questions: 1) Is there an association between smartphone usage (internet surfing, video gaming, texting, etc.) and mental health outcomes such as anxiety and depression?; 2) Is there an association between smartphone usage and physical health outcomes such as weight status?; and 3) Is there an association between smartphone usage and perceived health such as self-rated health and self-rated mental health?

Methods: This study is part of the Smart Platform, a digital epidemiological and citizen science initiative for ethical population health surveillance, integrated knowledge translation, and policy interventions. Citizen science engages all participants throughout the research process either for contribution, collaboration, or co-creation of knowledge. Citizen scientists provided all data via their smartphones using a custom-built smartphone application, including a baseline questionnaire that combines validated self-report surveys to record physical activity, sedentary
behaviours, screen time behaviours, demographic characteristics, and health outcomes such as mental wellbeing, weight status, and self-rated health.

Results: 808 youth and young adult citizen scientists (aged 13 to 21) were recruited through Regina Public and Catholic School engagement sessions held in various high schools throughout Regina, Saskatchewan in 2018. Binomial Regression analyses were conducted to determine how quantitative measures inform the relationship between smartphone usage and holistic wellbeing in youth populations in Saskatchewan.

Policy Implications: To our knowledge, this is the first digital epidemiological study to understand the association of smartphone usage with holistic health outcomes across youth and young adult populations. The findings of this study will have several policy implications, including: 1) Development of age-appropriate policy interventions to address smartphone usage; 2) Inform and influence ethical population health surveillance; 3) Advance recommendations for smartphone usage to deploy mHealth interventions to monitor, mitigate, and manage communicable and non-communicable diseases.
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Chapter 1: Introduction

1.1 Screen Time and Digital Device Usage

Time spent on screens using multiple digital devices (e.g., computer, mobile phone, tablet, television) engaging in a variety of behaviours (e.g., work, leisure, entertainment, gaming, etc.) has become fundamental in population behavior (Katapally & Chu, 2019; Deloitte, 2017; Wong et al., 2020). In the 21st century, populations across the world have access to digital devices and engage in screen time activities starting from early childhood (Radesky, Schumacher, & Zuckerman, 2015). The association between the excessive use of screen time devices and negative health outcomes is often only understood through sedentary behavior research. According to the Sedentary Behavior Research Network, sedentary behavior is any waking behavior that has an energy expenditure of less than or equal to 1.5 metabolic equivalents (METs) (Tremblay et al., 2017). Typically, Canadians are highly sedentary and spend most of their day sitting using digital devices and screens averaging well over 8 hours per day (Tremblay et al., 2017; Statistics Canada, 2017).

High levels of screen time behaviors have commonly been associated with negative health outcomes, even if individuals are highly active for other parts of the day and week (Tremblay et al., 2017; Owen et al., 2010). For example, individuals who report high rates of sedentary behavior, regardless of their physical activity level, are associated with negative health outcomes such as cardiovascular disease, type 2 diabetes, and some types of cancer (Hamilton et al., 2008; Wilmot et al., 2012). In Canada, it is recommended that youth engage in less than two hours of screen time per day (CSEP 2021), however, other countries have taken further steps to
regulate use of electronic devices. For example, most recently announced is the Chinese government’s decision to restrict online gamers under the age of 18 from playing video games during the week and only three hours on weekends (CNN, 2021). The situation is even more dire for Canadian adults as there are currently no concrete recommendations or guidelines set for adults in Canada; aside from limiting screen time as much as possible (Government of Canada, 2019).

It is evident that time spent on screens may have an association with health outcomes. However, types of screen time behavior may further exacerbate the association. Screen time behaviors, on a variety of devices, are all unique behaviors that have distinct impacts on health. In other words, on our electronic devices, time spent watching television does not have the same health impacts as time spent reading a novel on our tablet, or time spent texting-messaging our friends on a smartphone (Rosen, 2018; Meir et al., 2007). When attempting to understand how screen time can impact populations, it is important to not only consider how much screen time a population engages in, but rather, the entire context; what type, when, and what device (Rosen, 2018).

While there are recommendations available to limit screen time in general, the relationship between screen time use, type of digital device and activity, motivations, and overall health is complicated and not well understood. This is particularly concerning considering how emerging evidence shows that different types of digital devices may have unique impacts on health (Silva et al., 2018; Edelson et al., 2016) and that smartphones usage, specifically, has a relationship with health (Grimaldi-Puyana, et al., 2020). Screen time behaviors can have a wide range of negative health outcomes on mental, physical, emotional, and social health (Hoare, et al., 2016; Twenge, Martin, & Campbell, 2018; David, Roberts, & Christenson, 2018). For
example, excessive screen time has been associated with poor self-esteem, depression, anxiety, suicidal thoughts, (Hoare, et al., 2016; Twenge, Martin, & Campbell, 2018) poor eye development (Gudgel, Khurana, & Turbet, 2020; Ku et al., 2018; Wong et al., 2020), problems with posture, respiratory function (Jung et al., 2016) obesity, violent behavior, poor development of social skills, and negatively impacts relationships with friends and family (David, Roberts, & Christenson, 2018; Silva et al., 2018; Subrahmanyam et al., 2000). By contrast, emerging systematic reviews conclude that there is insufficient evidence for associations between screen time and many health issues (Stiglic & Viner, 2019).

Current evidence suggests that the association between high levels of screen time behavior and poor health are often consistent regardless of age, gender, socio-economic status, parental education, geographic location, physical activity levels, weight status, or nutrition (Hoare et al., 2016). However, other researchers present evidence that indicates health impacts from screen time behaviors can differ, for example, between genders and types of devices. For instance, in a study conducted by Silva et al. (2018) higher television viewing time, not computer/video gaming screen time was associated with poor self-rated health, but only for males. By contrast, higher television viewing time and computer/video gaming screen time had other negative health impacts for females; namely, with social relationships (Silva et al., 2018). For example, when adolescents were asked to rate their personal satisfaction in their relationships with their friends, family, and teachers, females who demonstrated higher television viewing time reported lower satisfaction in their social relationships. However, females who reported higher computer and video gaming screen time reported better self-rated health and higher satisfaction with family and friend relationships (Silva et al., 2018).
Moreover, although screen time is typically understood as a negative behavior, some studies conclude that not all screen time activity will necessarily have poor impacts on health. Current evidence suggests that youth can engage in screen time behaviors that help them succeed academically, socially, and cognitively (Javed, Ahmed, & Khan, 2017). For example, smartphone applications (apps), such as e-book apps have been associated with increased well-being (David, Roberts, & Christenson, 2018). Furthermore, digital technology enables social connection, which has been especially important since the Corona virus Disease (COVID-19) pandemic began. During this global health crisis access to digital tools has been invaluable to not only connect socially and maintain mental health while following physical distancing public health orders (De’, Pandey, & Pal, 2020; Government of Saskatchewan, 2020), but also to maintain productivity in many sectors (De’, Pandey, & Pal, 2020; United Nations, 2020).

Generations are using screen time now, more than ever, to connect, learn, and work (UNICEF, 2020; De’, Pandey, & Pal, 2020). Health Professionals heavily rely on technology to provide critical services (Ramsetty, & Adams, 2020). While higher volumes of digital device usage and screen time accumulation has become inevitable, it is critical to understand how these behaviors will influence population health, particularly in a world where digital engagement has become the primary form of communication (Clark, 2013; United Nations, 2020). It is clear that digital tools are essential to present day life, however, there is little evidence or understanding of what the population health impacts are of screen time accumulated on multiple devices. Without this evidence in place, it is difficult to develop policies and guidelines for healthy engagement using digital tools in the 21st century. As smartphones are the primary digital device of communication across the globe, it is imperative that we understand how smartphone usage will impact health. For the purposes of this study, smartphone usage includes behaviours such as
internet use, gaming, and texting; all of which youth and young adults self-reported using their own smartphone devices.

1.2 Prevalence of Smartphone Technology and Mobile Health Interventions

Globally, 53% of adults report sitting in front of a screen for over four hours per day (Harvey, Chastin, & Skelton, 2013). Most studies focus primarily on leisure time such as television and computer screen time activities, which have shown that adults are highly engaged in screen time-based sedentary behavior (Harvey, Chastin, & Skelton, 2013). Atkin et al. (2014) conducted a study where children aged 4-17 years old either self or proxy reported screen time usage and found that, even with public health guidelines in place, two thirds of the youth in their study engaged in an excessive amount of screen time, which was greater than two hours per day.

Historically, access to smartphone technology was more common for people living in wealthier countries, however, in recent years this gap has been closing (Poushter, Bishop, & Chew, 2018). Worldwide there are over 6 billion people that have smartphone subscriptions and it is projected that this will grow to over 7.5 billion by 2026 (O’Dea, 2021). In Canada, there are approximately 31.38 million smartphone users and this is projected to be over 34 million by 2024 (O’Dea, 2020). With the high rate of smartphone market penetration (O’Dea, 2020) across the globe, it is critical to understand the relationship between smartphone usage and population health.

Due to the ubiquitous nature of smartphone presence, all ages within a population can engage in a variety of screen time activities using just their smartphones, including learning and education, research, social communications, television watching, video gaming, online shopping, online banking, and checking email (Kahut, 2012; Clark, 2013). Some of the most commonly reported behaviors include texting, picture taking/sharing, and social networking (Kahut, 2012).
Furthermore, smartphone devices have the same capabilities of a fully functioning computer but in the convenient size of a wireless hand-held device. Smartphone technology has, arguably, more connectivity possibilities and advances than any other form of screen time technology in which populations can engage in primarily sedentary activities such as watching television, gaming, and communications such as texting. Youth, in particular, may be accessing smartphone technology even more so than any other device. For example, some studies in the United States show that while only 88% of teenagers report having access to a desktop or laptop computer, 95% report having access to a smartphone (Anderson & Jiang, 2018). Furthermore, reduced access to a computer was associated with household income, where families who had greater income were more likely to own a desktop or lap top computer, whereas, smartphone technology access appears to be universal among families regardless of gender, race, ethnicity, and socioeconomic background (Anderson & Jiang, 2018).

In recent years there is emerging research on specific screen time behaviours, mostly evidence focused on social media use, especially with the youth population. However, there is a lack of research on smartphone usage as a whole, including all behaviours such as internet, gaming, and texting, as well as, comparing how each of these behaviours are related to population health and wellbeing. This evidence is particularly important to generate because smartphones are being increasingly used for mobile health (mHealth) interventions. mHealth can be broadly defined as the use of mobile tools such as smartphones, tablets, and other wearable devices that can be used to engage with individuals for research purposes (Akter, 2010; Vital Wave Consulting, 2009). Evidence has also shown that there is potential for mobile devices to improve health care and patient monitoring in remote communities (Akter, 2010; Vital Wave Consulting, 2009). Furthermore, mobile devices are useful for collecting data with remote and
isolated populations since these devices can create, store, retrieve, and transmit data between users in real time (Akter, 2010; Vital Wave Consulting, 2009). As there is growing potential for mHealth interventions to address urgent population health crises, it is imperative to understand the impacts of smartphone usage to better inform these mHealth approaches.

1.3 Citizen Science and Digital Epidemiology

Citizen science based research is a participatory approach to conduct research, where researchers collaborate with participants, termed “citizen scientists,” starting from data collection all the way through to knowledge translation (Katapally et al., 2018; Silvertown, 2009; Katapally, 2019). Citizen science is applicable to the field of population health science to address health inequity (Katapally, 2019). Using reliable and accessible digital tools and technologies, such as smartphones, can enhance citizen science approaches (Katapally et al., 2018; Katapally, 2019). mHealth research has shown that the ubiquitous nature of mobile devices (e.g., inexpensive, accessible, user-friendly, fast, etc.) makes them a desirable technology for citizen science-based population health research (Akter, 2010; Kaplan, 2006).

In terms of population health, the growth in smartphone usage and increasingly digital connectivity (Deloitte, 2017) has resulted in advancements in the area of digital epidemiology (Salathé, 2018, p. 2; Park et al., 2018). In essence, digital epidemiology can be defined as epidemiology that uses digital data that was generated outside the public health system, i.e. with data that was not generated with the primary purpose of doing epidemiology (Salathé, 2018; Park et al., 2018). For instance, it is possible to gather data from internet web search engines or social media sites to better understand what a population is searching for, when they searched it, and where their location was while they searched it (Park et al., 2018). The future of digital epidemiology potentially lies in smartphone technology, where participants can be engaged in
real-time for ethical population health surveillance, integrated knowledge translation, policy, and real-time interventions (Katapally et al., 2018).

Smartphone devices can be used to capture complex data, including physical, social, and behavioral determinants of health (Katapally et al., 2018). Smartphones allow consistent engagement with participants through the entire research process, as opposed to just during data collection (Katapally, 2019). mHealth and citizen science methodological initiatives, such as Smart Platform are leveraging the unique characteristics of ubiquitous devices, such as smartphones, to better understand population behaviors and outcomes, and develop population health interventions (Katapally et al., 2018). The Smart Platform engages citizen scientists through their smartphones to understand health-related behaviors, including screen time use on a variety of electronic devices (Katapally, 2019). This thesis uses data obtained by the Smart Platform to understand smartphone usage in youth and young adults in urban Saskatchewan.

Chapter 2: Literature Review

It is undeniable that screen time, and more specifically, smartphone usage, is integrated into societal systems and daily activities, however, very little is known about how these behaviours impact populations health. In Saskatchewan, there are major challenges with finding opportunities to be active outdoors and there are concerns with how to balance this with screen time activities (Hassan, 2020). Additionally, the need for more and better access to mental health services in Saskatchewan has been identified as a major priority where rural and remote populations, as well as, youth are in great need of support (Government of Canada, 2020). This thesis attempts to capture a holistic approach to understanding the relationship between smartphone use and aspects of physical, mental, and self-rated health to inform policies and practices that support responsible screen time activity for youth.
2.1 Mental Health

While there may be advantages to advancing digital technology, excessive screen time is predominantly associated with poor mental health, including self-esteem, depression, anxiety, suicidal thoughts, and loneliness (Hoare et al., 2016; Twenge, Martin, & Campbell, 2018). Studies have shown that adults who engage in high levels of screen time behaviors, particularly those that are more passive, can experience above average levels of boredom, technological anxiety, and even poor executive functioning resulting in low academic performance (Rosen, 2018). Alternatively, some systematic reviews have argued that there is insufficient evidence for associations between screen time and health issues such as anxiety, poor self-esteem, poor cognition, poor sleep outcomes, or suicidal ideation (Stiglic & Viner, 2019). No systematic reviews were found that conducted research specifically targeting smartphone usage behaviors.

Emerging research suggests that social media use is becoming quite common on smartphones specifically (Anderson & Jiang, 2018) and there is cause for concern that this specific behavior may have negative impacts on mental health (Heffer et al., 2019). Heffer et al. (2019) conducted a longitudinal study with adolescent and young adult cohorts examining the relationship between depressive symptoms and social media specific screen time use. Results showed that in the female adolescent cohort, greater depressive symptoms actually predicted more frequent social media use (Heffer et al., 2019).

Alternatively, some research indicates that there is a more complicated bi-directional relationship between a variety of factors that have unique impacts on youth and adult mental health. In a longitudinal study conducted by Gunnell et al. (2016) with Canadian participants, the relationship between physical activity, screen time, anxiety, and depression were analyzed over a period of 11 years. Participants completed four questionnaires from the ages of 10 – 21 years old.
and it was found that, over time, rates of physical activity decreased while screen time usage and
symptoms of depression and anxiety increased (Gunnell et al., 2016). Not only was there an
association, but the researchers found that there is a bi-directional relationship that exists
between multiple factors including physical activity, screen time, and mental health. For
example, when controlling for demographic data and some social-determinants of health such as
parental education and school location, it was found that younger participants who felt higher
initial levels of depression were more were associated with higher initial screen time use.
Additionally, over time, an increase in anxiety and depression were associated with an increase
in screen time use. Furthermore, higher rates of depressive symptoms in youth predicted
behavior change before adulthood as higher initial symptoms of depression predicted a greater
decrease in physical activity over time (Gunnell et al., 2016). Given these results, it is clear that a
complicated relationship exists between multiple health behaviors, thus it is important to better
understand how a variety of factors related to screen time may impact health.

Smartphone screen time specifically may add an additional layer of influence on mental
health. For instance, studies specific to smartphone usage found that looking at just the overall
time spent using a device did not fully explain the relationship of screen time behavior and
anxiety and depression; rather, specific behaviors on the smartphone were associated with these
outcomes (David, Roberts, & Christenson, 2018). For example, David, Roberts, & Christenson
(2018) conducted a study in the United States where objective sensory data was collected for a
one week period via smartphones and feelings of wellbeing were self-reported using surveys.
The researchers found that time spent using apps for taking photos and videos was associated
with higher levels of reported anxiety and depression. On the contrary, it was also found that
time spent using productivity apps were associated with fewer reported relationship conflict and
book apps were associated with lower levels of anxiety and depression (David, Roberts, & Christenson, 2018). These findings suggest that smartphone-based screen time behavior is varied and potentially has different associations with mental health than other types of devices do. Therefore it is important to examine the relationship between digital device usage and mental health to support the development of policy and intervention, as well as, to prevent harmful behaviors and health outcomes.

2.2 Physical Health

Among other health behaviors, above normal weight status and weight gain are often associated with sedentary lifestyles, excessive screen time, and physical inactivity (Hruby et al., 2016). Physical inactivity is a major leading cause of global mortality and is associated with increased risk of chronic and non-communicable disease (WHO, 2020; Lee et al., 2012). Furthermore, chronic illness and non-communicable diseases have become leading causes of avoidable premature death worldwide (CDC, 2020; Lee et al., 2012; Hallal et al., 2012). Very few Canadians actually do engage in the minimum recommended amount of physical activity (CSEP, 2019; Hallal et al., 2012). In 2016 and 2017, only 40% of youth aged 5 – 17 years old and 16% of adults, aged 18 – 79 years old, met the recommended targets for physical activity (Statistics Canada, 2019).

Physical inactivity is often associated with screen time-based sedentary behavior, which has additional negative impacts on health, independent of those from physical inactivity (Hamilton et al., 2008). For instance, an individual can be highly active and highly sedentary on the same day (Van der Ploeg, & Hillsdon, 2017). Individuals who engage in highly sedentary behavior, regardless of their physical activity level, will still experience negative health impacts.
such as cardiovascular disease, type 2 diabetes, and some types of cancer (Hamilton et al., 2008; Wilmot et al., 2012).

Digital devices, such as smartphones, are often primarily only associated with sedentary behaviors such as text messaging, social networking, internet surfing, and video gaming (Lepp et al., 2013; Rosenberg et al., 2010). Lepp et al. (2013) conducted a study to look at the association between physical fitness of college students, via an exercise test, with self-reported cell phone use, physical activity, and sedentary behaviors. The researchers found that there are significant relationships between smartphone usage, physical activity, sedentary behavior, and physical fitness, and it was reported that higher rates of cell phone usage was associated with higher rates of sedentary behavior, lower rates of physical activity, and are less physically fit (Lepp et al., 2013). Furthermore, higher rates of cell phone usage was also associated with more of the traditionally defined sedentary behaviors such as video gaming and internet surfing (Lepp et al., 2013). Notably, some participants with lower rates of cell phone usage actually reported that they felt their phone use improved their physically active lifestyle due to the ability to easily connect with their physically active peers (Lepp et al., 2013).

Alternatively, for the younger age group, some researchers speculates that smartphone use may lead to a greater decrease in physical activity as children age. For instance, Raustorp et al. (2015) examined cross-sectional cohorts of school aged children from 2000 – 2013 where physical activity tended to decrease over time, particularly for boys. Furthermore, classification of overweight and obese typically rose as participants aged (Raustorp et al. 2015). Smartphone usage for each cohort was also monitored and researchers did observe that during recess breaks at school, grade 5 boys especially engaged in more frequent smartphone use (Raustorp et al., 2015). Raustorp et al. (2015) speculate that this gender difference in smartphone usage may be
due to fifth grade boys being more engaged in gaming smartphone activities, which typically requires more time. It appears that digital technology will certainly have an impact on physical activity, but the relationship between the types of smartphone-based screen time behaviors, physical activity, and weight status needs further investigation.

In a narrative study review conducted by Hruby et al. (2016) it was shown that weight and weight gain are significant risk factors for chronic and non-communicable diseases. Particularly individuals who belong to overweight or obese weight categories were associated with a higher risk of developing type 2 diabetes, cardiovascular diseases, cancers, and mortality (Hruby et al., 2016). The review also indicated that even adults with a BMI (Body Mass Index) at the upper end of the normal range were 3.6 times more likely than those with a normal BMI to develop type 2 diabetes (Hruby et al., 2016). Furthermore, weight gain after the age of 18 was highly associated with developing type 2 diabetes, hypertension and cardiovascular disease, some cancers, and result in higher mortality rates and an overall lower quality of life (Hruby et al., 2016).

Many studies have shown that youth who engage in more than 2 hours per day of screen time activity are more likely to have higher a BMI (Ullrich-French et al., 2010). In a study conducted by Ullrich-French et al. (2010) analyzing the association between physical fitness, screen time (watching television or playing video games), weight, and blood pressure, it was found that screen time had an independent impact on physical health. For example, when controlling for cardiorespiratory fitness, participants who met the daily recommendation of two hours or less of screen time had significantly lower BMI and blood pressure than participants who reported higher rates of screen time usage (Ullrich-French et al., 2010). Therefore, it is evident that regardless of physical fitness, youth may still experience negative health-related
impacts without early intervention to reduce sedentary behaviors. Additionally, youth who engage in above the recommended amount of screen time are more likely to carry these behaviors and have a higher BMI in adulthood (White et al., 2012). Although studies continue to emerge suggesting that multiple types of screen time devices and activities have negative impacts on physical health (Kenney et al., 2016) there remains a lack of evidence that analyzes the association specifically on smartphone usage and weight status with youth.

The ubiquitous nature of smartphones allow individuals to engage in active and sedentary behaviors while using smartphone features for a variety of reasons. It is important to understand the entire context behind smartphone usage to better gauge the impacts on health and develop appropriate population health interventions with these devices. Given that smartphones can play a supportive role in facilitating an active lifestyle, and that these digital devices can be used for health intervention, it is important to unpack the relationship between smartphone usage and physical health.

2.3 Self-Rated Health

Self-rated health and self-rated mental health are not only powerful predictors for morbidity and mortality (Idler & Benyamini, 1997) but are also concepts that are commonly used as a health indicators for both eudaimonic wellbeing and quality of life (Ryan, Huta, & Deci, 2006; CDC, 2000; Ryff, Radler, & Friedman, 2015; Mawani & Gilmour, 2010). While there is an abundance of literature that concludes physical inactivity and high rates of sedentary behavior have negative associations with self-rated health and, although fewer studies, self-rated mental health as well (Herman, Hopman, & Sabiston. 2015; Iannotti, et al., 2009; Kantomaa et al., 2015; Herman et al., 2014) psychological wellbeing will independently impact self-rated health irrespective of physical health behaviours (Ryff, Radler, & Friedman, 2015). Additionally,
studies show that screen time is independently and negatively associated with poor self-rated health in youth (Herman, Hopman, & Sabiston. 2015; Iannotti, et al., 2009). For example, irrespective of physical activity, youth who engaged in greater than the recommended hours of screen time activity are more likely to rate their overall health as sub-optimal (Herman, Hopman, & Sabiston. 2015). However, such studies consider screen time activity using computer, video games, internet surfing, and television; no studies were found that looked at the association of self-rated health specifically with smartphone usage in the youth population.

Although studies with youth and adolescents have shown that screen time behaviors significantly impact self-rated health (Zhang, Lu, & Wu, 2020), the association between screen time and self-rated health remain complicated. For example, some studies show that screen time activity directly impacts the self-rated health of male youth only; while screen time may only impact the self-rated health of female youth if there is also reported self-rated distress (feelings of sadness or stress) or dissatisfaction in social relationships (Werneck et al., 2018). Furthermore, current research indicates that types of screen time behavior will have unique impacts on self-rated health. For example, studies looking at screen time behaviors, such as television viewing and computer/video gaming, showed that higher television viewing time, not computer/video gaming screen time was associated with poor self-rated health, but only for males (Silva et al., 2018). By contrast, higher television viewing time and computer/video gaming based screen time had other negative health impacts for females; namely, with social friendships (Silva et al., 2018). Given that associations have been typically found with traditional screen time devices (i.e. television, desktop/laptop, video gaming consoles), further research is needed to investigate the relationship between smartphone device screen time and self-rated health, as well as, self-rated mental health.
Chapter 3: Research Questions and Hypotheses

3.1 Gaps in Evidence

As stated above, screen time behaviours are typically studied through sedentary behavior research. Alternatively, this study reviews screen time usage and implications of those behaviours from a holistic perspective. Holistic health is typically characterized as an approach that includes prevention, alternative measures, and an attempt to improve quality of life (Gross, 1980). This thesis attempts to capture a holistic approach to understanding the relationship between screen time use with health outcomes by encompassing aspects of physical, mental, and perceived health. Current evidence indicates that there is a lack of understanding in how a variety of smartphone usage behaviors are associated with health outcomes such as mental, physical, and self-rated health. These health outcomes were chosen to provide a holistic perspective on the influence of smartphone usage with youth. Globally, smartphone device usage has increased significantly and the technology is highly accessible and adaptable for all ages of the population. Since it has been established that youth are engaging in frequent smartphone usage, it is essential to better understand how this behavior will impact population health.

Currently, there is very little known about how time spent on smartphones can impact the holistic wellbeing of populations. Of the research available, the findings are mixed and when relationships are found, they are complicated and not well understood. In Saskatchewan, more evidence and awareness is needed to educate about responsible screen time use, and school wide policies on screen time behavior have been identified as an area for improvement (Hassan, 2020).
The current investigation has several important contributions to the literature and supports a concrete understanding of how smartphone usage can impact holistic health. Further to that, while technological advances have been associated with higher rates of smartphone usage, it is appropriate to understand how technology can be used to reverse this trend. The results from this paper can be used to leverage the advantages of smartphone technology to improve the health of Canadians and to use digital technology for mobile health interventions.

This research addresses the following questions:

**Research Question 1:**
Is there an association between smartphone usage (internet, gaming, texting) and mental health outcomes (depressions and anxiety) for high school aged youth in Saskatchewan?

**Hypothesis 1:**
Increased time spent on texting and social media on smartphones will increase likelihood of experiencing depression and anxiety in youth (Sohn et al., 2019).

**Research Question 2:**
Is there an association between smartphone usage and physical health outcomes (weight status) for high school aged youth in Saskatchewan?

**Hypothesis 2:**
Increased time spent on texting and social media on smartphones will be associated with a higher weight status in youth (Ullrich-French et al., 2010).

**Research Question 3:**
Is there an association between smartphone usage and self-rated health for high school aged youth in Saskatchewan?

**Hypothesis 3:**
Increased time spent on texting and social media on smartphones will decrease self-rated health in youth (Silva et al., 2018).

Chapter 4: Methodology and Procedures

4.1 Framework

This research uses the Smart Framework as a theoretical approach to better understand the relationship between smartphone usage and holistic health outcomes in youth cohorts. The Smart Framework combines citizen science, community-based participatory research, and systems science to conduct population health research using digital tools (Katapally, 2019). Using the Smart Framework, the current research study has made efforts to engage with citizen scientists and stakeholders throughout the entire research process. Figure 1 shows the linkages and direction of flow between the key components of the Smart Framework (Katapally, 2019).
**Figure 1:** The Smart Framework: Integration of citizen science, community-based participatory research, and systems science via ubiquitous tools (Katapally, 2019).
4.2 Design

This thesis is part of the Smart Platform, a citizen science and digital epidemiological initiative for ethical population health surveillance, integrated knowledge translation, and real-time behavioral interventions (Katapally et al., 2018). The Smart Framework informs the implementation of the Smart Platform by engaging with citizens across the life course both within and outside Canada to conduct studies with varied designs (cross-sectional and longitudinal, to quasi-experimental and community-trials) (Katapally et al., 2018). Depending on scope, design, and goals of each study, citizen science participation in the Smart Platform begins at collaboration during the data collection and analysis stages to the co-creation of knowledge translation products (Bonney, Cooper, & Ballard, 2016).

The Smart Platform is an innovative approach that leverages the market buy-in of digital technology such as citizen-owned smartphones to utilize smartphone sensors (Katapally & Chu, 2019) and deploy Ecological Momentary Assessments (Shiffman, Stone, & Hufford, 2008; Katapally & Chu, 2020), to better understand population health behaviors. Ecological momentary assessments (EMA) are short questionnaires that are deployed each day to the participants’ smartphones to capture, in real time, their physical activity and smartphone usage behaviours. The preliminary results of the Smart Platform have enabled the implementation of various studies including the projects that will be analyzed for this thesis: Smart Youth: a quasi-experimental study that engages with youth to capture mental and physical health to inform school policies and develop ecological momentary interventions (DEPtH Lab, 2019b). Data for this research is being derived from the cross-sectional components of Smart Youth studies of the Smart Platform.
4.3 Recruitment and Data Collection Strategy

A custom-built smartphone app, developed as part of the Smart Platform, was used to engage participants as citizen scientists to capture behavior patterns and their relationship with mental and physical health outcomes (Katapally et al., 2018). Ethics approval (Appendix A) for the Smart Platform was obtained from both the University of Regina and the University of Saskatchewan (Katapally et al., 2018). Following the instructions outlined in Figure 2, participants had the option to download the app using both Android and iPhone smartphones through either the Google Play Store or Apple App Store (Katapally et al., 2018). With respect to this study, participants provided all data via their smartphones, including demographic and subjective data through survey questions using their smartphone. Previous studies have shown that smartphone apps can be used to collect valid and reliable health data in both rural and urban centres, and within diverse populations; for example, from university students and lower-income families (Knowles, Stanley, & Osgood, 2014; Petrenko et al., 2014; Hashemian et al., 2012).
Figure 2: Instructions to become a citizen scientist

Download Ethica to become a Citizen Scientist

ANDROID USERS: Go to the Google Play Store and search for "ETHICA"

iPhone users: Go to App Store and search for "ETHICA"

1. Click to download Ethica and sign up by providing your email address.
2. At the top of the screen, you will see a plus sign (+), click on it and enter the digits *40* for the study ID.
3. You will see an informed consent page, please read it and provide consent by clicking "Register."

You are now ready to become a Citizen Scientist!

What’s next?

- You will immediately get the one-time SMART survey which will take you 10 minutes to complete. You can complete this survey in parts if you wish to do so, but PLEASE DO NOT CLOSE the survey. Simply exit Ethica and finish the survey at a later time.
For the purpose of this study, youth and young adults are defined as individuals between the ages of 13 to 21. A total of 808 youth and young adult citizen scientists (13 to 21 years) were recruited through Regina Public and Catholic School engagement sessions held in various high schools throughout Regina, Saskatchewan in 2018. To recruit citizen scientists, a collaborative relationship was established with school administrators to schedule in-person recruitment sessions. During each session, research team members spent time describing the study, answering questions, and assisting youth to download the study app on their smartphones.

All participants were required to confirm their age, but only the young adult participants aged 18 years or older were required to complete informed consent (Figure 3) via the App on their smartphone. Implied informed consent was provided to the caregivers of each youth (13 – 18 years) ahead of the recruitment session so that parents had the opportunity to read about the study, ask questions, and contact the research team if they did not want their child to participate in the study. To accomplish this, we collaborated with school administrators who emailed the informed consent forms to each household ahead of a scheduled data collection engagement session. If any parent did not want their child to participate in the study, they could email our team at smart.study@uregina.ca or smart.study@usask.ca to notify us. This way, the child would be excluded from participating. However, if the child did not have permission to participate in the study, but wanted to attend the in-person engagement session with their friends, they were welcome to do so. Additionally, if the child accidently participated by downloading the app, we could obtain their email address to remove any data collected.
Figure 3: Informed Consent Form
The smartphone app provided an informed consent section where youth and their caregivers were advised that each participant could refuse to participate in the study or withdraw from the study without any penalty at any time during the data collection cycle (Figure 4). Participants were provided clear instructions on how to withdraw from the study within the app and these instructions were available to them at all times, via the app (Katapally et al., 2018).
**Figure 4:** Study Dropout Option in the Smartphone App

Your participation is voluntary and the consent process continues throughout the study honoring the commitments made by the researchers and the study participants. Please answer only those questions that you are comfortable with, decline to answer any particular question(s) you are not comfortable with, and feel free to ask any questions regarding the procedures and goals of the study or participant’s role. At any time during the study, you are free to withdraw consent without explanation or penalty of any sort. If you wish to withdraw from the study, you can navigate to the “About” section of the application and click “Leave Study”. This will ensure that your participation ceases immediately. As you would be providing data in 8-day cycles in each season, you can withdraw from the study on any day during any 8-day cycle. For example, if you decide to withdraw from the study on the 2nd day of a particular cycle, you can do so without informing the researchers. The data

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**Drop Out of the Study**

By choosing this option, all data collection related to this study will be stopped immediately, and you will not receive any notification related to this study anymore. Note that the data you have collected so far will not be deleted. To delete your collected data, please refer to the Profile section of the website.
Youth were also advised of the initial data 8 consecutive day collection period, starting on the day they downloaded the app. Lastly, participants were asked not to change their usual smartphone carrying habits to ensure that objective mobile phone sensor data were representative of their typical daily living conditions (Katapally et al., 2018).

4.4 Measures

All data were collected through a combination of validated self-report surveys on participants’ smartphone devices. Participants completed the 124-item Youth Survey (Appendix B), which was the baseline questionnaire that combines validated self-report surveys to record sedentary behaviours, screen time behaviours (including smartphone usage), demographic characteristics (Appendix C), and health outcomes such as mental wellbeing, weight status, and self-rated health. Although the SBQ has been recognized as a reliable and valid measurement for adults (Rosenberg et al., 2010), emerging evidence suggests that subjective reporting of screen time use is often severely underreported (Katapally & Chu, 2019) and further research should consider deploying EMAs via smartphone technology as a measurement tool to capture daily prospective data (Katapally & Chu, 2020).

Included in the Youth Survey was a modified version of the 9-question Sedentary Behaviour Questionnaire (SBQ) used to measure sedentary behavior and screen time accumulation (Rosenberg et al., 2010). The purpose of adapting this survey was to capture complex screen time-based behaviors on a variety of digital devices (computer, laptop, tablet, smartphone, etc.) and included options such as internet surfing and social media use (Katapally et al., 2018). The SBQ was used to derive the smartphone usage (internet surfing, texting, video gaming) variable for this thesis.
Furthermore, the Youth Survey was also developed to also include questions specific to mental health including stress levels, depression, anxiety, and suicidal ideation. A complete list of these questions can be found in Appendix B. Examples of these questions are as follows:

“During the past 12 months, did you ever seriously consider attempting suicide? 1. Yes; or 2. No”

“How often over the last 2 week were you bother by feelings of nervous, anxious, or on edge? 1. Not at all; 2. Several days; 3. Mother than half the days; or 4. Nearly every day”

In regards to the self-reported health aspect of this study. The Youth Survey included two single questions requesting the participant to report how they feel about their general health, and also about their mental health. For this study, data obtained from Smart Youth via the Youth Survey were used to analyze the relationship between smartphone screen time usage and mental health, physical health, and self-rated health outcomes.

4.4.1 Screen Time Variables

Participants self-reported the amount of time they typically spend engaged in smartphone specific screen time activities. Screen time was broken down by week day and weekend day during the school year, as well as, by activity such as internet surfing (e.g. Facebook, Snapchat, Instagram, Youtube, Reddit, reading news etc.), playing video games, and texting. This study used these self-reported data to calculate a total of 12 binomial smartphone usage variables including a weekday variable for internet, one for gaming, one for texting, as well as, a variable that encompassed total screen time during the week and included the sum time of all behaviours added together. Weekend day screen time variables were also calculated in the same manner. Additionally, a two day screen time variable was calculated for each activity which was the sum of one week day and one weekend day self-reported smartphone usage. Given that the general
recommendation for youth screen time usage is less than two hours per day (CSEP, 2021), a two hour or more cut off point was used for variables that analyzed only one day of smartphone usage and a four hour or more cut off point was established for variables that included an average two day total, i.e. one week day and one weekend day).

Average screen time variables were calculated to identify mean hours spent on smartphones for each separate behaviour (internet surfing, gaming, or texting) during the week, weekend, and as well, the two day total which included both one week day and one weekend day. Additionally, average screen time variables were calculated for total smartphone screen time hours, which included all screen time behaviours together for a week day, a weekend day, and a two day total which included both one week day and one weekend day.

4.4.2 Mental Health Outcome Variables

In this study, mental health outcomes have been broken down into components of anxiety and depression which participants self-reported symptoms that are consistent with the Diagnostic and Statistical Manual of Mental Disorders (2013) used for diagnosing patients with depressive and anxiety disorders. Four mental health variables (2 anxiety and 2 depression) were established using the data via the self-reported mental health survey included in Appendix B.

Variables representing anxiety in this study include feeling nervous, on edge, or anxious and the inability to control worry. For example, participants were asked to respond to the following question: “How often over the last 2 weeks were you bothered by feeling nervous, anxious, or on edge?” Participants were provided choices of “Not at all,” “Several days,” “More than half the days,” or “Nearly every day.” Responses were amalgamated to represent “yes” or “no” categories. A binomial regression was conducted to analyze those who reported feelings of nervousness versus those who reported none at all. Participants were also asked to respond to
the following question: “How often over the last 2 weeks were you bothered by not being able to stop or control worrying?” Participants were provided choices of “Not at all,” “Several days,” “More than half the days,” or “Nearly every day.” Responses were amalgamated to represent responses as “yes” or “no.” A binomial regression was conducted to analyze those who reported feelings of worry versus those who reported none at all.

Variables representing depression in this study included self-reported thoughts about attempting suicide, as well as, feeling sad or hopeless almost every day for at least two weeks. Participants were asked to respond to the following question: “During the last 12 months, did you ever seriously consider attempting suicide?” Participants were provided choices of “Yes” or “No.” A binomial regression was conducted to analyze those who reported suicidal ideation versus those who reported not. As well, participants were asked to respond to the following question: “During the last 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?” Participants were provided choices of “Yes” or “No.” A binomial regression was conducted to analyze those who reported feelings of depression versus those who reported none at all.

4.4.3 Physical Health Outcome Variables

In this study, the physical health outcome component was weight status, which was included as an overweight or obese BMI compared to a normal BMI for youth age group. Participants self-reported their height in centimeters and weight in pounds in the Youth Survey. Height and weight were converted to meters and kilograms respectively so that BMI could be calculated and weight status could be determined. World Health Organization (2021) BMI cut-offs were used to interpret weight status categories such as thinness, normal weight, overweight,
and obese. For the purpose of this study, a binomial regression was conducted to analyze overweight/obese (equivalent to a BMI of 25kg/m2 or higher) compared to normal weight.

4.4.4 Self-Reported Health Outcome Variables

Finally, two variables for self-rated health were included in this study. Participants were asked to respond to the following question: “In general, would you say your health is…” Participants were provided choices of “Very good,” “Good,” “Fair,” “Bad,” or “Very Bad.” Responses were amalgamated to represent categories of “Very good/Good” versus “Fair/Bad/Very bad.” A binomial regression was conducted to analyze those who felt they have good health vs. those who felt they have poor health. Participants were asked to respond to a similar self-rated health question for mental health: “In general, would you say your mental health is…” Participants were provided choices of “Excellent,” “Very Good,” “Good,” “Fair,” “Poor,” or “Don’t know.” Responses were amalgamated to represent categories of “Fair/Good/Very Good/Excellent” versus “Poor.” A binomial regression was conducted to analyze those who felt they have good mental health vs. those who felt they have poor health.

4.5 Data Analyses

This research has attempted to investigate the association between screen time accumulated specifically on smartphone devices and a variety of health outcomes including mental, physical, and self-rated health. A quantitative analysis was conducted to determine how a combination of validated measures inform the relationship between smartphone usage and holistic wellbeing in youth populations in Saskatchewan. All analyses were completed using IBM SPSS Statistics version 21 (IBM Corps, 2012). Separate linear and binary models were run for each research question to assess the association between the health outcome and smartphone screen time. Each model controlled for gender, school, grade, and ethnicity.
The variables that were analyzed were smartphone usage, depression and anxiety, weight status, and self-rated health. To answer the first research question (Is there an association between smartphone usage [internet surfing, video games, and texting] and mental health outcomes?), data from the modified SBQ were used to calculate smartphone usage. The Youth Survey provides a list of Mental Health specific questions where participants can report feelings of depression, anxiety, and suicidal ideation.

Using the Youth Survey modified SBQ, participants recalled their typical smartphone usage behaviors for weekdays and weekends during the school year. Amount of time spent on smartphones was reported in minutes (0, 15 minutes or less, 30 minutes, 1 hour, 2 hours, etc.) engaging in behaviors such as internet surfing (Facebook, Instagram, Reddit, YouTube, reading news, etc.); playing video games; and texting. The mental health survey provided participants an opportunity to report feelings of stress, anxiety, sadness, depression, hopelessness, etc. and to indicate how often and how extreme they felt these feelings.

For the second research question (What is the relationship between smartphone usage and physical health outcomes?) the modified SBQ was used to calculate smartphone usage and weight status was calculated by using BMI via self-reported height (centimeter), weight (pounds) and following the World Health Organization (2021) cut-offs for youth aged 5-19 years old of overweight (approximate BMI of 25kg/m2) and obese (approximate BMI of –30 kg/m2).

To answer the third research question (What is the relationship between smartphone usage and self-rated health?) participants reported smartphone usage using the modified SBQ and self-rated health via the Youth Survey responding to a single question on how they feel about their overall health (very good, good, fair, bad, very bad) and mental health (fair, good, very good, excellent, poor).
Demographic frequencies were calculated. Although current research suggests there could be a difference in health outcomes between the genders, this was not the scope of the current study. A bivariate regression was conducted for each research question examining the association between smartphone usage and depression or anxiety; smartphone usage and weight status; and smartphone usage and self-rated health.

**Chapter 5: Results**

A total of 808 youth and young adult citizen scientists (13 to 21 years) were recruited through Regina Public and Catholic School engagement sessions held in various high schools throughout Regina, Saskatchewan in 2018. For this study, 436 participants who fully completed the Smart Youth survey were included. Table 1 shows that, of these participants, 55.7% identified as female, 38.5% as male, and 5.7% as transgender, other, or preferred not to disclose their gender. Although the scope of this study is not to analyze how gender orientation of the participants may influence their smartphone usage or association with health, it is recommended that future investigations should focus on sex and gender-based analyses. While the survey allowed for a variety of options to choose ethnicity (Appendix D), for the purpose of this study, given that the context is within a Saskatchewan setting, categories were adapted to represent the Indigenous (5%), Canadian (39.8%), and other (55.2%) populations (Statistics Canada, 2017). The average age was approximately 16 years old with a standard deviation (SD) of 1.8 and students were recruited from grades 9 (29.7%), 10 (20.4%), 11 (14.5%), and 12 (35.4%).
Table 1: Frequency Table for Demographic Variables

<table>
<thead>
<tr>
<th>Smart Youth (N=436)</th>
<th>Demographic Variables</th>
<th>Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>125</td>
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<td>10</td>
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<td>12</td>
<td></td>
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<td>149</td>
<td>35.4</td>
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</tr>
<tr>
<td>1</td>
<td></td>
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<td>110</td>
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</tr>
<tr>
<td>5</td>
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<td>122</td>
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<tr>
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<td></td>
<td>21</td>
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<td></td>
<td>166</td>
<td>39.8</td>
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<td></td>
<td>230</td>
<td>55.2</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>Female</td>
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<td>233</td>
<td>55.7</td>
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<tr>
<td>Male</td>
<td></td>
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<td>161</td>
<td>38.5</td>
</tr>
<tr>
<td>Transgender/other/did not disclose</td>
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<td>24</td>
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<tr>
<td>Age</td>
<td></td>
<td></td>
<td>1.80</td>
<td>16.04</td>
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</table>

SD = Standard Deviation
Table 2 shows the frequencies, means and standard deviations of participants’ recall for their last week of smartphone usage, specifically for internet use, gaming, or texting in minutes. On a typical two day recall during the school year, 57.1% of participants engaged in four or more hours of internet smartphone usage in the past week; 15.8% gaming on their smartphone; 21.3% texting; and 73.1% on all behaviours combined.

Alternatively, one day averages were also calculated which used the two hours or more of screen time usage as a cut off point. On a typical weekend day, 47.8% of participants reported using their smartphone for two hours or more for internet use; 12% for gaming; 20% for texting; and 73.9% for all behaviours combined. Finally, on a typical week day, 45.5% of participants reported using their smartphone for two hours or more for internet use; 11.4% for gaming; 15.3% for texting; and 66.3% for all behaviours combined.

Per week day, the total smartphone screen time mean was 4.40 hours (SD of 3.84) and the means for individual behaviours, internet, gaming, and texting, were 2.44 hours (SD of 1.98), 0.83 hours (SD of 1.41), and 1.18 hours (SD of 1.60) respectively. For weekend days the total smartphone mean was 4.73 hours (SD of 3.81) and the means for individual behaviours, internet, gaming, and texting were 2.57 hours (SD of 2.07), 0.88 hours (SD of 1.46), and 1.34 hours (SD of 1.66) respectively. The weekly total smartphone mean was 8.99 hours (SD of 7.01) and the weekly total for individual behaviours, internet, gaming, and texting were 4.93 hours (SD of 3.61), 1.67 hours (SD of 2.57), and 2.45 hours (SD of 3.04) respectively.
<table>
<thead>
<tr>
<th>Screen Time Variables</th>
<th>Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Day Internet Recall (weekly binomial)</td>
<td>&gt; 4 Hours</td>
<td>244</td>
<td>57.1</td>
</tr>
<tr>
<td>Two Day Gaming Recall (weekly binomial)</td>
<td>&gt; 4 Hours</td>
<td>66</td>
<td>15.8</td>
</tr>
<tr>
<td>Two Day Texting Recall (weekly binomial)</td>
<td>&gt; 4 Hours</td>
<td>89</td>
<td>21.3</td>
</tr>
<tr>
<td>Total Two Day Screen Time Behaviour Recall (weekly binomial)</td>
<td>&gt; 4 Hours</td>
<td>312</td>
<td>73.1</td>
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<tr>
<td>One Weekend Day Internet Recall (weekend binomial)</td>
<td>&gt; 2 Hours</td>
<td>200</td>
<td>47.8</td>
</tr>
<tr>
<td>One Weekend Day Gaming Recall (weekend binomial)</td>
<td>&gt; 2 Hours</td>
<td>49</td>
<td>12.0</td>
</tr>
<tr>
<td>One Weekend Day Texting Recall (weekend binomial)</td>
<td>&gt; 2 Hours</td>
<td>82</td>
<td>20.0</td>
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<tr>
<td>Total One Weekend Day Screen Time Behaviour Recall (weekend binomial)</td>
<td>&gt; 2 Hours</td>
<td>305</td>
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<tr>
<td>One Day Internet Recall (weekday binomial)</td>
<td>&gt; 2 Hours</td>
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<td>One Day Gaming Recall (weekday binomial)</td>
<td>&gt; 2 Hours</td>
<td>47</td>
<td>11.4</td>
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<tr>
<td>One Day Texting Recall (weekday binomial)</td>
<td>&gt; 2 Hours</td>
<td>63</td>
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<tr>
<td>Total One Day Screen Time Behaviour Recall (weekday binomial)</td>
<td>&gt; 2 Hours</td>
<td>281</td>
<td>66.3</td>
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<table>
<thead>
<tr>
<th>Category</th>
<th>SD</th>
<th>Mean</th>
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<tbody>
<tr>
<td>Two Day Internet Recall (1 to 12+ Hours)</td>
<td>3.61</td>
<td>4.93</td>
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<tr>
<td>Two Day Gaming Recall (1 to 12+ Hours)</td>
<td>2.57</td>
<td>1.67</td>
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<tr>
<td>Two Day Texting Recall (1 to 12+ Hours)</td>
<td>3.04</td>
<td>2.45</td>
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<tr>
<td>Total Two Day Screen Time Behaviour Recall (1 to 36+ Hours)</td>
<td>7.01</td>
<td>8.99</td>
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<tr>
<td>One Weekend Day Internet Recall (1 to 6+ Hours)</td>
<td>2.07</td>
<td>2.57</td>
</tr>
<tr>
<td>One Weekend Day Gaming Recall (1 to 6+ Hours)</td>
<td>1.46</td>
<td>0.88</td>
</tr>
<tr>
<td>Study Duration</td>
<td>Mean 1</td>
<td>Mean 2</td>
</tr>
<tr>
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</tr>
<tr>
<td>One Weekend Day Texting</td>
<td>1.66</td>
<td>1.34</td>
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<tr>
<td>Recall (1 to 6+ Hours)</td>
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<td>Total One Weekend Day</td>
<td>3.81</td>
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<td>Screen Time Behaviour</td>
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<tr>
<td>Recall (1 to 18+ Hours)</td>
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<tr>
<td>One Week Day Internet</td>
<td>1.98</td>
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<td>Recall (1 to 6+ Hours)</td>
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<td>One Week Day Gaming</td>
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<td>Recall (1 to 6+ Hours)</td>
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<td></td>
</tr>
<tr>
<td>One Week Day Texting</td>
<td>1.60</td>
<td>1.18</td>
</tr>
<tr>
<td>Recall (1 to 6+ Hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total One Week Day</td>
<td>3.84</td>
<td>4.40</td>
</tr>
<tr>
<td>Screen Time Behaviour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall (1 to 18+ Hours)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Frequencies were also calculated for health outcome variables. For mental health outcomes that are associated with anxiety and depression (Table 3), 63% of participants reported feeling anxious for several days in a row in recent weeks; 55.7% feeling worried; 58.8% feeling depressed; and 22.8% seriously considered attempting suicide. For self-rated health (Table 4), 37.8% of participants rated their general health as fair/bad/very bad and 17.8% of participants rated their mental health as poor. Finally, table 5 shows that that 35.1% of participants would be categorized as overweight or obese.
Table 3: Frequency Table for Mental Health Variables

<table>
<thead>
<tr>
<th>Mental Health Variables</th>
<th>Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nervousness</td>
<td>How often over the last 2 weeks were you bothered by feeling nervous, anxious, or on edge?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not at All</td>
<td>154</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Several Days</td>
<td>262</td>
<td>63</td>
</tr>
<tr>
<td>Worry</td>
<td>How often of the last 2 weeks were you bothered by not being able to stop or control worrying?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not at All</td>
<td>184</td>
<td>44.3</td>
</tr>
<tr>
<td></td>
<td>Several Days</td>
<td>231</td>
<td>55.7</td>
</tr>
<tr>
<td>Depressed 2 Weeks</td>
<td>During the past 12 months did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>247</td>
<td>58.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>173</td>
<td>41.2</td>
</tr>
<tr>
<td>Suicide Ideation</td>
<td>During the past 12 months did you every seriously consider attempting suicide?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>321</td>
<td>77.2</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>95</td>
<td>22.8</td>
</tr>
</tbody>
</table>
Table 4: Frequency Table for Self-Rated Health Variables

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-Rated Health</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good/Very Good</td>
<td>262</td>
<td>62.2</td>
</tr>
<tr>
<td>Fair/Bad/Very bad</td>
<td>159</td>
<td>37.8</td>
</tr>
<tr>
<td><strong>Self-Rated Mental Health</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair/Good/Very Good/Excellent</td>
<td>337</td>
<td>82.2</td>
</tr>
<tr>
<td>Poor</td>
<td>73</td>
<td>17.8</td>
</tr>
</tbody>
</table>
Table 5: Frequency Table for Physical Health Variable

<table>
<thead>
<tr>
<th>Physical Health Variables</th>
<th>Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>Normal</td>
<td>183</td>
<td>64.9</td>
</tr>
<tr>
<td></td>
<td>Overweight/Obese</td>
<td>99</td>
<td>35.1</td>
</tr>
</tbody>
</table>
Binomial regression analyses were conducted to determine how quantitative measures inform the relationship between smartphone usage and holistic wellbeing in youth populations in Saskatchewan.

5.1 Mental Health

This research investigates potential associations between smartphone screen time use and mental health outcomes.

Table 6 shows results from the regression analyses that assessed the relationships between smartphone use and feelings of nervousness. Participants who engaged in 4 or more hours of internet screen time recalled for two days per week were 2.00 times more likely than those who engaged in less than 4 hours of screen time to report feelings of nervousness in the last 2 weeks (95% C.I. = 1.202, 3.339, results of Model 1). Participants who engaged in 4 or more hours of total screen time (texting, gaming, internet use) for two days per week were 1.90 times more likely than those who engaged in less than 4 hours of screen time to report feelings of nervousness in the last 2 weeks (95% C.I. = 1.146, 3.139, results of Model 4).

Participants who engaged in 2 or more hours of internet screen time on a weekend day were 1.93 times more likely than those who engaged in less than 2 hours of internet screen time to report feelings of nervousness in the last two weeks (95% C.I. = 1.172, 3.186, results of Model 2). Participants who engaged in 2 or more hours of total screen time (texting, gaming, internet use) on a weekend day were 1.73 times more likely than those who engaged in less than 2 hours of total screen time to report poor feelings of nervousness in the last two weeks (95% C.I. = 1.041, 2.859, results of Model 5).
Table 6: Feelings of Nervousness

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two-day mobile screen time (more than or less than 4 hours)</td>
<td>Weekend mobile screen time (more than or less than 2 hours)</td>
<td>Weekday mobile screen time (more than or less than 2 hours)</td>
</tr>
<tr>
<td></td>
<td>Exp(B)</td>
<td>95% CI</td>
<td>Exp(B)</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td>2.003**</td>
<td>(1.202, 3.339)</td>
<td>1.932**</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>0.842</td>
<td>(0.434, 1.634)</td>
<td>0.929</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td>0.924</td>
<td>(0.505, 1.694)</td>
<td>0.998</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.897*</td>
<td>(1.146, 3.139)</td>
<td>1.725*</td>
</tr>
</tbody>
</table>

*a consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*p<0.05, **p<0.01, ***p<0.001
All models controlled for Grade, Ethnicity, School, and Gender
Table 7 shows the relationships found between smartphone use and feelings of worry. Participants who engaged in 4 or more hours of internet screen time recalled for two days per week were 1.88 times more likely than those who engaged in less than 4 hours of internet screen time to report feelings of worry in the last two weeks (95% C.I. = 1.158, 3.064, results of Model 7). Participants who engaged in 4 or more hours of total screen time (texting, gaming, internet use) for two days per week were 1.67 times more likely than those who engaged in less than 4 hours of total screen time to report feelings of worry in the last two weeks (95% C.I. = 1.024, 2.735, results of Model 10). Participants who engaged in 2 or more hours of internet screen time on a weekend day were 2.11 times more likely than those who engaged in less than 2 hours of internet screen time to report feelings of worry in the last two weeks (95% C.I. = 1.313, 3.393, results of Model 8). Participants who engaged in 2 or more hours of total screen time (texting, gaming, internet use) on weekend day were 1.82 times more likely than those who engaged in less than 2 hours of total screen time to report poor feelings of worry in the last two weeks (95% C.I. = 1.112, 2.981, results of Model 11).
### Table 7: Bothered by Worry

#### Categorical Data Worry - Not at all vs. Several days in the last 2 weeks

<table>
<thead>
<tr>
<th></th>
<th>Model 7</th>
<th>Model 8</th>
<th>Model 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two-day mobile screen time</td>
<td>Weekend mobile screen time</td>
<td>Weekday mobile screen time</td>
</tr>
<tr>
<td></td>
<td>(more than or less than 4 hours)</td>
<td>(more than or less than 2 hours)</td>
<td>(more than or less than 2 hours)</td>
</tr>
<tr>
<td>Exp(B)</td>
<td>1.884*</td>
<td>2.110**</td>
<td>1.089</td>
</tr>
<tr>
<td>95% CI</td>
<td>(1.158, 3.064)</td>
<td>(1.313, 3.393)</td>
<td>(0.673, 1.763)</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td>0.961</td>
<td>0.951</td>
<td>1.085</td>
</tr>
<tr>
<td>95% CI</td>
<td>(0.505, 1.827)</td>
<td>(0.466, 1.938)</td>
<td>(0.513, 2.293)</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>1.146</td>
<td>1.172</td>
<td>1.140</td>
</tr>
<tr>
<td>95% CI</td>
<td>(0.645, 2.035)</td>
<td>(0.658, 2.089)</td>
<td>(0.580, 2.244)</td>
</tr>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>1.673*</td>
<td>1.821*</td>
<td>1.412</td>
</tr>
<tr>
<td>95% CI</td>
<td>(1.024, 2.735)</td>
<td>(1.112, 2.981)</td>
<td>(0.890, 2.241)</td>
</tr>
</tbody>
</table>

* consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*p<0.05, **p<0.01, ***p<0.001

All models controlled for Grade, Ethnicity, School, and Gender
Table 8 shows the relationships found between smartphone use and suicidal ideation within the last year. Participants who engaged in 4 or more hours of gaming screen time recall for two days per week were 2.12 times more likely than those who engaged in less than 4 hours of gaming screen time to report feelings of suicidal ideation in the last year (95% C.I. = 1.056, 4.246, results of Model 13). Participants who engaged in 2 or more hours of gaming screen time on a weekend day were 3.08 times more likely than those who engaged in less than 2 hours of gaming screen time to report feelings of suicidal ideation in the last year (95% C.I. = 1.458, 6.506, results of Model 14). Participants who engaged in 2 or more hours of total screen time (texting, gaming, internet use) on weekend day were 2.71 times more likely than those who engaged in less than 2 hours of total screen time to report feelings of suicidal ideation in the last year (95% C.I. = 1.333, 5.516, results of Model 17).
Table 8: Suicidal Ideation

<table>
<thead>
<tr>
<th></th>
<th>Model 13</th>
<th>Model 14</th>
<th>Model 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-day (^a) mobile screen time (more than or less than 4 hours)</td>
<td>(\exp(B))</td>
<td>95% CI</td>
<td>(\exp(B))</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td>1.196</td>
<td>(0.668, 2.142)</td>
<td>1.012</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>(2.118^*)</td>
<td>(1.056, 4.246)</td>
<td>(3.080^{**})</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td>1.231</td>
<td>(0.658, 2.304)</td>
<td>1.327</td>
</tr>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>1.866</td>
<td>(0.971, 3.585)</td>
<td>(2.711^{**})</td>
</tr>
</tbody>
</table>

\(^a\) consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

\(^*p<0.05, \^{**}p<0.01, \^{***}p<0.001\)

All models controlled for Grade, Ethnicity, School, and Gender.
Table 9 shows the relationships found between smartphone use and feelings of depression within the last year. Participants who reported 4 or more hours of gaming screen time use on their smartphone for two days per week were 48.3% (95% C.I. = 0.516, 1.341, results of Model 19) less likely than their peers who engaged in less than 4 hours of gaming screen time to report feelings of depression in the last year. Participants who engaged in 4 or more hours of total screen time (texting, gaming, internet use) for two days per week were 63.7% less likely than those who engaged in less than 4 hours of total screen time to report feelings of depression in the last year (95% C.I. = 0.214, 0.616, results of Model 22). Participants who engaged in 2 or more hours of gaming screen time on a weekend day were 60% less likely than those who engaged in less than 2 hours of gaming screen time to report feelings of depression in the last year (95% C.I. = 0.197, 0.809, results of Model 20). Participants who engaged in 2 or more hours of total screen time (texting, gaming, internet use) on weekend day were 74.2% less likely than those who engaged in less than 2 hours of total screen time to report feelings of depression in the last year (95% C.I. = 0.148, 0.452, results of Model 23). Participants who engaged in 2 or more hours of total screen time (texting, gaming, internet use) on a week day were 45% less likely than those who engaged in less than 2 hours of total screen time to report feelings of depression in the last year (95% C.I. = 0.343, 0.866, results of Model 24).
Table 9: Feelings of Depression

<table>
<thead>
<tr>
<th>Categorical Data Depressed for 2 weeks in last year- Yes vs. No</th>
<th>Model 19</th>
<th>Model 20</th>
<th>Model 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-day (^a) mobile screen time (more than or less than 4 hours)</td>
<td>Exp(B)</td>
<td>95% CI</td>
<td>Exp(B)</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td>0.832</td>
<td>(0.516, 1.341)</td>
<td>0.883</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>0.517*</td>
<td>(0.275, 0.972)</td>
<td>0.399*</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td>0.705</td>
<td>(0.406, 1.222)</td>
<td>0.397</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 22</th>
<th>Model 23</th>
<th>Model 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>Exp(B)</td>
<td>95% CI</td>
</tr>
<tr>
<td>0.363***</td>
<td>(0.214, 0.616)</td>
<td>0.258***</td>
</tr>
</tbody>
</table>

\(^a\) consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*p<0.05, **p<0.01, ***p< 0.001
All models controlled for Grade, Ethnicity, School, and Gender
The results from this study show interesting and significant associations between smartphone use overall, as well as, with certain behaviours that are specific to separate mental health outcomes. First, both the anxiety derived variables (feelings of nervousness and feelings of worry) were highly associated with excessive screen time use. Specifically, total screen time recall which includes all behaviours (internet, gaming, and texting) resulted in participants more likely to feel worry and nervousness. This was consistent for cut-off points of 4 hours or more for a two day total (includes one week day and one week end day) and also 2 hours or more cut-off points but only for weekend days. Furthermore, internet specific behaviour was significantly related with feelings of anxiety. Those who reported greater feeling of nervousness also reported higher two day weekly totals of internet surfing (one weekend plus one week day), as well as, higher weekend internet surfing. While participants who reported higher rates of worry also had higher weekend internet surfing, they did not report higher two day weekly totals as did the participants with significant nervousness.

In contrast, the variables derived for depression (feelings of sadness and suicidal ideation) were significantly different from the associations between smartphone use and anxiety. Participants who reported higher rates of suicidal ideation also reported excessive weekend day totals for smartphone usage which includes all behaviours (internet, gaming, texting). However, participants who reported higher levels of total smartphone usage for both weekend days and week days were actually protected against feelings of depression as they were less likely than those who reported lower rates of total screen time behaviours to report feelings of sadness or hopelessness. Furthermore, rather than internet surfing on smartphones, participant’s feelings of depression were highly associated specifically with gaming activities, which is contrary to self reported anxiety. For example, participants who reported high two day total (one week day plus
one weekend day), as well as, weekend day gaming screen time on their smartphone also had a higher likelihood to report suicidal ideation but were less likely to report feelings of sadness. These results are significant and are consistent with the proposed notion in this study that smartphone usage has a complicated association with mental health outcomes and therefore that it matters when during the week a participant is engaged in this behaviour, as well as what type of activity, and amount of screen time accumulated on their smartphone.

5.2 Self-Rated Health

In addition to mental health variables, this study also analyzed the relationship between self-reported mental health and general health with smartphone screen time usage. Table 10 shows the relationships found between smartphone use and self-reported general health. Participants who engaged in 4 or more hours of gaming screen time two day recall per week were 2.58 times more likely than those who engaged in less than 4 hours of gaming screen time to report fair/bad/very bad self rated health (95% C.I. = 1.388, 4.811, results of Model 25). Similarly, participants who engaged in 2 or more hours of gaming screen time on the weekend were 2.51 times more likely than those who engaged in less than 2 hours of gaming screen time to report fair/bad/very bad self rated health (95% C.I. = 1.271, 4.960, results of Model 26).
### Table 10: Self-Rated Health

**Categorical Data SRH - Very Good/Good vs. Fair/Bad/Very Bad**

<table>
<thead>
<tr>
<th></th>
<th>Model 25</th>
<th>Model 26</th>
<th>Model 27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-day (a) mobile screen time (more than or less than 4 hours)</td>
<td>(\text{Exp(B)})</td>
<td>95% CI</td>
<td>(\text{Exp(B)})</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td>0.826 (0.512, 1.334)</td>
<td>0.877 (0.552, 1.396)</td>
<td>0.925 (0.580, 1.476)</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>2.584** (1.388, 4.811)</td>
<td>2.511** (1.271, 4.960)</td>
<td>1.793 (0.881, 3.648)</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td>1.157 (0.661, 2.025)</td>
<td>1.135 (0.645, 1.996)</td>
<td>1.227 (0.640, 2.354)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Model 28</th>
<th>Model 29</th>
<th>Model 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>1.207 (0.735, 1.982)</td>
<td>1.556 (0.933, 2.596)</td>
<td>1.421 (0.893, 2.261)</td>
</tr>
</tbody>
</table>

\(a\) consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*\(p<0.05\), **\(p<0.01\), ***\(p<0.001\)

All models controlled for Grade, Ethnicity, School, and Gender.
By contrast, participants who reported poor self-rated mental health (Table 11) differed in terms of the screen time behaviors associated with this negative health outcome. Participants who engaged in 4 or more hours of total screen time behaviour (internet, gaming, texting) for two days per week were 2.2 times more likely than those who engaged in less than 4 hours of total screen time to report poor self-rated mental health (95% C.I. = 1.046, 4.694, results of Model 34). Additionally, participants who engaged in 2 or more hours of total screen time (internet, gaming, texting) on the weekend were 2.88 times more likely than those who engaged in less than 2 hours of total screen time to report poor self-rated mental health (95% C.I. = 1.278, 6.472, results of Model 35).
Table 11: Self-Rated Mental Health

<table>
<thead>
<tr>
<th></th>
<th>Model 31</th>
<th></th>
<th>Model 32</th>
<th></th>
<th>Model 33</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Categorical Data SRMH - Fair/Good/Very Good/Excellent vs. Poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-day * mobile screen time (more than or less than 4 hours)</td>
<td></td>
<td>Exp(B) 95% CI</td>
<td></td>
<td>Exp(B) 95% CI</td>
<td></td>
<td>Exp(B) 95% CI</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td></td>
<td>1.477 (0.786, 2.774)</td>
<td></td>
<td>1.747 (0.957, 3.190)</td>
<td></td>
<td>1.195 (0.644, 2.216)</td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td></td>
<td>1.08 (0.460, 2.532)</td>
<td></td>
<td>0.954 (0.366, 2.491)</td>
<td></td>
<td>1.138 (0.435, 2.978)</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td></td>
<td>0.693 (0.327, 1.470)</td>
<td></td>
<td>0.646 (0.300, 1.393)</td>
<td></td>
<td>0.806 (0.337, 1.927)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>2.216*</td>
<td>(1.046, 4.694)</td>
<td>2.876*</td>
<td>(1.278, 6.472)</td>
<td>1.684</td>
<td>(0.885, 3.201)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*p<0.05, **p<0.01, ***p<0.001

All models controlled for Grade, Ethnicity, School, and Gender
Similar to the mental health variables, the associations found in self-rated health models significantly differed in terms of behaviours, accumulated time, and day of the week. For the two day total (one weekend day plus one week day) screen time variable, total accumulated screen time behavior (internet, gaming, texting) was associated with poor self-rated mental health, but only gaming activities specifically were associated with poor self-rated general health. Additionally, similar to mental health variables, weekend activities also appeared to be problematic. Participants who reported higher rates of total smartphone screen time (including all behaviours of internet surfing, gaming, and texting) were more likely to report poor self-rated mental health. However, again, only gaming screen time on weekends was associated with poor self-rated general health.

5.3 Physical Health

Finally, this study also analyzed the binomial relationship between weight status and smartphone specific screen time usage (table 12). Participants self-reported their height and weight in the Youth Survey so that BMI and weight status could be calculated for this study. Consistent with the literature, there were significant findings between weight status in youth and screen time usage. Participants who engaged in 4 or more hours of gaming screen time for two days per week were 2.29 times more likely than those who engaged in less than 4 hours of gaming screen time to report an overweight/obese BMI status (95% C.I. = 1.068, 5.336, results from Model 37).
Table 12: Weight Status

<table>
<thead>
<tr>
<th>Categorical BMI - normal vs. overweight/obese</th>
<th>Model 37</th>
<th>Model 38</th>
<th>Model 39</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp(B)</td>
<td>95% CI</td>
<td>Exp(B)</td>
</tr>
<tr>
<td>Two-day * mobile screen time (more than or less than 4 hours)</td>
<td>0.722 (0.397, 1.312)</td>
<td>0.727 (0.412, 1.285)</td>
<td>0.978 (0.549, 1.740)</td>
</tr>
<tr>
<td>Internet Recall (Hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaming Recall (Hours)</td>
<td>2.387* (1.068, 5.336)</td>
<td>1.422 (0.588, 3.438)</td>
<td>2.292 (0.892, 5.886)</td>
</tr>
<tr>
<td>Texting Recall (Hours)</td>
<td>0.848 (0.420, 1.714)</td>
<td>0.799 (0.397, 1.607)</td>
<td>0.78 (0.339, 1.794)</td>
</tr>
<tr>
<td>Total Screen Time Behaviour Recall (Hours)</td>
<td>0.948 (0.522, 1.721)</td>
<td>0.78 (0.424, 1.433)</td>
<td>0.851 (0.490, 1.479)</td>
</tr>
</tbody>
</table>

* consisted of the sum of 1 weekend and 1 weekday screen time for that screen time behaviour.

*p<0.05, **p<0.01, ***p<0.001
All models controlled for Grade, Ethnicity, School, and Gender
Similar to mental and self-reported health, the findings in this model show significant results associated with a unique smartphone behaviour. Only the two day total (one weekend day plus one week day) gaming screen time variable was associated with an overweight or obese weight status. It is significant that the two day weekly total screen time, which includes all behaviours, was not associated with a higher weight status. This would indicate that gaming specifically has a relationship with weight status, not just total screen time accumulated on a smartphone over a week. It is also important to note that the results in this model did not reflect significant results for week day or weekend day binary variables. Both mental and self-rated health were associated with weekend smartphone screen time, even depression which showed a protective value. Additionally, screen time guidelines indicate that youth should limit their screen time to less than 2 hours per day to reduce their likelihood of negative health outcomes, mostly associated with physical health. However, the findings in this study did not reflect the 2 hour cut-off point. More research is needed to better understand how the impacts of gaming specific smartphone screen time activities are associated with weight status and if there are any physical inactivity or other covariates that would help understand the relationship with physical wellness and screen time use.

Chapter 6: Discussion

6.1 Associations between Smartphone Use and Health Outcomes

The objective of this thesis was to investigate the relationship between screen time accumulated on smartphones and holistic wellbeing, which included components of mental, physical, and self-rated health. This thesis is part of the Smart Platform, which is a citizen science and digital epidemiological initiative for ethical population health surveillance, integrated knowledge translation, and real-time behavioral interventions (Katapally et al., 2018).
This research investigated the relationship between screen time accumulated specifically on smartphones and the potential association that excessive smartphone usage has on holistic wellbeing among youth and young adults in Saskatchewan urban centres. To accomplish this, youth responded to survey questions via their smartphones, including demographic and subjective data reporting on mental, physical, and self-reported health. The following questions were addressed: 1) Is there an association between smartphone usage (internet surfing, video gaming, texting, etc.) and mental health outcomes such as anxiety or depression?; 2) Is there an association between smartphone usage and physical health outcomes such as weight status?; and 3) Is there an association between smartphone usage and perceived health such as self-rated health and self-rated mental health?

Overall, the findings from this study further support the current literature which indicates that those who engage in excessive screen time are at greater risk of poor health outcomes (Silva et al., 2018; Edelson et al., 2016; Hoare et al., 2016). However, there are several findings in this study that address gaps in the current body of knowledge with respect to what is known about the youth cohort and one of the most commonly used technological devices - smartphones.

Although there is a wealth of existing knowledge that focuses primarily on sedentary specific behaviours, generally this existing evidence characterizes these behaviours as television watching, video gaming, or computer use (Silva et al., 2018; Rosen, 2018; Gunnell et al., 2016; Saunders & Vallance, 2017). However, televisions and computers are not the only technology where populations can engage in these behaviours. The rise in use of smartphone technologies require that research must consider the unique health consequences that these devices may have on health (Saunders & Vallance, 2017; Anderson & Jiang, 2018). Furthermore, smartphone technology is not just limited to a traditional understanding of what television watching, video gaming, or internet use is. Young populations are increasingly engaged in YouTube, social
media, picture taking, and text-messaging among many other sedentary behaviours (Anderson & Jiang, 2018) that are commonly left out of research. This study is unique, as it focuses on device specific behaviours, as well as, expands our understanding of sedentary behaviours, and provides a deeper understanding of how smartphone screen time specifically is associated with health.

Research must also continue to adapt to a new understanding of screen time and sedentary behaviours are defined. Screen time is predominately used as a proxy for sedentary behavior (Lepp et al., 2013; Rosenberg et al., 2010), and health outcomes focus primarily on adiposity (Saunders & Vallence, 2017; Tremblay et al., 2011a; Tremblay et al., 2011b; Carson et al., 2016). However, in recent years, screen time research has been moving toward inclusion of other aspects of health, such as psychosocial factors (Hoare et al., 2016; Twenge, Martin, & Campbell, 2018; Gunnell et al., 2016; Saunders & Vallance, 2017). As previously mentioned, smartphone devices are ubiquitous in nature and provide ample opportunity for a variety of screen time behaviours that have been known to have unique impacts on health (Gunnell et al., 2016; David, Roberts, & Christenson, 2018). Still, few studies review the relationship between screen time, specifically smartphone usage, and multiple health outcomes. This study moves beyond current knowledge by undertaking a new perspective on screen time research and population health by analyzing smartphone usage as a unique behavior separate from other types of screen time, as well as, aspects of mental, physical, and self-rated health to provide a more holistic perspective.

A report in the United States that surveyed youth aged 8-18 years of age found that, on average, youth report spending over 7 hours per day engaged in leisure activities on their smartphone and when learning was involved, this increased to over 9 hours per day (Rideout & Robb, 2019). In this study, majority of youth and young adults in Regina high schools reported engaging in greater than 4 hours of weekly (the sum of one weekend day plus one week day) and
greater than 2 hours of weekend and week day screen time activities in almost all behavioural
categories. Consistent with the literature (Anderson & Jiang, 2018; Rideout & Robb, 2019), this
study found that the highest reported smartphone usage was for internet surfing (including social
media) where 57.1%, 47.8%, and 45.5% of participants in this study reported over 4 hours for a
two day sum or over 2 hours per day on the weekend days and week days respectively. Total
screen time, which included all behaviours (internet, gaming, and texting) only exasperated these
results, where 73.1%, 73.9% and 66.3% of participants reported over 4 hours for two day sum or
over 2 hours per day on the weekend days and week days respectively.

The first important findings in this study are associated with youth mental health
outcomes. For this research, symptoms of anxiety and depression were reported to cover
components of mental health. Anxiety was defined by two variables of self-reported feelings of
nervousness and worry, where results from this study showed that smartphone usage was
significantly associated with feelings of nervousness and worry. Specifically, participants who
engaged in excessive internet and total smartphone usage (sum of all behaviours) for a two day
sum, as well as, just during weekends were more likely than their peers to report feelings of both
nervousness and worry. These findings are consistent with research that supports the notion that
excessive screen time is associated with anxiety (Hoare, et al., 2016; Twenge, Martin, &
Campbell, 2018; Sohn et al., 2019). However, this study is unique in that these findings were
specifically associated with smartphone devices, and shows that only some screen time
behaviours at different days of the week have unique associations with mental health in the youth
population.

For instance, even though 45.5% of students reported greater than 2 hours of internet
smartphone usage during the weekdays, there were no significant associations found between
week day internet smartphone activity and mental health outcomes; contrary to weekend internet
use where 47.8% of participants reported greater than 2 hours of internet smartphone usage and were more likely to report feelings of anxiety. As hypothesized, excessive levels of internet use was associated with higher levels of anxiety but an unexpected finding also emerged which showed that only weekend internet activity is associated with anxiety. Current research suggests that passive screen time activities may be associated with poor mental health outcomes, thus, perhaps students are using internet time during the week to complete homework or other learning activities, whereas on the weekend, they may be more engaged in social media or passive activities (Rosen, 2018; David, Roberts, & Christenson, 2018). This study provides an interesting starting point for further research to be conducted on internet specific screen time behaviours accumulated on smartphones that may have passive or active learning components.

Depression was defined by two variables, self-reported feelings of sadness and suicidal ideation. Similar to the current body of knowledge (Hoare et al., 2016; Twenge, Martin, & Campbell, 2018; Gunnell et al., 2016), results from this study showed that excessive screen time was associated with depression. However, there were significant contributions found in this study regarding the associations between depression and screen time, which specifically analyzed smartphone usage as opposed to screen time typically defined by computer, television, and video gaming devices. An important association found in these models, and contrary to what was hypothesized, was the finding that the same screen time behaviours which increased the likelihood of suicidal ideation were also the same behaviours that are associated with the reduced likelihood of youth reporting feelings of sadness or hopelessness.

The results in this study show that participants who reported excessive amounts of smartphone usage (i.e. greater than 2 hours per day), specifically for gaming, as well as, total screen time behaviours (internet use, gaming, and texting) actually resulted in a protective value. In other words, youth were less likely to report feelings of sadness or hopelessness than were
their peers who were engaged in less smartphone usage. Associations were found in both the two day recall (which includes the sum of one week day and one weekend day), as well as, separately for weekend day recall and week day recall. For example, week day total screen time (internet, gaming, texting) accumulated on smartphones reduced participant’s likelihood of reporting sadness or hopelessness by 45%. Furthermore, self reported depression (feelings of sadness or hopelessness) was the only health outcome in this study that had a significant association with week day smartphone usage, as well as, protective value. Therefore, further research should investigate week day activities that youth engage in on their smartphones to better understand how positive mental health outcomes can be supported.

Alternatively, excessive smartphone gaming was also associated with increased likelihood that a participant had seriously considered attempting suicide within the last year. In this study, participants who reported greater than 4 hours of two day gaming on their smartphone, as well as, greater the 2 hours of gaming and total screen time on weekends were more likely than their peers to report suicidal ideation. In other words, both two day screen time (one weekend day plus one week day) and weekend screen time behaviours specific to gaming were significantly associated with youth reporting suicidal ideation but also reduced their reported feelings of sadness and hopeless. Furthermore, overall screen time behaviours (internet, gaming, texting) on the weekends were also associated with suicidal ideation and reduced feelings of sadness and hopelessness. For example, participants who engaged in greater than 2 hours per day of gaming on their smartphone on the weekend were 60% less likely to report feelings of sadness and hopelessness but over 3 times more likely to report suicidal ideation. These results should not only re-direct how we think about screen time accumulation but also how we understand and address feelings of depression in youth. Further research could use smartphone technology to employ the citizen science-based approach developed through the
Smart Platform in not only engaging youth, but also understanding population health crises through their perspectives and in their lived experiences (Katapally, 2020).

While some studies suggest that there are bi-directional relationships between screen time and mental health (Gunnell et al., 2016), this is the first study, to our knowledge, that shows a protective association between smartphone usage and depression. However, the results from this study show that the same behaviours are also associated with suicidal ideation. It is essential to further investigate the complicated results found with this association to better understand exactly what behaviours promote positive mental health outcomes, what behaviours result in negative mental health outcomes, and further, to find better ways to reach and protect youth from experiencing poor mental health.

Self-reported health outcomes were also investigated in this study. Youth and young adults were more likely to self-report fair/bad/very bad general health (37.8%) than they were to report poor self-rated mental health (17.8%). Overall, research suggests that youth who engage in greater than 2 hours per day of screen time activities are at risk for poor self-rated health, and although there are much fewer studies regarding perceived mental health, the negative association has been found in studies that focus on screen time and self-rated mental health as well (Zhang, Lu, & Wu, 2020; Werneck et al., 2018; Silva et al., 2018; Herman, Hopman, & Sabiston, 2015; Iannotti, et al., 2009). This study is consistent with the current body of knowledge, however, provides significant contributions given that no studies were found specifically using smartphone devices, as well as, the lack of evidence available for self-rated mental health with the youth population.

In this study, youth who reported poor general health were associated with higher levels of gaming screen time accumulation on their smartphone over a two day sum (one weekend day and one week day) as well as just during the weekend. Alternatively, poor self-rated mental
health was not significantly associated with gaming smartphone usage but was associated with overall smartphone screen time behaviours (internet, gaming, texting) over a two day sum, as well as, specifically during the weekend.

The findings from this study shows that smartphone specific screen time is consistent with evidence that suggests excessive screen time behaviours are negatively associated with self-rated health and self-rated mental health. However, this research shows that individual screen time behaviours on a smartphone device have unique associations with self-rated health outcomes. Furthermore, evidence from this study shows that it is essential to not just consider total screen time behaviour, but also when during the week the behaviour occurs. For both health outcomes, weekend smartphone usage was consistently associated with poor self-rated health.

The final health outcomes considered in this study, as part of a holistic perspective on screen time use, were physical health outcomes. Specifically, overweight and obese weight status were analyzed in this study. The results of this research showed that participants who were categorized with an overweight or obese weight status were more often engaging in excessive amounts of gaming screen time, specifically on their smartphones. Further considerations to take into account for weight status is the amount of time accumulated on smartphones. For example, generally it is recommended that youth do not engage in anymore than a maximum of 2 hours per day of screen time on any device (CSEP, 2021). However, significant associations in this study were only found for participants who reported 4 hours or more of gaming screen time for a weekly basis (which includes one weekend day and one week day). Although this still averages to 2 hours per day, the single day binary screen time variables derived in this study to investigate weekend day and week day behaviours separately, were not associated with over weight or obese weight status in this study.
It is well documented that screen time behaviours, including smartphone usage, is highly associated with poor physical fitness and a higher weight status (Lepp et al., 2013; Raustorp et al. 2015; Ullrich-French et al., 2010; White et al., 2012; Vandewater, Shim, & Caplovitz, 2004). Although evidence for the adult population is widely accepted, some researchers insist that findings regarding weight status and video gaming with the youth age group still remains ambiguous (Kracht, Joseph, & Staiano, 2020). This may be in part due to emerging popularity of active video gaming which encourages youth to move while engaging in screen time (O’Loughlin et al., 2012; Bochner, Sorensen, & Belamarich, 2014). However, a meta-analysis conducted by Bochner, Sorensen, and Belamarich (2014) indicated that even though active screen time behaviours improved physical activity, the energy expenditure is generally not high enough to affect weight in youth. Alternatively, some studies show that young adults feel that the ability to easily connect with physically active peers improves their physically active lifestyle (Lepp et al., 2013). As promising and optimistic as that outcome may seem, there is no evidence available to support this idea with the youth populations. Therefore, future research could inform a multi directional relationship between weight status, physical activity, and gaming screen time on smartphones with a focus on what type of active gaming smartphone usage activities are available to the youth population.

The results of this study indicate that nuances with regards to when screen time is accumulated and which behaviours youth are engaged in, are important factors to consider when attempting to address screen time guidelines and smartphone policies with the youth populations. The current investigation makes several important contributions to the literature and intends to provide a concrete understanding on how smartphone usage can impact holistic health. Further to that, while technological advances have been associated with higher rates of smartphone usage, it

65
is appropriate to understand how technology can be used to reverse this trend. This is evident in the findings where protective factors have been found with depressive health outcomes.

6.2 The Smartphone Paradox

Globally, smartphone usage is growing and population dependency on smartphone devices has become a physical and psychological health issue (Parasuraman et al., 2017). For instance, in a study conducted by Parasuraman et al. (2017), using an online survey where adults could self-report smartphone usage behavior, the findings showed that smartphone usage had become such an integral part of participant lives that adults are beginning to show signs of psychological dependency (Parasuraman et al., 2017). Over 74% of participants reported feelings of dependency on their smartphones; almost 40% of the participants reported that they checked their phones 21-30 times per day; almost 12% checked their phones 30 or more times per day; and just over 36% have developed the habit of checking their device in between sleep (Parasuraman et al., 2017). High volumes of smartphone usage persist even though participants reported that they were aware of the dangers that prolonged smartphone usage may have on their physical and psychological health and 50% reported that they would not quit using their smartphone even if their daily lifestyle was impacted by smartphone usage (Parasuraman et al., 2017). Furthermore, female participants reported higher behavioral awareness and increased dependency on smartphones as compared to males, however, were more ready to quit using their smartphone if it affected their daily living (Parasuraman et al., 2017).

Dependency on smartphone technology has been found in young age groups as well, where some youth report feelings of anxiety when their smartphones are not available and they neglect other daily activities to engage in smartphone activity (Sohn et al., 2019). Ease of access to smartphone technology may also be fueling screen time behaviours, particularly online
activities (Anderson & Jiang, 2018). As previously outlined, smartphone usage in the youth cohort is associated with poor mental health, particularly depression and anxiety (Sohn et al., 2019), however, in a study conducted on United States youth aged 13-17 years old, 45% of respondents indicated they did not believe social media platforms had any impact on their health; while 31% reported a positive impact for reasons mainly associated with the ability to connect with friends/family and 24% reported negative effects for reasons mainly associated with bullying (Anderson & Jiang, 2018). No studies were found that compared the amount of time spent on smartphones, a variety of types of activities to engage in, or a clear consensus of self-reported awareness on usage and the impacts on health.

While smartphone-based screen time has thus far predominantly been understood as negative, not all smartphone usage necessarily has poor impacts on health. Ecological momentary interventions (EMI) that are delivered through smartphones, have become important mHealth behavioral modification tools (Daughert et al., 2017; Heron & Smyth, 2010). An EMI is an intervention or treatment that targets mental or physical health behaviors and can be deployed through a smartphone to an individual in real time while in their lived-environments (Heron & Smyth, 2010). Studies have shown that daily interactions using smartphone technology, to engage with participants, can have positive impacts on eudaimonic wellbeing (Daughert et al., 2017) and physical health (Heron & Smyth, 2010).

Nevertheless, while it is important to recognize that smartphone usage may have positive impacts on health, evidence has shown that high rates of smartphone usage and screen time behaviors are known to have negative impacts on psychological wellbeing, social relationships, and quality of life (Hruby et al., 2016; Tremblay et al., 2017; Rosen, 2018; Meier et al., 2007; Ryan, Huta, & Deci, 2006). While populations are inevitably becoming reliant on digital
technology, more research and awareness is needed to create healthy screen time guidelines for smartphone use, specific to age group and type of activity, in order to promote healthy screen time behaviors. Ultimately, smartphone usage is a complicated phenomenon, which needs to be understood to minimize poor health outcomes and maximize mHealth approaches.

6.3 Policy Implications

To our knowledge, this is the first digital epidemiological study to understand the association of smartphone usage with holistic health outcomes across with youth and young adult populations. The findings of this study will have several policy implications, including: 1) Development of age-appropriate policy interventions to address smartphone usage; 2) Inform and influence ethical population health surveillance; 3) Advance recommendations for smartphone usage to deploy mHealth interventions to monitor, mitigate, and manage communicable and non-communicable diseases.

First, the development of age appropriate policy recommendations to address smartphone usage. This research reviews screen time accumulated on smartphone during the school year with youth in Regina, Saskatchewan high schools and by doing so, determined what some of the most common screen time behaviours are, how much time is spent engaging these in behaviours, and which specific behaviours have significant associations with health outcomes. We have also been able to advance which screen time behaviours can have positive impacts on health outcomes. Thus, screen time behavior guidelines specific to smartphone use can be developed. For example, since youth engage in significant amount of time spent playing games on their smartphones, particularly during the weekend, and there are a significant associations between gaming and mental, physical, and self-reported health outcomes then guidelines can be
developed for the broader Canadian context but also targeted for school administration and caregivers.

Secondly, the findings of this study may be used to inform and influence ethical population health surveillance through citizen science based techniques which employs meaningful engagement practises, and shifts the control and ownership of personal data back to the citizen scientists. While sedentary behaviors are becoming more prominent as technology advances, smartphone devices present an opportunity for the development of an accessible tool for surveillance (Katapally, 2019), particularly for populations that are regularly neglected in academic research due to the challenges of reaching them. Smartphone devices can be used to capture complex data, including physical, social, and behavioral determinants of health (Katapally et al., 2018). The Smart Platform protocol and process of data collection, management, and consistent engagement on smartphones may be used to refine population health data collection, particularly in the context of mental health with youth populations.

Finally, the findings of this study may be used to advance recommendations for smartphone usage to deploy mHealth interventions to monitor, mitigate, and manage communicable and non-communicable diseases. Smartphone applications are already being developed for population health and tracking communicable diseases and infections (Michael & Geleta, 2013; Wilson et al., 2014; Hines & Sibbald, 2015), and most recently the COVID-19 pandemic has escalated the need for an innovative approach to using digital technology as an opportunity for efficient case detection, contact tracing, and monitoring of quarantined patients (Mello & Wang, 2020). For example, through the use of Ecological Momentary Assessments (short questionnaires deployed to a participant’s smartphone) and Ecological Momentary Interventions (real-time health treatments deployed to a participant’s smartphone), smartphones
have potential to be used as a data surveillance tool to mitigate, predict, and address poor mental health in populations, particularly those that are remote or isolated. While time spent gaming on a smartphone is negatively associated with some health outcomes, this study found that gaming can also reduce likelihood that youth will report depressive symptoms of feeling sad or hopeless. Future research must leverage this finding to better understand how its possible to use technology to reverse or reduce negative health impacts on the youth population, and if needed, to intervene in a safe and positive way. Digital interaction is becoming a norm and population health may benefit from improved access to internet based talking therapies (Abi-Jaoude, Naylor, & Pignatiello, 2020; Moskalenko, Hadjistavropoulous, & Katapally, 2020). This is particularly important given the current context of youth in Saskatchewan learning online during the COVID-19 pandemic.

6.4 Anticipating and Addressing Challenges

6.4.1 Data Security and Anonymity

Ensuring data security and safeguarding the privacy of participants in the Smart Youth projects are major priorities as part of the Smart Platform. When Citizen Scientists participate in this research, they provide all data and respond to surveys using a custom-made app on their smartphone. Data is stored on the participants’ smartphones until they are connected to WiFi where the data is then uploaded to the online server we use to store data. To ensure confidentiality, all data are encrypted before being stored on participants’ smartphones and before streamed to servers (Katapally, 2019). The study app that participants have downloaded onto their phone does not monitor personal activity, such as texting or internet searching, and is unable to access any personal information on smartphones such as the camera roll or contact lists (Katapally, 2019). Additionally, participants do have the option to disable data collection of the
objective sensors (such as GPS and screen state) for a period of time. Finally, during the informed consent process, participants were informed that they were able to withdraw from the study at any time during the data collection cycle (Katapally et al., 2018). The parents of youth for the Smart Youth project could request to have their child’s data destroyed if they changed their mind during the data collection cycle.

6.4.2 Internet Inequity

Although access to digital tools and technology is becoming a global norm overall (Poushter, Bishop, & Chew, 2018; Radesky, Schumacher, & Zuckerman, 2015), there are still challenges and barriers to equitable access to internet and smartphone data and it is essential to consider systemic restrictions to this access for participatory citizen science based research (Katapally, 2019). Through the Smart Platform, we are working to address internet inequity by engaging schools to provide youth access to WiFi to participate in the study, and if this is not possible, allocating funds to provide mobile data plans for the duration of the study (Katapally, 2019).

6.5 Strengths and Limitations

The main strengths of this research are associated with the Smart Platform and the implementation of a citizen science based research framework. Attempting to engage in a meaningful collaboration with participants, school administration, and parents of youth promotes trust in the researchers and encourages questions and concerns to be addressed so that study compliance is improved.

Additionally, the innovative tools in which data was collected is unique and a strength to this research. The Youth Survey adapted validated self-report surveys to further investigate behaviours specific to smartphone devices. As well, accessibility to study participants was
improved by engaging completely on smartphone technology. This allowed for an efficient process in deploying survey questions and also the ability to quickly address survey issues as survey questions could be adapted in real time using the online platform.

Furthermore, screen time was derived in a variety of unique ways to determine if there were deeper associations than what is currently understood about screen time behaviour. Screen time focused specifically on the smartphone device which included internet use, gaming, and texting. A two day binary screen time variable was derived to investigate total accumulated screen time for a whole week, which included recall for one week day and one weekend day. Additionally, there were two single day binary screen time variables derived in this study to investigate weekend day and week day behaviours separately.

Although innovative and efficient, a possible limitation of this research is the idea that the tool through which we are conducting research (via smartphones), could promote the further participation in sedentary behavior and screen time use. In other words, responses to the surveys for this study were entirely through a smartphone device which may have increased the amount of time youth spend on their smartphones.

Additionally, as with all research that relies on participant recall, the Youth survey recall could limit the validity of the study. Future research should try to replicate the approach employed in this study using the Smart Framework and compare self-reported data in the validated surveys with daily prospective data, through ecological momentary assessments deployed to participants’ smartphones to address limitations in survey recall (Romanzini et al., 2019; Katapally & Chu, 2019).
Chapter 7: Conclusion

To our knowledge, this is the first empirical study to investigate multiple smartphone-based screen time behaviours’ association with holistic health outcomes among youth. This research will inform policy recommendations to effectively use smartphones for digital health interventions, while minimizing poor health outcomes associated with smartphone-based screen time behaviours.

The results from this study show that there are multiple complicated relationships between smartphone usage and health outcomes. Given that the prevalence and accessibility of smartphone technology is growing exponentially among all age cohorts across the globe, further investigation of the impacts of screen time accumulated on smartphone devices and holistic health is a necessary next step to better inform health policy and protect population health.

Ultimately, the recommendations resulting from this research focus on reducing smartphone screen time behaviours that have poor impacts on health and promote other smartphone behaviours that could potentially contribute to better overall holistic health. The deeper understanding of smartphone behaviours and health outcomes discovered in this study within the youth population would not have been possible without the invaluable knowledge provided by the citizen scientists who participated in this study. Future research should continue to leverage community-driven approaches, such as the Smart Study Platform, to truly co-develop solutions to population health crises.
Appendix A: Research Ethics Board Certificate

The University of Regina Research Ethics Board has renewed the above-named research project for an additional 12 months beginning February 28, 2021.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair of the Research Ethics Board for consideration in advance of implementation.

AMENDMENT CERTIFICATION
The University of Regina Research Ethics Board has reviewed the changes to the above-named research project as outlined in your memo dated February 23, 2021, and they are approved.

ONGOING REVIEW REQUIREMENTS
In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions:
http://www.uregina.ca/research/for-faculty-staff/ethics-compliance/human/forms1/ethics-forms.html

Ara Steininger
Research Ethics Board

Please send all correspondence to:
Research Office
University of Regina
Research and Innovation Centre 109
Regina, SK S4S 0A2
Telephone: (306) 585-4775 Fax: (306) 585-4893
research.ethics@uregina.ca
Appendix B: Smart Youth Survey

Baseline survey

Questions

1 (Q#107): Physical Activity: Physical activities include all activities you do on a daily basis, including running, sports, hiking, and even skateboarding. There are two main types of physical activities: Vigorous and Moderate. Vigorous physical activities make your heartbeat and breathing faster, and can make you sweat, such as high intensity sports (e.g., hockey), aerobics, fitness and weight training, fast running, and difficult and advanced hiking. Moderate physical activities require less effort than vigorous activities, such as jogging, low intensity sports (e.g. curling), light hiking and biking. Think about all the vigorous and moderate activities that you did in the past 7 days and enter the minutes for each day.

2 (Q#196): How many minutes did you spend doing vigorous or moderate physical activity on Tuesday - October 2

3 (Q#203): How many minutes did you spend doing vigorous or moderate physical activity on Monday - October 1

4 (Q#202): How many minutes did you spend doing vigorous or moderate physical activity on Sunday - September 30

5 (Q#201): How many minutes did you spend doing vigorous or moderate physical activity on Saturday - September 29

6 (Q#200): How many minutes did you spend doing vigorous or moderate physical activity on Friday - September 28

7 (Q#199): How many minutes did you spend doing vigorous or moderate physical activity on Thursday - September 27

8 (Q#198): How many minutes did you spend doing vigorous or moderate physical activity on Wednesday - September 26

9 (Q#7): Active Transportation: Active transportation is walking, biking or skateboarding to move between places (i.e., travel from home to school and back).
Appendix C: Smart Youth Demographic – Eligibility Survey

DEMOGRAPHICS - Eligibility Survey
- completed

Questions

1 (Q#25): Welcome, you are now on your way to becoming a Youth Citizen Scientist!!
   Please take your time answering the questions on this App.

2 (Q#28): Please enter the name of your school

3 (Q#2): How old are you? (age in years)

4 (Q#3): What grade are you in?
   1) ☐ Grade 9
   2) ☐ Grade 10
   3) ☐ Grade 11
   4) ☐ Grade 12

5 (Q#5): What is your gender?
   1) ☐ Male
   2) ☐ Female
   3) ☐ Transgender
   4) ☐ Other
   5) ☐ Prefer not to disclose

6 (Q#6): Please specify:
Appendix D: Frequency Table for Ethnicity Variable

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