2-28-2020 1:30 PM

Examining the environmental influences on physical activity among children in rural Northern Ontario

Brenton L G Button, *The University of Western Ontario*

Supervisor: Gilliland, Jason, *The University of Western Ontario*

A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Geography

Abstract

Low levels of physical activity (PA) among children in Canada have been a primary health concern over the last decade. Higher levels of PA are associated with numerous social, physical, and mental health benefits, and research has also shown that different social, built, and natural elements of local environments are associated with varying levels of PA. Despite growing evidence around the connection between a child's environment and PA, little research has examined the influence of the environment on the PA of rural Canadian children.

Broadly based on the ecological systems theory, this dissertation used data from the Spatial Temporal Environment and Activity Monitoring (STEAM) project. The STEAM project used a multi-method design to gather both quantitative and qualitative health data on a geographically diverse group of children aged 8-14 years in Ontario.

Analyses using logistic regression indicated that correlates of PA differ from weekdays to weekends and that on weekends children from rural Northern Ontario were more active than children from different neighbourhood types (urban, suburban, rural) in Southern Ontario. This established difference between rural Southern and Northern Ontario children provided evidence to support a more in-depth analysis of the factors associated with PA levels among rural Northern children.

A cross-classified model was used to explore correlates of PA among rural children from Northern Ontario, specifically focusing on weather. Boys were more active than girls, children were more active on weekdays, children were less active on days with precipitation, and higher temperature led to higher levels of PA.

Qualitative methods were used to further explore the environmental influences on rural children's PA. Based on a thematic analysis of focus groups, three important themes were identified as having an impact on children's PA: physical environment, social environment, and perceptions of safety.

This dissertation demonstrated the temporal and contextual nuances of children's PA. Specifically, temporal factors like day type and season and contextual factors including, fear

of wildlife, had an impact on children's PA. This work provided important evidence for policymakers and decision-makers to help guide future interventions and policies for increasing PA levels among children in rural communities.

Keywords

Rural, Children, Physical Activity, Northern Ontario, Socio-Ecological Model

Summary for Lay Audience

Children in Canada are not getting enough physical activity (PA). Increasing the amount of PA that children get is important because higher levels of PA offer numerous health benefits. One area that has had a positive impact on children's PA is the environment in which they live and go to school. However, most of the previous research linking environment and PA has been done in larger cities with little research examining rural areas. The purpose of this dissertation was to examine the environmental influences of PA among children in rural Northern Ontario. To achieve this purpose, a mix of surveys, PA monitoring devices, and focus groups were used to gather data on children and their PA.

First, data on children from Southern Ontario and rural Northern Ontario showed that different factors influence PA on weekdays as compared to weekends and children from rural Northern Ontario were more active than children from rural, urban, and suburban Southern Ontario on weekends.

Second, data from Northern Ontario were analyzed, and boys were more active than girls, children were more active on weekdays compared to weekends, children were less active on days with precipitation, and higher temperature led to an increase in PA.

Third, researchers asked small groups of children about their thoughts about their PA in their environment. Children said places to play, weather, friends, and fearing animals impacted their PA.

Overall, all these results suggest that different components of time and specific factors related to living in a rural environment impact children's PA. These results can be used to plan intervention in these rural areas to help promote children's PA levels and overall health.

Co-Authorship Statement

The following dissertation includes three integrated articles and a version of each article has already been (or will be) submitted for publication in peer-reviewed journals. In all cases, Brenton Button is the primary author recruiting, conducting and performing all data collection in Northern Ontario, performing statistical analysis, and writing in each article. In all cases, Dr Jason Gilliland designed the original STEAM study, helped with conceptual design and analyses in this dissertation, and provided editorial feedback on drafts. The co-authorship statement for each remaining author is presented below.

Chapter 4: was also co-authored by Dr Andrew Clark, who assisted with data analysis procedures and editorial feedback.

Chapter 5: was also co-authored by Dr Andrew Clark, Dr Tayyab Shah, and Dr Pitor Wilk. Dr Clark and Dr Shah assisted with data analysis procedures and gave editorial feedback. Dr Wilk was involved in the development and implementation of the cross-classified model.

Chapter 6: was also co-authored by Suzanne Tillmann, who was involved with data collection, data analysis, and editorial feedback.

Acknowledgments

I want to thank my advisor, Dr Jason Gilliland, for his support throughout this process. You took a chance by sending myself and other students to rural Northern Ontario to complete a project in my hometown, and I will be forever grateful for this experience. Your dedication to community, thoughts, and ideas have helped me grow and understand better interdisciplinary research in creating healthy and vibrant communities.

Dr Andrew Clark, after a few years away from academic writing, I shudder to think of the first few documents I sent you. I am forever thankful for your reviews and your revisions of my manuscripts.

To the HEAL team, over the past five years, I had the privilege to work with some of the brightest minds and, more importantly, the best people. The interdisciplinary nature of this lab has forced me to grow and learn beyond what I thought was possible.

To the STEAM North team, thank you for leaving your home to visit mine. The project would not have been the same without any of you!

To the STEAM North communities, schools (teachers, principals, secretaries, custodians, and educational assistants), and students. The project would not have happened without your contributions.

Finally, I would like to thank my family. DA, your love and support have meant a lot throughout this process. BE, thanks for being the best big sister. D and B, if it were not for you two, I do not know whether I would have had the motivation to move home and to take on this demanding research project. Mom and Dad, words cannot describe the importance of your sacrifices and contributions, thank you.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1 Introduction

1.1 Research Context

Low levels of physical activity (PA) among people of all ages are a major health concern for developed countries around the world (Hallal et al., 2012; ParticipACTION., 2018, 2019). Public health professionals are especially concerned with declining levels of PA among children, as habits formed in childhood tend to continue throughout the life course (Telama et al., 2005). According to the most recent cycle of the Canadian Health Measures Survey, only 35% of 5- to 17-year-olds in Canada meet the Canadian Society for Exercise Physiology's target of 60 minutes of moderate-to-vigorous PA (MVPA) per day (Colley et al., 2017). Public health professionals aim to increase the number of children meeting the PA guidelines, as higher levels of MVPA are linked to a decrease in chronic disease risk factors, such as obesity, high blood pressure, and waist circumference (Carson et al., 2013, 2014). In addition, increasing MVPA improves academic performance (Singh, et. al, 2012), social skills, and self-esteem (Liu et al., 2015).

Over the past 20 years, the built environment has become an increasingly popular area of research in the PA field (Ding & Gebel, 2012; Gordon-Larsen et al., 2005). The built environment is defined as "the components of our physical surrounding constructed by humans, such as buildings, parks, and transport networks" (Gilliland, 2010). Alterations to neighbourhood environmental features can have a positive influence on the PA levels of large groups of children over an extended period (Ding & Gebel, 2012; Gordon-Larsen et al., 2005). Over the past two decades, the PA literature has become saturated with studies examining different nuances of the urban environment to further our understanding of the influence of the urban environment on children's PA (Ding et al., 2011; Oliveira et al., 2014; Rich et al., 2012; Tucker & Gilliland, 2007). Despite the massive body of research focusing on urban environments, there is limited research on the effects of living in more rural areas.

In 2015, a group of 28 experts from across Canada convened a "consensus conference on physical activity in rural, remote and northern settings" (Nykiforuk et al., 2018). As a group, the experts developed an evidence synthesis called *Promotion of physical activity in rural, remote and northern settings: a Canadian call to action* (Nykiforuk et al., 2018). This evidence synthesis highlights the need for PA research in underserved communities in rural, remote, northern, and natural settings. The synthesis explicitly highlights a lack of relevant research on PA and its association with features of the physical, built, and natural environment in rural settings (Nykiforuk et al., 2018). Furthermore, the experts argue that if researchers continually neglect rural, remote, and northern communities, this could lead to population health inequities (Nykiforuk et al., 2018). This dissertation contributes evidence to address these identified gaps in children's health, rural health, and health geography by examining the environmental influences on rural children's PA.

1.2 Research Question and Objectives

The purpose of this dissertation is to address the aforementioned knowledge gaps by addressing the following overarching research question: *What are the environmental influences on physical activity among children in rural Northern Ontario?* This dissertation is written as a collection of three manuscripts. Each manuscript coincides with one chapter, and each has its own specific research objective:

1. Examine what factors influence whether children achieve their recommended minutes of MVPA on weekdays and weekend days (Chapter 4).
2. Examine the seasonal and weather influences on rural children's PA (Chapter 5).
3. Explore the multi-level facilitators and barriers to rural children's PA (Chapter 6).

1.3 Geographic Context

The geographic context to which this dissertation relates is to other rural areas across developed countries, but more specifically to rural North America. Chapter 2 is a literature review regarding existent knowledge about rural children's PA levels, and the environmental features that influence urban children's PA are reviewed, as these features are potentially transferable to rural areas. The methods of the Spatial Temporal Environment and Activity Monitoring (STEAM) project and the geographical context of

the study are described in detail in Chapter 3. Chapter 4 uses data from the entire STEAM project, including the cities of London and St. Thomas, the counties of Middlesex, Elgin, Chatham-Kent, Essex, Huron, and Oxford, and four rural communities and one reserve in Northern Ontario (Nipigon, Red Rock, Dorion, Hurkett, and the Lake Helen Reserve). This study area represents distinct geographical areas with a mix of urban, suburban, small town, rural small town, and rural areas in Southern Ontario, and rural small town and rural areas in Northern Ontario. These diverse locations present different environmental attributes that allow for a unique opportunity to explore different environmental influences on PA. Chapters 5 and 6 focus on rural Northern Ontario, and a multi-method approach is used to examine environmental influences on rural children's PA. Further details of these case study areas are provided in their respective chapters. The results are specifically relevant to certain rural communities across North America.

1.4 Conceptual Framework

The focus of this dissertation is on children's PA. Researchers from various disciplines have been trying to understand factors that influence children's PA. Each discipline examines different factors or approaches these factors in different ways based on their field of study. This dissertation examines children's PA from the perspective of a health geographer. Health geography is a section of human geography that examines the relationships between humans and their environments (Dummer, 2008). Health geography takes a holistic approach, hypothesizing the role of place and location in health, well-being, and disease (Dummer, 2008). Health geographers have been instrumental in improving our understanding of children's environments and PA, as they aim to understand the role of place, and their approaches to measurement and conceptualizations of place have helped them conclude that environment can influence children's PA (Gordon-Larsen et al., 2005). However, most of this research focuses on the urban environment, and researchers try to apply these urban based findings to rural areas. This approach can be used as a starting point, but researchers need to understand the unique challenges of rural living (Meyer et al., 2016). Powell et al. (2013) claim that rural children are often a marginalized group, and a common narrative surrounding rural children is that they live in an area that is characterized by safety, freedom, more space to

play, and greater environmental exploration. This narrative is not always the case, however, as rural children sometimes describe their home as dull and boring (Powell et al., 2013). The application of urban strategies in rural environments, a reliance on adult views to represent children's views, and an overall lack of research, has failed to lead to an understanding of rural children's PA. To explore the complex interaction between rural children and the environment, this dissertation uses a pragmatic philosophical approach combined with the ecological systems theory.

Pragmatists link the choice of approach directly to the purpose and nature of the research questions posed (Creswell, 2014; Morgan, 2014). Research is often multi-purpose, and a "what works" tactic allows the researcher to address questions that do not sit comfortably within a wholly quantitative or qualitative approach. With such a lack of research on environmental determinants of children in rural areas, this dissertation provides both empirical evidence and a richness of data, both of which, when combined, provide valuable contributions to understanding rural children's PA.

Health researchers have been attempting to solve the declining PA problem for decades. Some researchers have attempted to use individual behaviour change interventions, while others have focused on more upstream determinants of PA, such as policy change. These methods are subject to their own unique limitations, as individual behaviour change models fail to recognize social, cultural, and economic factors, and upstream models fail to recognize more individual-level issues, such as a child not having anyone to play with. Responding to these oversights, some researchers have used the ecological systems theory and the socio-ecological model to help develop an understanding of the upstream and downstream factors that influence children's MVPA (Martins et al., 2017; Sallis at al., 2008). Originally developed by Bronfenbrenner (1979), and based on the person, the environment, and the continual interaction of both, the ecological systems theory and the corresponding model organizes impacts on behaviour as a series of concentric circles with the individual in the middle and each circle representing a different part of the individual's environment, as shown Figure 1.1 (Brofenbrenner, 1979). Brofenbrenner eventually added a temporal element, referred to as a chronosystem, to this model. The

chronosystem examines how the interaction between the individual and the environment is influenced by different time scales. The time scales can be as short as minutes or as long as decades (Brofenbrenner, 1979).

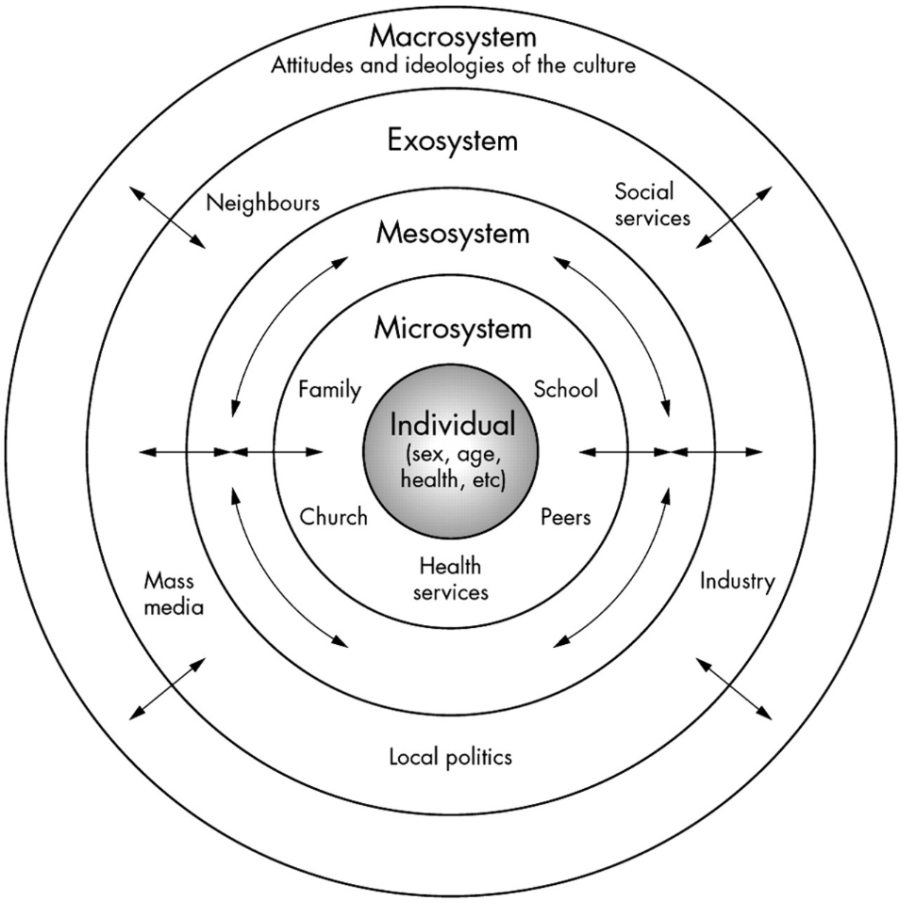


Figure 1.1 Bronfenbrenner's (1979) ecological model

Building on Bronfenbrenner's work, Sallis and colleagues created the socio-ecological model for active living, responding to the need to achieve population change in PA (Sallis et al., 2008). The researchers created a list of potential, testable variables and hypotheses related to each level of the model. These models have generally been accepted or adapted in the field of health behaviour (Egger & Swinburn, 1997; Giles-Corti et al., 2005; Langille & Rodgers, 2010; Taylor et al., 2018).

The socio-ecological model provides a framework for understanding the complex interactions of the intrapersonal, interpersonal, and environment, rather than isolating the

effects of a single variable. The basic idea is that a child's health behaviour is influenced by interactions between the child's characteristics (or intrapersonal characteristics) (e.g., age, gender), immediate context (or interpersonal relationships) (e.g., family, school) and the broader social and environmental context (e.g., community, neighbourhood) (Sallis et al., 2008; Spence & Lee, 2003). This approach suggests that, for individuals to effectively change their behaviours, their surroundings must present them with a convenient way to maintain these behaviours (Ding & Gebel, 2012). The socio-ecological model does not necessarily describe how behaviour is changed but is used to identify variables and potential interaction between those variables that are conducive to a behaviour. As such, the ecological approach allows for a fit between the individual and the environment. This model provides a framework to examine rural children's PA.

1.5 Dissertation Framework and Structure

Through an integrated article format, this dissertation leverages one large and unique dataset to explore the environmental influences on rural children's PA. The following chapter (Chapter 2) provides a literature review on PA, the socio-ecological model, rural children's PA, environmental factors that influence PA, and a discussion of the term "rural" in the context of this study. Chapter 3 discusses the methods used in the STEAM project, including a description of the geographical context. Chapters 4 to 6 are written manuscripts in formats selected for publications in specific academic journals. The aim of Chapter 4 is to use the socio-ecological model to guide an evaluation of factors associated with children's PA on weekdays and weekends using the entire STEAM sample. Based on the results of Chapter 4, Chapter 5 applies the socio-ecological model to examine children's PA, specifically in rural Northern Ontario. Since no modifiable factors are significant in Chapter 5, Chapter 6 uses a qualitative approach, based on the socio-ecological model, to examine children's perceptions and barriers to PA. Chapter 7 concludes the dissertation, explores the results, connects the findings to the overarching research question, discusses the limitations of the dissertation, offers actionable steps from findings, and suggests opportunities for future research. Throughout this dissertation, certain material might be repeated or revisited, but this is necessary to fulfill the requirements of an integrated article dissertation.

1.6 References

Brofenbrenner, U. (1979). *The ecology of human development: experiments by nature and design*. Cambridge, Mass: Harvard University Press.

Carson, V., Ridgers, N. D., Howard, B. J., Winkler, E. A. H., Healy, G. N., Owen, N., Dunstan, D. W., & Salmon, J. (2013). Light-intensity physical activity and cardiometabolic biomarkers in US adolescents. *PLoS ONE*, *8*(8). https://doi.org/10.1371/journal.pone.0071417

Carson, V., Rinaldi, R. L., Torrance, B., Maximova, K., Ball, G. D. C., Majumdar, S. R., Plotnikoff, R. C., Veugelers, P., Boulé, N. G., Wozny, P., McCargar, L., Downs, S., Daymont, C., Lewanczuk, R., & McGavock, J. (2014). Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. *International Journal of Obesity (2005)*, *38*(1), 16–21. https://doi.org/10.1038/ijo.2013.135

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C., & Tremblay, M. S. (2017). Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports*, *28*(10), 8–16.

Creswell, J. (2014). *Research design qualitative, quantitative, and mixed methods apporaches* (4th ed.). SAGE PublicationsSage CA: Los Angeles, CA.

Ding, D., & Gebel, K. (2012). Built environment, physical activity, and obesity: what have we learned from reviewing the literature? *Health & Place*, *18*(1), 100–105. https://doi.org/10.1016/j.healthplace.2011.08.021

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth: a review. *American Journal of Preventive Medicine*, *41*(4), 442–455. https://doi.org/10.1016/j.amepre.2011.06.036

Dummer, T. J. (2008). Health geography: supporting public health policy and planning. *Canadian Medical Association Journal*, *178*(9), 1177–1180. https://doi.org/10.1503/cmaj.071783

Egger, G., & Swinburn, B. (1997). An “ecological” approach to the obesity pandemic. *BMJ (Clinical Research Ed.)*, *315*(7106), 477–480. https://doi.org/10.1136/bmj.315.7106.477

Giles-Corti, B., Timperio, A., Bull, F., & Pikora, T. (2005). Understanding physical

activity environmental correlates: increased specificity for ecological models. *Exercise and Sport Sciences Reviews*, *33*(4), 175–181. https://doi.org/10.1097/00003677-200510000-00005

Gilliland, J. (2010). The built environment and obesity: trimming wasitlines through neighbourhood design. In T. Bunting, P. Filion, & R. Walker (Eds.), *Canadian cities in transition: new directions in the twenty-first century* (Fourth, pp. 391–410). Oxford University Press

Gordon-Larsen, P., Nelson, M. C., Page, P., & Popkin, B. M. (2005). Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*, *117*(2). https://doi.org/10.1542/peds.2005-0058

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U., & Lancet Physical Activity Series Working Group. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet*, *380*(9838), 247–257. https://doi.org/10.1016/S0140-6736(12)60646-1

Langille, J.-L. D., & Rodgers, W. M. (2010). Exploring the influence of a social ecological model on school-based physical activity. *Health Education & Behavior*, *37*(6), 879–894. https://doi.org/10.1177/1090198110367877

Liu, M., Wu, L., & Ming, Q. (2015). How does physical activity intervention improve self-esteem and self-concept in children and adolescents? Evidence from a meta-analysis. *PLoS ONE*, *10*(8), 1–17. https://doi.org/10.1371/journal.pone.0134804

Martins, J., Marques, A., Peralta, M., Palmeira, A., & Carreiro Da Costa, F. (2017). Correlates of physical activity in young people: a narrative review of reviews. Implications for physical education based on a socio-ecological approach. *Retos*, *31*, 292–299. https://doi.org/Recuperado de https://recyt.fecyt.es/index.php/retos/article/view/53505

Meyer, M. R. U., Moore, J. B., Abildso, C., Edwards, M. B., Gamble, A., & Baskin, M. L. (2016). Rural active living: a call to action. *Journal of Public Health Management and Practice*, *22*(5), E11–E20. https://doi.org/10.1097/PHH.0000000000000333

Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qualitative Inquiry*, *20*(8), 1045–1053. https://doi.org/10.1177/1077800413513733

Nykiforuk, C. I. J., Atkey, K., Brown, S., Caldwell, W., Galloway, T., Gilliland, J., Kongats, K., McGvock, J., & Raine, K. D. (2018). Promotion of physical activity in rural, remote and northern settings: a Canadian call to action. *Health Promotion and Chronic Disease Prevention in Canada*, *38*(11), 419–435. https://doi.org/10.24095/hpcdp.38.11.03

Oliveira, A. F., Moreira, C., Abreu, S., Mota, J., & Santos, R. (2014). Environmental determinants of physical activity in children: a systematic review. *Archives of Exercise in Health and Disease*, *4*(2), 254–261. https://doi.org/10.5628/aehd.v4i2.158

ParticipACTION. (2018). *The Brain + Body Equation: Canadian kids need active bodies to build their best brains.* The 2018 ParticipACTION report card on physical activity for children and youth. Toronto: ParticipACTION; 2018.

ParticipACTION. (2019). Better with age. *ParticipACTION report card on physical activity for adults*. Toronto: ParticipACTION; 2018.

Powell, M. A., Taylor, N., & Smith, A. B. (2013). Constructions of rural childhood: challenging dominant perspectives. *Children's Geographies*, *11*(1), 117–131. https://doi.org/10.1080/14733285.2013.743285

Rich, C., Griffiths, L. J., & Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 8. https://doi.org/10.1186/1479-5868-9-49

Sallis, J., Cervero, R., Ascher, W., Henderson, K., Kraft, K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health*, *27*, 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100

Sallis, J., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: theory, research, and practice, 4th edition* (Fourth, pp. 465–485). Jossey-Bass https://doi.org/10.7326/0003-4819-116-4-350_1

Singh, A., Uijtdewilligen, L., Twisk, J. W. R., van Mechelen, W., & Chinapaw, M. J. M. (2012). Physical activity and performance at school: a systematic review of the literature including a methodological quality assessment. *Archives of Pediatrics &*

Adolescent Medicine, *166*(1), 49–55. https://doi.org/10.1001/archpediatrics.2011.716

Spence, J. C., & Lee, R. E. (2003). Toward a comprehensive model of physical activity. *Psychology of Sport and Exercise*, *4*(1), 7–24. https://doi.org/10.1016/S1469-0292(02)00014-6

Taylor, L., Clark, A. F., & Gilliland, J. A. (2018). Context matters: examining children's perceived barriers to physical activity across varying Canadian environments. *Health & Place*, *54*, 221–228. https://doi.org/10.1016/j.healthplace.2018.10.002

Telama, R., Yang, X., Viikari, J., & Välimäki, I. (2005). Physical activity from childhood to adulthood: a 21 year tracking study. *American Journal of Preventive Medicine*, *28*(3), 267–273. https://doi.org/10.1016/j.amepre.2004.12.003

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909–922. https://doi.org/10.1016/j.puhe.2007.04.009

Chapter 2

2 Background

2.1 Overview

The focus of this dissertation is on children's physical activity (PA) in a rural setting. Prior to developing the research questions and analysis plan, it is important to summarize what is known in the literature and to identify gaps. In this chapter, I (1) summarize the information on the prevalence of children's PA in general, and in the rural environment in particular; (2) describe the socio-ecological model and some of the variables that have been considered in this model in relation to PA; and (3) present information on urban children's PA and the environment as a starting point to discuss rural children's PA and the environment. This section concludes with (4) a discussion of the term "rural."

2.2 Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). This dissertation focuses primarily on moderate to vigorous PA (MVPA), which includes any type of PA that significantly increases one's heartrate, breathing, and body temperature (Canadian Society for Exercise Physiology, 2012), for example, hiking or playing tag (Jete et al., 1990). Among school-aged children, MVPA is associated with both short- and long-term health benefits; short-term benefits include higher self-esteem (Liu et al., 2015), reduced anxiety (Biddle & Asare, 2011), and lower levels of depression (Korczak et al., 2017). Some long-term benefits of PA include control of blood pressure, reduced risk factors associated with the metabolic syndrome, improved bone-mineral density, and the regulation of body weight and body fat (Carson et al., 2013, 2014; Janssen et al., 2010).

Researchers have discovered that 60 minutes of daily MVPA is adequate to achieve many of the health benefits listed above (Janssen et al., 2010). As such, Canada's PA Guidelines state that school-aged children and youth (5-17 years of age) should accumulate at least 60 minutes of MVPA daily to achieve health benefits (Canadian Society of Exercise Physiology, 2012; Tremblay et al., 2011). This guideline is similar to

that in the United States (US) (Song et al., 2013) and some European countries (Kahlmeier et al., 2015). Unfortunately, according to data from the 2014-2015 Canadian Health Measures Survey, a nationally representative survey that assesses MVPA through objective methods (accelerometers), only 35% of children met the guideline of 60 minutes per day (Colley et al., 2017; PartipACTION, 2018). This figure has remained relatively consistent since 2007 (Colley et al., 2017). The poor adherence to the PA guidelines is concerning because PA declines into adulthood (Brown et al., 2017; Dwyer et al., 2009) and low levels of PA in adulthood are associated with increased morbidity (Dwyer et al., 2009), mortality (Nechuta et al., 2016), and healthcare spending (Janssen, 2012). Thus, establishing a healthy and active lifestyle early in childhood has the potential to increase a child's quality of life and to reduce future risk of chronic diseases and premature death. In the rural environment, especially in the Canadian context, it is difficult to determine whether the prevalence of PA is similar or different compared with the national level mentioned above as little research has been conducted focusing on children in rural Canada.

2.2.1 Physical Activity in the Rural Environment

Living in a rural area is becoming a more recognized determinant of health, as both youth and adults in some rural areas are considered to be less healthy than their urban/suburban counterparts (Hansen et al., 2015; Meit et al., 2014; Mitura & Bollman, 2004; Pong et al., 2009). However, research on PA in the rural environment among children is mixed. For example, four studies found that urban youth were more active than rural youth (Collins et al., 2012; Davis et al., 2008; Moore et al., 2013; Rainham et al., 2012). One study, conducted on 50 youths aged 13 to 14 years old in England, suggests that urban children (52.1 minutes MVPA per day) were more active than rural children (26.6 minutes MVPA per day) (Collins et al., 2012). A study of adolescents in Canada found similar results, with urban children being most active (196.6 minutes of MVPA) followed by suburban children (84.9 minutes of MVPA), and rural children being least active (81.7 minutes of MVPA) (Rainham et al., 2012). A study of 284 middle-school students from the Southeastern US found that rural youth had a significantly lower amount of MVPA. Youth from rural communities accumulated about 16 min/day of PA; whereas, urban

children accumulated about 19 min/day (Moore et al., 2013). Finally, a study from the US on 138 children aged 10 years old found that urban children had a higher metabolic equivalent (MET) expenditure per week compared to rural children, with urban children expending about 62 METs per week, and rural children expending about 43 METs per week (Davis et al., 2008).

While some of research to date has suggested that urban youth are more active than rural youth some studies have found that rural youth are more active than urban youth. One study from the US, on 3,416 children in grades 4 to 6, found that urban children were the least active, with rural children from small cities being most active (based on self-reported data) (Joens-Matre et al., 2008). A study on 804 children in North Carolina (US) found that there was no difference in MVPA between boys, but rural girls accumulated about 8.5 minutes MVPA per day more than suburban and urban girls (Moore et al., 2014). While a study conducted in Greece found that PA levels are seasonally dependent. In the winter, urban children took about 1,147 more steps than rural children per day; while in the summer months, rural children took approximately 1,919 more steps per day (Loucaides et al., 2004). These mixed results are echoed in a narrative review on urban versus rural children's PA in the US (McCormack & Meendering, 2016), as well as in other developed countries (Sandercock et al., 2010).

These differing results on PA levels between urban/suburban and rural children and youth make it difficult to draw any conclusions on whether rural children are more or less active than their urban counter parts. With PA levels being so low in North America, and no substantial evidence on whether rural children are more or less active than urban children, it is pertinent for researchers to study these specific areas and to understand rural-specific influences on PA or risk health inequities. Understanding these differences in PA can be challenging, but one model that has become more accepted and prevalent in health, specifically PA, research is the socio-ecological model. This model allows researchers to conceptualize the interplay between multiple variables, ranging from the individual to the environment, including urban and rural status.

2.3 Physical Activity and the Socio-Ecological Model

As discussed in the opening chapter, the ecological systems theory forms the broad theoretical basis for this dissertation. The ecological approach represents a shift in health research. Traditionally, a very narrow conceptualization of health existed, and researchers focused on simply understanding biological factors and excluded psychological, environmental, and social influences. However, there were underlying premises in the biomedical models, such as illness having a single cause, that have generally been accepted as false. In general, ecological models were developed from a desire to improve upon the biological model.

One specific model, the socio-ecological model has been used by some researchers to frame their research on health behaviours and, specifically, on PA. This model offers researchers a framework to move beyond thinking about variables in isolation to an approach that tries to understand an individual's health behaviour as a complex interaction among numerous variables. The model posits that a child's behaviour is influenced by variables and interactions between variables in each system, and between variables in different systems at different points in time (Brofenbrenner, 1979; Sallis et al., 2008). The systems start close to the individual and grow larger and larger in concentric rings, as displayed in Figure 2.1. The temporal aspect is depicted as an arrow to represent how these relationships change over time. The systems considered in this dissertation are intrapersonal, interpersonal, and environment (natural and built) during different time points (temporal). Specifically, this dissertation examines and reinforces the importance of temporal factors (day type and season) in influencing children's PA, as well as potentially adding variables and understanding the strength of variables in the rural context using the socio-ecological model. However, before the built and natural environments are examined, it is necessary to understand potential variables in the other systems of the socio-ecological model.

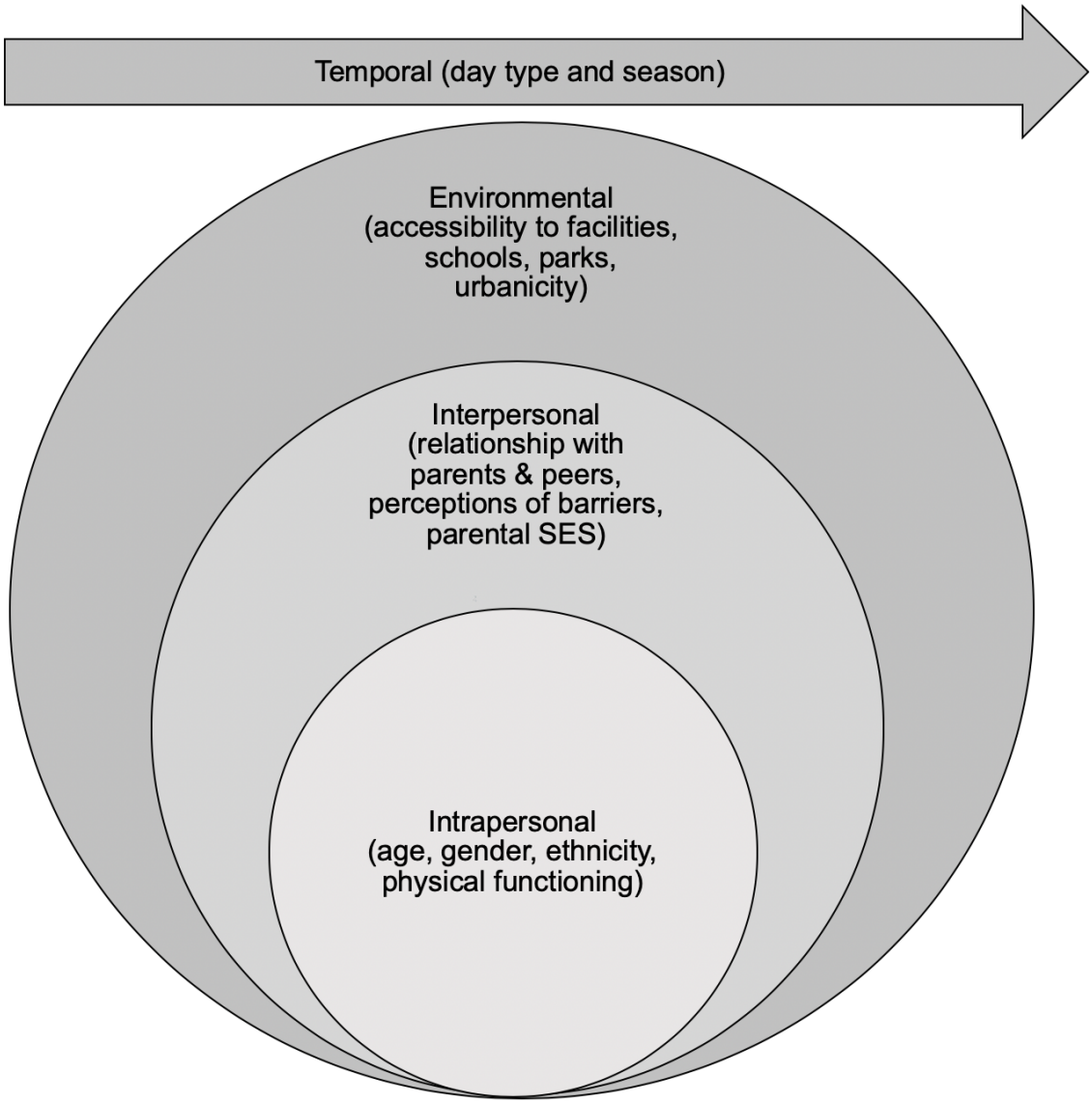


Figure 2.1 Socio-ecological model for children's physical activity with different levels and potential variables, adapted from Sallis et al. (2008)

2.3.1 Intrapersonal Factors Influencing Physical Activity

The intrapersonal level consists of factors such as personal history, biological factors, and other internal characteristics (Sallis et al., 2008). More specific examples tested in research studies include gender, age, ethnicity, and physical literacy. For example, being male has been positively associated with PA (Sallis et al., 2000; Van Der Horst et al., 2007), and age has been inconsistently linked to PA among children aged 4 to 12 years

old (Sallis et al., 2000; Van Der Horst et al., 2007). Furthermore, it was found that Caucasian children were more active than other ethnic groups (Sallis et al., 2000), but no strong result was found in an updated review (Van Der Horst et al., 2007).

Recently, the term "physical literacy" has become more common in PA literature, describing the skills, movement patterns, and knowledge to be physically active in multiple settings (Belanger et al., 2018). In 2018, 14 articles were published as a special supplement on the topic of physical literacy in *BMC Public Health* (Naylor & Temple, 2018). One of the articles examined the relationship between physical literacy and children meeting the PA guidelines. The study showed that, for children aged 8 to 12 years old, if they met the minimum physical literacy guidelines for physical competence, motivation, and confidence, they were more likely to meet the PA guidelines than children who did not meet the minimum guideline (Belanger et al., 2018).

2.3.2 Interpersonal Factors Influencing Physical Activity

In the most general description, interpersonal factors are variables that involve other people, including family or friends' support, the socioeconomic status (SES) of parents, children's perceptions of barriers, and social networks (Sallis et al., 2008). These variables are usually difficult to measure and often rely on different proxy variables. A review by Gustafson and Rhodes (2006) of parental correlates and children's PA found a strong positive relationship between children's PA and parental support (parental support has been measured as involvement, encouragement, and facilitation of or in PA) (Gustafson & Rhodes, 2006; Pyper et al., 2016; Van Der Horst et al., 2007; Wilk et al., 2018). Research on parental correlates has found also that children from two-parent households are more likely to participate in sports than children from other households (McMillan et al., 2016).Work by Taylor and colleagues found that children's perceptions of safety, social, and neighbourhood barriers can have an inverse relationship with PA (Taylor et al., 2018a; Taylor et al., 2018b). In a review by Gustafson and Rhodes (2006), which examined family SES as a predictor of PA through parental employment and/or parental education questions, suggests that family SES is positively related to childhood PA levels (Gustafson & Rhodes, 2006). Socioeconomic status has also been measured

using median household income (Mitchell et al., 2016; Shearer et al., 2012). Finally, relationships with friends have been examined, but the results are not strong enough to draw any conclusions from in the review by Sallis et al. (2000). However, a 2007 review found a positive association between PA and friends' support in adolescents aged 13 to 18 years old (Van Der Horst et al., 2007).

2.3.3 Temporal Factors Influencing Physical Activity

Originally referred to as the chronosystem, this system differs as it is not a concentric ring but is now depicted as an arrow in Figure 2.1 to illustrate how the intrapersonal, interpersonal, and environmental influences on PA might change over time. The time scales can be as short as minutes or as long as decades. In most environmental research, the temporal realm is often omitted (Spence & Lee, 2003), but temporal changes can significantly impact children's PA. Specifically, research suggests that children are more active during the week than at weekends (Belton et al., 2016; Comte et al., 2013), and that they are more active at different times of the year (Rich et al., 2012; Tucker & Gilliland, 2007).

2.4 Built Environment Factors Influencing Physical Activity

Research suggests that planning and altering the built environment could have a positive, enduring, and population-level impact on participation in PA (Ding & Gebel, 2012; Sallis et al., 2012). The built environment consists of all physical environments created or modified by humans, including urban design, physical features, land use, and transportation systems (Gilliland, 2010; Srinivasan et al., 2003). Previous studies have identified several factors in the built environment that play a role in influencing childhood PA: parks (e.g., access/density/proximity); recreation facilities (e.g., access/density/proximity); residential density, pedestrian street safety (e.g., zebra crossings, traffic lights, and speed bumps); traffic speed/volume; walking/biking/wheeling facilities (e.g., sidewalks, bike paths, and shortcuts); and neighbourhood disorder (e.g., crime, vandalism, and graffiti) (Clark et al., 2016; Davison & Lawson, 2006; de Vet et al., 2010; Ding et al., 2011; Larsen et al., 2009, 2012; Loebach and Gilliland, 2010; Taylor et al., 2018a; Tucker et al., 2009; Wilson et al.,

2018) These variables have been measured using different methods, including geographical software and self- or proxy (parent) reporting. Regardless of the strengths, weaknesses, or gaps in research of these measurement types, most of these variables have only been tested among an urban population of children. The results have been mixed but, generally, a positive association between features of the built environment and PA has been found (de Vet et al., 2010; Ding & Gebel, 2012).

Little information exists on environmental influences on rural children's MVPA, but a systematic review on the influence of the built environment and PA was completed on adults in the rural setting (Frost et al., 2010). One of the conclusions of that review was that elements of the built environment appear to have different impacts depending on the geographical setting (Frost et al., 2010). This conclusion suggests that environmental features impact PA levels differently in different geographical settings (Frost et al., 2010), but these environmental features identified in urban studies still offer a valuable starting point for research in rural areas. The following section examines the influence of urban studied features and hypothesizes the different impacts these features have on rural children's PA.

2.4.1 Parks and Outdoor Spaces

Public spaces, including local parks, playgrounds, green space, and cul-de-sacs on neighbourhood roads, are recognized as neighbourhood resources that offer children a place to engage in either free or structured play (Potwarka et al., 2008). Some measures of park accessibility include distance to the nearest park (Greer et al., 2016) and parks inside a particular buffer (e.g., 500 m around a school, 1 km around a child's house) (Mitchell et al., 2016). Research on parks and outdoor spaces has generally found a positive association between access/density/proximity of park space with levels of PA (Mitchell et al., 2016; Moore et al., 2010). For example, a review of the literature on children aged 3 to 12 years old found that almost half the studies identified a positive association between objectively measured park access/density/proximity and PA outcomes (Ding et al., 2011).

A study of 435 students in grades 5 to 8 from urban London (Ontario, Canada), using objective PA and park measures (park space in a buffer around a child's home), found that children with greater access to parks had significantly higher average daily MVPA during non-school hours than those children without access ($\beta = 2.653$ $p = 0.020$) (Mitchell et al., 2016). The authors speculate that urban neighbourhoods with greater access to parks with sports fields afford opportunities for both structured (e.g., sports teams) and unstructured (e.g., playing with friends) PA. In contrast, a study in New Zealand on 184 children with a mean age of 7.6, using an objective measure of PA and Global Positioning System (GPS) units, found that less than 2% of children's weekly PA was in a park (Quigg et al., 2010).

While parks add green space to a city and create a welcoming place to play (Mitchell et al., 2016), they do not necessarily perform the same functions in a rural setting. Parks in rural settings might not be as important or useful as they are in urban settings, because they could be too far for children to travel to independently, or lack people to play with (structured activities such as team sports run less often than in urban settings), and there is generally more outdoor space to be active in rural environments, so children do not need to find a park. Similar conclusions are highlighted in a qualitative study by Moore et al. (2010) on a sample of rural children.

2.4.2 Recreation Facilities

There are numerous public and commercial recreation facilities, such as soccer pitches, baseball diamonds, tennis courts, community centres, arenas, pools, and outdoor basketball courts, which provide children with the opportunity to engage in active play or more structured activities (e.g., sports). Since it is difficult for children to travel long distances on their own, recreation facilities in local communities or neighbourhoods may serve as a hub for children's free play or sporting activities. Recreation facilities have been studied in the built environment/PA literature, including density within a buffer (Nichol et al., 2010) and proximity to home (Wilk et al., 2018). A literature review examining children aged 3 to 12 years old found that recreation facilities are positively

associated with PA, with a little less than half the studies using objectively measured access/density/proximity to recreational facilities (Ding et al., 2011).

For example, a study conducted in London (Ontario, Canada) on students in grades 7 and 8, using self-reported measures of PA (survey), found that both their subjective (survey) and objective measures of access to recreational opportunities (geographic information systems (GIS) measured land-use mix, density of recreation opportunities, and level of park coverage) were significantly related to PA (Tucker et al., 2009). Furthermore, parent-reported access to recreation facilities identified that children were 2.04 (95% CI 1.06-3.92 $p < 0.05$) times more likely to fall within the upper quartile of after-school PA (>180 min/day) than those in the bottom quartile (<60min/day) without access. Using objective measurements of the environment, children living in a neighbourhood with two or more recreation facilities were 1.65 (95% CI 1.09-2.50, $p < 0.05$) times more likely to be categorized in the upper quartile of PA (Tucker et al., 2009). In comparison, a study examining children in grades 6 to 10 across Canada found no consistent relationship between the availability of objectively measured recreational facilities (number of recreation facilities in a buffer) and self-reported adolescent PA. For example, boys living in areas with the fewest recreational facilities compared with boys living in areas with the most recreational features experienced slightly higher rates of PA (1.15, CI: 0.98-1.32), and the opposite was true for girls (0.86, CI: 0.69–1.04) (Nichol et al., 2010), but neither result was statistically significant.

In rural environments, recreation facilities may not be associated with an increase in PA. In some instances, distance to recreation facilities could be too great, which is a commonly cited concern in rural areas (Hennessy et al., 2010). Another reported issue is that recreation facilities in rural areas often offer limited programming that does not engage children and youth (Walia & Leipert, 2012).

2.4.3 Residential Density

Residential density is defined as the number of dwellings within a specified area (Forsyth, 2003) and is used to convey how concentrated a specific area is with people.

Residential density can be measured in different ways, but usually involves a basic ratio calculation with the number of dwellings divided by the area of land they occupy (Larsen et al., 2009). A review of studies on children aged 3 to 12 years old found that just below half the studies identified a positive association between residential density and objectively measured PA (Ding et al., 2011).

A study of 799 suburban adolescents aged 11 to 15 years old living in San Diego, California found that there was no association between residential density and PA (Norman et al., 2006). Conversely, a study of children aged 5 to 18 years old from Seattle, US found that residential density was the most important predictor of PA in the walkability index. The walkability index is a mix of 19 factors that have been demonstrated to be related to active transportation. The study found that when students in the lowest tertile of residential density were compared with the upper tertile, those in the upper tertile of objectively measured residential density were 3.2 times (1.44–7.30) more likely to actively commute to school at least once per week (Kerr et al., 2006). A study from Vancouver (British Columbia, Canada) of children aged 8 to 11 years old also found that residential density was a significant predictor of PA, but only at a 1600 m buffer around a child's address (Van Loon et al., 2014).

These results could be similar for some rural environments. For example, in rural Ontario, some communities are based on single industries. In these single-industry towns, the main population is centrally located and has a higher residential density than other people living in more dispersed rural areas surrounding the community. The areas with higher residential density might be more conducive to PA because there are more nearby children to play with than in areas with a lower residential density; sprawling rural areas, compared with defined residential areas, can be a major barrier to children building PA into their lives (Yousefian et al., 2009).

Although the research on the urban environment can be mixed, it generally suggests a positive relationship between supportive built-environment features (e.g., parks, recreation facilities, residential density) and children's PA. This urban research provides

rural researchers with a valuable starting point for determining environmental variables that could be important in rural environments.

2.5 Rural Built Environment and Physical Activity

Children from rural environments have different levels of PA when compared with urban children (McCormack & Meendering, 2016). This discrepancy might be accounted for by the differences in the urban and rural environments and the way that rural children use their environment. However, few studies have examined the influence of the environment on rural children. Some studies that have analyzed the rural environment have had an urban comparison group. These unique studies suggest that differing environmental features are important for rural and urban children.

A study from the United Kingdom on 100 males and females aged 9 to 10 years old found that rural children were most active in farmland (8.8 minutes of MVPA per day) and grassland (7.1 minutes of MVPA per day), while urban children were most active in gardens (11.0 minutes of MVPA per day) and on roads and paved areas (7.9 minutes of MVPA per day) (Jones et al., 2009). A study in Nova Scotia (Canada) of children aged 12 to 16 years old found that boys (28.8 minutes of MVPA) and girls (32.3 minutes of MVPA) living in rural areas were most active in the school environment, while boys (70.5 minutes of MVPA) and girls (96.7 minutes of MVPA) living in urban areas were most active commuting (Rainham et al., 2012). However, a large study on 4,503 students from 20 schools using subjective PA measurements found none of the environment-level factors were associated with students' time spent in PA across rural schools. The study did find that having an extra room for PA, having a shopping mall within a 1 km radius, and offering daily physical education led to increases in PA in urban and suburban schools (Hobin et al., 2013). Overall, these studies suggest that there is something in rural and urban contexts that influences the importance of environmental factors.

Some qualitative studies have further examined the perceptions of children living in rural areas and their environments and have found some common themes related to children's perceptions of facilitators and barriers to their PA and the environment. Most studies

found that limited resources, “stranger” danger, and distance have a negative influence on PA (Findholt et al., 2011; Moore et al., 2010). For example, 84 males and females aged 10 to 18 years old and living in the rural US shared in focus groups that the presence of criminals may deter them from being active outside more in a rural environment than in an urban environment. This finding might be explained by a perceived higher risk of being threatened in an isolated or remote setting, such as a rural community (Yousefian et al., 2009). Other perceived barriers for using the built environment included a lack of outdoor amenities, a lack of transportation from the city and school-based facilities, and large shopping centres with box stores that encourage residents to drive rather than to walk to complete errands (Yousefian et al., 2009). Another study, using photovoice with nine teenagers aged 13 to 18 years old from Southern Ontario, found that having a lack of opportunities for PA close to home, living in a sparsely populated area, not having streetlights or sidewalks, and a lack of transportation were all considered barriers to PA (Walia & Leipert, 2012)

Overall, it does appear that some urban features that have been studied could be important in certain rural contexts, providing researchers with a valuable starting point. However, few studies focus on examining the environmental influences on rural children’s PA. The paucity of information of the environmental influences on rural children’s PA is a threat to health equity in Canada (Nykiforuk et al., 2018). Using urban areas to create a starting point is particularly valuable in this research project as the concurrently designed methods allow for only one opportunity for data collection. In this dissertation, the quantitative data are used to examine popular environmental features, while the qualitative research adds nuance and suggest new variables to explore.

2.6 Natural Environment Factors Influencing Physical Activity

One limitation of most PA research is that it rarely reports on the impact of the natural environment, in this case, specifically seasonality and weather. Seasonality is essentially the change in broad weather patterns that typically happen throughout the year. This aspect is important to consider, because studies have shown that PA varies with the season (Rich et al., 2012; Tucker & Gilliland, 2007). A systematic review found that

levels of PA appear to be highest in spring and summer months (Tucker & Gilliland, 2007). Results from a more recent review using only accelerometer-based studies are mixed, but they too generally suggest that children are more active in the spring and summer (Rich et al., 2012).

Currently, there seems to be a shift in research on seasonality, from a more simplistic analysis of looking at whether different seasons affect PA, to a more advanced method of trying to determine how daily weather patterns influence PA. Specifically, a study on 307 children aged 8 to 13 years old found that temperatures between 20 ℃ and 22 ℃ corresponded with the highest PA levels (Remmers et al., 2017). Another example, a study on 23,451 children from the International Children's Accelerometry Database, found that precipitation and wind are associated with decreased counts per minutes, and that more daylight, visibility, and increased temperature result in increases in counts per minute (Harrison et al., 2017).

Few studies have been conducted in Canada, and those studies that do exist are located in major cities (Katapally et al., 2015; Lewis et al., 2016; Mitra & Faulkner, 2012). In Canada, there is the potential for drastic weather change: in 2019, the average maximum temperature in January in London ON was -7 ℃; in Thunder Bay ON, it was -16 ℃; and in Pickle Lake ON, it was -20 ℃, and these three locations are all located in one province. With most of the research being done in urban areas, researchers do not understand the influence of weather on PA in rural areas. For example, a study in urban environments during the school day found that having access to indoor recreation facilities reduces the impact of weather-related declines in MVPA (Harrison et al., 2011). In urban areas during poor weather, children can use one of the many recreation facilities available to be active. However, in rural areas during poor weather, these facilities may not exist or, if they do, children may face the additional barrier of distance and transportation. Understanding how PA differs by season and in different locations is imperative for understanding PA levels in Canadian children.

A significant limitation that exists on children's PA literature is the lack of research that has been done in rural areas (Meyer et al., 2016; Nykiforuk et al., 2018). Most of the studies use samples from a single urban area. These studies do provide valuable information but offer little generalizability to rural areas, especially rural northern areas. With other research revealing differences between rural and urban health statuses, it is paramount that researchers surveil and examine the environmental influences on rural children's PA (Hansen et al., 2015; Meit et al., 2014; Mitura, & Bollman, 2004; Pong et al., 2009). Rural areas account for a substantial portion of the Canadian population; therefore, it is imperative that we understand how rural environments influence childhood PA (Statistics Canada, 2018). The aim of this dissertation is to address these limitations using the socio-ecological model.

2.7 Defining the Rural Environment

In the preceding section, the word "rural" was used in a comprehensive sense and encompassed a diverse set of spaces. This issue of meaning was highlighted at a conference/think tank with some of the best rural researchers in North America. At this conference, they identified "a lack of clarity and transparency in how the term rural is conceptualized in the literature" (Nykiforuk et al., 2018). The ambiguity of the term is problematic because it makes it difficult to compare studies or generalize the results of studies (Frost et al., 2010; McCormack & Meendering, 2016). Statistics Canada uses at least six different definitions to delineate rural regions. These definitions use population density, population size, distance from an urban area, distance to an essential service, or a combination of these factors (du Plessis & Clemson, 2001). There are other definitions that are also used to define the term in specific research studies. For example, a study from Halifax uses the local planning guide (Rainham et al., 2012), and some studies fail to define "rural" at all (Cottrell et al., 2015; Loucaides et al., 2004). Similar to Canada, studies from other countries use comparable measures, such as population size, population density, distance to the nearest metropolitan area, or a combination of the three, but since the exact cut-offs are rarely the same, it is difficult to compare or combine the research from other countries. For example, the US define areas under 2,500

people as rural (Ratcliffe et al., 2016); whereas, one of Canada's definition uses 1,000 people (du Plessis & Clemson, 2001).

Using different definitions of rural is problematic because different definitions could lead to different samples being selected, making it difficult to compare research studies or biasing the results. Depending on what definition is used, Canada's rural population can differ by 16%, from 6.3 million to 10.8 million people (du Plessis et al., 2001; Ricketts et al., 1998). Regarding this dissertation, these populations could have different traits related to PA. For example, overall, there is a difference between Canada's rural and urban income levels in adults (Singh, 2002). Thus, if researchers choose a definition that includes more urban populations, they could be including people with a higher income, and higher incomes are sometimes used as a proxy for SES, which has been associated with higher PA levels in children (Gustafson & Rhodes, 2006).

The purpose of this dissertation is not to argue for a specific definition of rural, but to use an easily definable and consistent definition to examine the environmental influences on children's PA. In this dissertation, we use four general categories: urban, suburban, urban small town, and rural. However, most of the focus is on four communities with fewer than 2,000 people. These categories are based on population size and a working meeting between members of the STEAM team and are described in greater detail in the following chapter. Population is used to differentiate between categories because it has previously been used in other academic studies and is easy to distinguish between the groups (Joens-Matre et al., 2008; Moore et al., 2014). Using this definition, we understand that potential bias could exist, but when the term "rural" is highly contested, some sampling bias is inevitable. Table 2.1 contains the urbanicity breakdown, with a brief description of each. In the following section, descriptions of the communities from each level of urbanicity are discussed.

Table 2.1 Description of each urbanicity

Classification	Description
Urban Large City	Geographical areas with more than 100,000 people residing in the subjectively defined city limits
Suburban Large City	Surrounding larger geographical region with more than 100,000 residents
Urban Small Town	Regions with a population of 10,000-99,999
Rural Small Town	Geographical areas with a population of fewer than 9,999

2.8 Conclusion

The purpose of this chapter was to (1) summarize the information on the prevalence of children's PA in Canada; (2) to describe the socio-ecological model and the variables considered in this model; and (3) to present information on urban children's PA and the environment as a starting point to discuss rural children's PA and the environment. This section concluded with (4) a discussion of the term "rural" regarding how it is used in this dissertation. There is a paucity of research focusing on children in rural areas in Canada, and a tendency for research to focus efforts on metropolitan areas. These metropolitan areas have provided us with some valuable information as a starting point for examining environmental influences in the rural environment. However, the lack of rural-specific information leaves policymakers and practitioners without evidence. This dissertation contributes evidence to this area by examining the environmental influences on PA among children in rural Northern Ontario.

2.9 References

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., & Lancet Physical Activity Series Working Group (2012). Correlates of physical activity: why are some people physically active and others not ? *The Lancet*, *380*(9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1

Belanger, K., Barnes, J. D., Longmuir, P. E., Anderson, K. D., Bruner, B., Copeland, J. L., Gregg, M. J., Hall, N., Kolen, A. M., Lane, K. N., Law, B., Macdonald, D. J., Martin, L. J., Saunders, T. J., Sheehan, D., Stone, M., Woodruff, S. J., & Tremblay, M. S. (2018). The relationship between physical literacy scores and adherence to Canadian physical activity and sedentary behaviour guidelines. *BMC Public Health*, *18*(Suppl 2).

Belton, S., O'Brien, W., Issartel, J., McGrane, B., & Powell, D. (2016). Where does the time go? Patterns of physical activity in adolescent youth. *Journal of Science and Medicine in Sport*, *19*(11), 921–925. https://doi.org/10.1016/j.jsams.2016.01.008

Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine*. https://doi.org/10.1136/bjsports-2011-090185

Brofenbrenner, U. (1979). *The ecology of human development: experiments by nature and design*. Cambridge, Mass: Harvard University Press.

Corder, K., Winpenny, E., Love, R., Brown, H., White, H., & van Sluijs, E. (2017). Change in physical activity from adolescence to early adulthood: a systematic review and meta-analysis of longitudinal cohort studies. *British Journal of Sports Medicine*, bjsports-2016-097330. https://doi.org/10.1136/bjsports-2016-097330

Canadian Society of Exercise Physiology. (2012). *Canadian physical activity and sedentary behaviour guidelines*. Ottawa. https://doi.org/978-1-896900-30-8

Carson, V., Ridgers, N. D., Howard, B. J., Winkler, E. A. H., Healy, G. N., Owen, N., Dunstan, D. W., & Salmon, J. (2013). Light-intensity physical activity and cardiometabolic biomarkers in US adolescents. *PLoS ONE*, *8*(8). https://doi.org/10.1371/journal.pone.0071417

Carson, V., Rinaldi, R. L., Torrance, B., Maximova, K., Ball, G. D. C., Majumdar, S. R., Plotnikoff, R. C., Veugelers, P., Boulé, N. G., Wozny, P., McCargar, L., Downs, S.,

Daymont, C., Lewanczuk, R., & McGavock, J. (2014). Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. *International Journal of Obesity (2005)*, *38*(1), 16–21. https://doi.org/10.1038/ijo.2013.135

Caspersen, C. J., Powell, K.E. & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*.

Clark, A. F., Bent, E. A., & Gilliland, J. (2016). Shortening the trip to school: examining how children's active school travel is influenced by shortcuts. *Environment and Planning B: Planning and Design*, *43*(3), 499–514. https://doi.org/10.1177/0265813515614678

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C., & Tremblay, M. S. (2017). Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports*, *28*(10), 8–16. https://doi.org/October 2017

Collins, P., Al-Nakeeb, Y., Nevill, A., & Lyons, M. (2012). The impact of the built environment on young people's physical activity patterns: a suburban-rural comparison using GPS. *International Journal of Environmental Research and Public Health*, *9*(9), 3030–3050. https://doi.org/10.3390/ijerph9093030

Comte, M., Hobin, E., Majumdar, S. R., Plotnikoff, R. C., Ball, G. D. C., McGavock, J., & MIPASS Healthy Hearts Investigators Teams. (2013). Patterns of weekday and weekend physical activity in youth in 2 Canadian provinces. *Applied Physiology, Nutrition, and Metabolism*, *38*(2), 115–119. https://doi.org/10.1139/apnm-2012-0100

Cottrell, L., Zatezalo, J., Bonasso, A., Lattin, J., Shawley, S., Murphy, E., Lilly, C., & Neal, W. A. (2015). The relationship between children's physical activity and family income in rural settings: a cross-sectional study. *Preventive Medicine Reports*, *2*, 99–104. https://doi.org/10.1016/j.pmedr.2015.01.008

Davis, A. M., Boles, R. E., James, R. L., Sullivan, D. K., Donnelly, J. E., Swirczynski, D. L., & Goetz, J. (2008). Health behaviors and weight status among urban and rural children. *Rural and Remote Health*, *8*(2), 810.

Davison, K. K., & Lawson, C. T. (2006). Do attributes in the physical environment

influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity* 3(1), 19. https://doi.org/10.1186/1479-Received

du Plessis, V., Beshiri, R., Bollman, D., & Clemenson, H. (2001). *Definitions of rural* (Vol. 3).

de Vet, E., de Riddle, D., & de Wit, J. (2010). Environmental correlates of physical activity and dietary behaviours among young people: a systematic review of reviews. *Obesity Reviews*, (5), 130–142. https://doi.org/10.1111/j.1467-789X.2010.00784.x

Ding, D., & Gebel, K. (2012). Built environment, physical activity, and obesity: what have we learned from reviewing the literature? *Health & Place*, *18*(1), 100–105. https://doi.org/10.1016/j.healthplace.2011.08.021

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth: a review. *American Journal of Preventive Medicine*, *41*(4), 442–455. https://doi.org/10.1016/j.amepre.2011.06.036

Dwyer, T., Magnussen, C. G., Schmidt, M. D., Ukoumunne, O. C., Ponsonby, A. L., Raitakari, O. T., Zimmet, P. Z., Blair, S. N., Thomson, R., Cleland, V., & Venn, A. (2009). Decline in physical fitness from childhood to adulthood associated with increased obesity and insulin resistance in adults. *Diabetes Care*, *32*(4), 683–687. https://doi.org/10.2337/dc08-1638

Edited by Naylor, PJ & Temple, V. (2018). Canadian assessment of physical literacy. *BMC Public Health*, *18*(2).

Findholt, N. E., Michael, Y. L., Jerofke, L. J., & Brogoitti, V. W. (2011). Environmental influences on children's physical activity and eating habits in a rural oregon county. *American Journal of Health Promotion*, *26*(2), 74–86. https://doi.org/10.4278/ajhp.100622-QUAL-210

Forsyth, A. (2003). *Measuring density: working definitions for residential density and building intensity*. Retrieved from http://www.corridordevelopment.org/pdfs/from_MDC_Website/db9.pdf

Frost, S. S., Goins, R. T., Hunter, R. H., Hooker, S. P., Bryant, L. L., Kruger, J., & Pluto, D. (2010). Effects of the built environment on physical activity of adults living in

rural settings. *American Journal of Health Promotion*, *24*(4), 267–283. https://doi.org/10.4278/ajhp.08040532

Gilliland, J. (2010). The built environment and obesity: trimming waistlines through neighbourhod design. In T. Bunting, P. Filion, & R. Walker (Eds.), *Canadian cities in transition: new directions in the twenty-first century* (Fourth, pp. 391–410). Oxford University Press

Greer, A. E., Castrogivanni, B., & Marcello, R. (2016). Park use and physical activity among mostly low-to-middle income, minority parents and their children. *Journal of Physical Activity and Health*, *14*(2), 83–87. https://doi.org/10.1123/jpah.2016-0310

Gustafson, S. L., & Rhodes, R. E. (2006). Parental correlates of physical activity in children and early adolescents. *Sports Medicine*, *36*(1), 79–97. https://doi.org/10.2165/00007256-200636010-00006

Hansen, A. Y., Meyer, M. R. U., Lenardson, J. D., & Hartley, D. (2015). Built environments and active living in rural and remote areas: a review of the literature. *Current Obesity Reports*, 484–493. https://doi.org/10.1007/s13679-015-0180-9

Harrison, F., Goodman, A., van Sluijs, E. M. F., Andersen, L. B., Cardon, G., Davey, R., Janz, K. F., Kriemler, S., Molloy, L., Page, A. S., Pate, R., Puder, J. J., Sardinha, L. B., Timperio, A., Wedderkopp, N., & Jones, A. P. (2017). Weather and children's physical activity; how and why do relationships vary between countries? *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1–13. https://doi.org/10.1186/s12966-017-0526-7

Harrison, F., Jones, A. P., Bentham, G., Sluijs, E. M. F. Van, Cassidy, A., & Griffin, S. J. (2011). The impact of rainfall and school break time policies on physical activity in 9-10 year old British children: a repeated measures study. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 47. https://doi.org/10.1186/1479-5868-8-47

Hennessy, E., Kraak, V. I., Hyatt, R. R., Bloom, J., Fenton, M., Wagoner, C., & Economos, C. D. (2010). Active living for rural children: community perspectives using photoVOICE. *American Journal of Preventive Medicine*, *39*(6), 537–545. https://doi.org/10.1016/j.amepre.2010.09.013

Hobin, E., Leatherdale, S., Manske, S., Dubin, J., Elliot, S., & Veugelers, P. (2013). Are

environmental influences on physical activity distinct for urban, suburban, and rural schools? A multilevel study among secondary school students in Ontario, Canada. *Journal of School Health*, *83*(5), 357–367.

Janssen, I. (2012). Health care costs of physical inactivity in Canadian adults. *Applied Physiology, Nutrition, and Metabolism*, 803–806. https://doi.org/10.1139/H2012-061

Janssen, I. & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 40. https://doi.org/10.1186/1479-5868-7-40

Jete, M., Sidney, K., & Blumchent, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clinical Cardiology*, *565*, 555–565.

Joens-Matre, R. R., Welk, G. J., Calabro, M. A., Russell, D. W., Nicklay, E., & Hensley, L. D. (2008). Rural – urban differences in physical activity, physical fitness, and overweight prevalence of children. *The Journal of Rural Health*, *24*(1), 49–54.

Jones, A. P., Coombes, E. G., Griffin, S. J., & van Sluijs, E. M. (2009). Environmental supportiveness for physical activity in English school children: a study using global positioning systems. *The International Journal of Behavioral Nutrition and Physical Activity*, *6*, 42. https://doi.org/10.1186/1479-5868-6-42

Kahlmeier, S., Wijnhoven, T. M. A., Alpiger, P., Schweizer, C., Breda, J., & Martin, B. W. (2015). National physical activity recommendations: systematic overview and analysis of the situation in European countries. *BMC Public Health*. https://doi.org/10.1186/s12889-015-1412-3

Katapally, T. R., Rainham, D., & Muhajarine, N. (2015). Factoring in weather variation to capture the influence of urban design and built environment on globally recommended levels of moderate to vigorous physical activity in children. *BMJ Open*, 1–10. https://doi.org/10.1136/bmjopen-2015-009045

Kerr, J., Rosenberg, D., Sallis, J. F., Saelens, B. E., Frank, L. D., & Conway, T. L. (2006). Active commuting to school: associations with environment and parental concerns. *Medicine and Science in Sports and Exercise*, *38*(4), 787–794.

https://doi.org/10.1249/01.mss.0000210208.63565.73

Korczak, D. J., Madigan, S., & Colasanto, M. (2017). Children's physical activity and depression: a meta-analysis. *Pediatrics*, *139*(4). https://doi.org/10.1542/peds.2016-2266

Larsen, K., Gilliland, J., & Hess, P. M. (2012). Route-based analysis to capture the environmental influences on a child's mode of travel between home and school route-based analysis to capture the environmental influences on a child's mode of travel between home and school. *Annals of the Association of American Geographers ISSN:*, *5608*. https://doi.org/10.1080/00045608.2011.627059

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., & He, M. (2009). The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. *American Journal of Public Health*, *99*(3), 520–526. https://doi.org/10.2105/AJPH.2008.135319

Lewis, L. K., Maher, C., Belanger, K., Tremblay, M., Chaput, J., & Olds, T. (2016). At the mercy of the gods: associations between weather, physical activity, and sedentary time in children. *Pediatric Exercise Science*, 152–163.

Liu, M., Wu, L., & Ming, Q. (2015). How does physical activity intervention improve self-esteem and self-concept in children and adolescents? Evidence from a meta-analysis. *PLoS ONE*, *10*(8), 1–17. https://doi.org/10.1371/journal.pone.0134804

Loebach, J., & Gilliland, J. (2010). Child-led tours to uncover children's perceptions and use of neighborhood environments. *Children, Youth and Environments*, *20100139*(201). https://doi.org/10.7721/chilyoutenvi.20.1.0052

Loucaides, C. A., Chedzoy, S. M., & Bennett, N. (2004). Differences in physical activity levels between urban and rural school children in Cyprus. *Health Education Research*, *19*(2), 138–147. https://doi.org/10.1093/her/cyg014

Martins, J., Marques, A., Peralta, M., Palmeira, A., & Carreiro Da Costa, F. (2017). Correlates of physical activity in young people: a narrative review of reviews. Implications for physical education based on a socio-ecological approach. *Retos*, *31*, 292–299. https://doi.org/Recuperado de https://recyt.fecyt.es/index.php/retos/article/view/53505

McCormack, L. A., & Meendering, J. (2016). Diet and physical activity in rural vs urban

children and adolescents in the United States: a narrative review. *Journal of the Academy of Nutrition and Dietetics*, *116*(3), 467–480. https://doi.org/10.1016/j.jand.2015.10.024

McMillan, R., McIsaac, M., & Janssen, I. (2016). Family structure as a correlate of organized sport participation among youth. *PLoS ONE*, *11*(2), 1–12. https://doi.org/10.1371/journal.pone.0147403

Meit, M., Knudson, A., Gilbert, T., Yu, A. T., Tanenbaum, E., Ormson, E., TenBroeck, S., Bayne, A., Popat, S., & NORC. (2014). *The 2014 update of the rural-urban chartbook* (Issue October).

Meyer, M. R. U., Moore, J. B., Abildso, C., Edwards, M. B., Gamble, A., & Baskin, M. L. (2016). Rural active living: a call to action. *Journal of Public Health Management and Practice*, *22*(5), E11–E20. https://doi.org/10.1097/PHH.0000000000000333

Mitchell, C., Clark, A., & Gilliland, J. (2016). Built environment influences of children's physical activity: examining differences by neighbourhood size and sex. *International Journal of Environmental Research and Public Health*, *13*(1), 130. https://doi.org/10.3390/ijerph13010130

Mitra, R., & Faulkner, G. (2012). There's no such thing as bad weather, just the wrong clothing: climate, weather and active school transportation in Toronto, Canada. *Canadian Journal of Public Health*, *103*(SUPPL. 3), 35–41. https://doi.org/10.1016/j.jpain.2012.09.005

Mitura, V & Bollman, R. (2004). *Health status and behaviours of Canada's youth: a rural-urban comparison Rural and Small Town Canada Analysis Bulletin* (Vol. 5).

Moore, J. B., Beets, M. W., Morris, S. F., & Kolbe, M. B. (2014). Comparison of objectively measured physical activity levels of rural, suburban, and urban youth. *American Journal of Preventive Medicine*, *46*(3), 289–292. https://doi.org/10.1016/j.amepre.2013.11.001

Moore, J. B., Brinkley, J., Crawford, T. W., Evenson, K. R., & Brownson, R. C. (2013). Association of the built environment with physical activity and adiposity in rural and urban youth. *Preventive Medicine*, *56*(2), 145–148. https://doi.org/10.1016/j.ypmed.2012.11.019

Moore, J. B., Jilcott, S. B., Shores, K. A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010). A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Education Research*, *25*(2), 355–367. https://doi.org/10.1093/her/cyq004

National Physical Activity Plan Alliance. (2018). *The 2018 United States report card on physical activity for children and youth*.

Nechuta, S., Shu, OS, Yang, G., Cai, H., Gao, YT., Li, HL., Yong-Bing X., Zheng, W. (2016). Adolescent exercise in association with mortality from all causes, cardiovascular disease, and cancer among middle-aged and older Chinese women. *Cancer Epidemiology, Biomarkers, & Prevention*, *24*(8), 1270–1276. https://doi.org/10.1109/77.233453

Nichol, M., Janssen, I., & Pickett, W. (2010). Associations between neighborhood safety, availability of recreational facilities, and adolescent physical activity among Canadian youth. *Journal of Physical Activity and Health*, *7*(4), 442–450. https://doi.org/10.1123/jpah.7.4.442

Norman, G., Nutter, S., Ryan, S., Sallis, J., Calfas, K., & Patrick, K. (2006). Community design and access to recreational facilities as correlates of adolescent physical activity and body-mass index. *Journal of Physical Activity and Health*, *3*(Suppl 1), S118–S128.

Nykiforuk, C. I. J., Atkey, K., Brown, S., Caldwell, W., Galloway, T., Gilliland, J., Kongats, K., McGavock, J., & Raine, K. D. (2018). Promotion of physical activity in rural, remote and northern settings: a Canadian call to action. *Health Promotion and Chronic Disease Prevention in Canada*, *38*(11), 419–435. https://doi.org/10.24095/hpcdp.38.11.03

ParticipACTION. (2018). *The Brain + Body Equation: Canadian kids need active bodies to build their best brains. The 2018 ParticipACTION report card on physical activity for children and youth*. Toronto. ParticipACTION; 2018.

Pong, R. W., Desmeules, M., & Lagacé, C. (2009). Rural – urban disparities in health: how does Canada fare and how does Canada compare with Australia ? *Australian Journal of Rural Health*, 58–64. https://doi.org/10.1111/j.1440-1584.2008.01039.x

Potwarka, L. R., Kaczynski, A. T., & Flack, A. L. (2008). Places to play: association of

park space and facilities with healthy weight status among children. *Journal of Community Health*, *33*(5), 344–350. https://doi.org/10.1007/s10900-008-9104-x

Pyper, E., Harrington, D., & Manson, H. (2016). The impact of different types of parental support behaviours on child physical activity, healthy eating, and screen time: a cross-sectional study. *BMC Public Health*, 1–15. https://doi.org/10.1186/s12889-016-3245-0

Quigg, R., Gray, A., Reeder, A. I., Holt, A., & Waters, D. L. (2010). Using accelerometers and GPS units to identify the proportion of daily physical activity located in parks with playgrounds in New Zealand children. *Preventive Medicine*, *50*(5–6), 235–240. https://doi.org/10.1016/j.ypmed.2010.02.002

Rainham, D. G., Bates, C. J., Blanchard, C. M., Dummer, T. J., Kirk, S. F., & Shearer, C. L. (2012). Spatial classification of youth physical activity patterns. *American Journal of Preventive Medicine*, *42*(5), e87–e96. https://doi.org/10.1016/j.amepre.2012.02.011

Ratcliffe, B. M., Burd, C., Holder, K., & Fields, A. (2016). *Defining rural at the U.S. Census Bureau American Community Survey and Geography Brief*.

Remmers, T., Thijs, C., Timperio, A., Salmon, J., Veitch, J., Kremers, S., & Ridgers, N. (2017). Daily weather and children's physical activity patterns. *Medicine & Science in Sports & Exercise*, (25), 922–929.

Rich, C., Griffiths, L. J., & Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 8. https://doi.org/10.1186/1479-5868-9-49

Ricketts, T., Johnson-Webb, K., Taylor, P. (1998). *Definitions of rural: a handbook for health policy makers and researchers*. *Federal Office of Rural Health Policy*.

Sallis, J. F., Floyd, M., Rodríguez, D., & Saelens, B. (2012). The role of built environments in physical activity, obesity, and CVD. *Circulation*, *125*(5), 11–16. https://doi.org/10.1161/CIRCULATIONAHA.110.969022.The

Sallis, J., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: theory, research, and practice, 4th edition* (Fourth, pp. 465–485). Jossey-Bass

https://doi.org/10.7326/0003-4819-116-4-350_1

Sallis, J., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise*, *32*(5), 963–975.

Sandercock, G., Angus, C., & Barton, J. (2010). Physical activity levels of children living in different built environments. *Preventive Medicine*, *50*(4), 193–198. https://doi.org/10.1016/j.ypmed.2010.01.005

Shearer, C., Blanchard, C., Kirk, S., Lyons, R., Dummer, T., Pitter, R., Rainham, D., Rehman, L., Shields, C., & Sim, M. (2012). Physical activity and nutrition among youth in rural, suburban and urban neighbourhood types. *Canadian Journal of Public Health*. 103(3), S55-S60.

Singh, V. (2002). *Rural income disparities in Canada: a comparison across the provinces* (Vol. 3). Ottawa.

Song, M., Carroll, D. D., & Fulton, J. E. (2013). Meeting the 2008 physical activity guidelines for americans among U.S. youth. *American Journal of Preventive Medicine*, *44*(3), 216–222. https://doi.org/10.1016/j.amepre.2012.11.016

Spence, J. C., & Lee, R. E. (2003). Toward a comprehensive model of physical activity. *Psychology of Sport and Exercise*, *4*(1), 7–24. https://doi.org/10.1016/S1469-0292(02)00014-6

Srinivasan, S., O'Fallon, L. R., & Dearry, A. (2003). Creating healthy communities, healthy homes, healthy people: initiating a research agenda on the built environment and public health. *American Journal of Public Health*, *93*(9), 1446–1450. https://doi.org/10.2105/AJPH.93.9.1446

Statistics Canada. (2018). Census Profile, 2016 Census. Retrieved October 29, 2018, from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

Taylor, L., Clark, A. F., & Gilliland, J. A. (2018a). Context matters: examining children's perceived barriers to physical activity across varying Canadian environments. *Health & Place*, *54*, 221–228. https://doi.org/10.1016/j.healthplace.2018.10.002

Taylor, L., Clark, A., Wilk, P., Button, B., & Gilliland, J. (2018b). Exploring the effect of perceptions on children's physical activity in varying geographic contexts: using a

structural equation modelling approach to examine a cross-sectional dataset. *Children*, *5*(12), 159. https://doi.org/10.3390/children5120159

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., Kho, M. E., Hicks, A., LeBlanc, A. G., Zehr, L., Murumets, K., & Duggan, M. (2011). New Canadian physical activity guidelines. *Applied Physiology, Nutrition, and Metabolism*, *36*(1), 36–46. https://doi.org/10.1139/H11-009

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909–922. https://doi.org/10.1016/j.puhe.2007.04.009

Tucker, P., Irwin, J. D., Gilliland, J., He, M., Larsen, K., & Hess, P. (2009). Environmental influences on physical activity levels in youth. *Health & Place*, *15*(1), 357–363. https://doi.org/10.1016/j.healthplace.2008.07.001

Van Der Horst, K., Paw, M. J. C. A., Twisk, J. W. R., & Van Mechelen, W. (2007). A brief review on correlates of physical activity and sedentariness in youth. *Medicine and Science in Sports and Exercise*, *39*(8), 1241–1250. https://doi.org/10.1249/mss.0b013e318059bf35

Van Loon, J., Frank, L. D., Nettlefold, L., & Naylor, P. J. (2014). Youth physical activity and the neighbourhood environment: examining correlates and the role of neighbourhood definition. *Social Science and Medicine*, *104*, 107–115. https://doi.org/10.1016/j.socscimed.2013.12.013

Walia, S., & Leipert, B. (2012). Perceived facilitators and barriers to physical activity for rural youth: an exploratory study using photovoice. *Rural Remote Health*, *12*, 1842. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22283830

Wilk, P., Clark, A. F., Maltby, A., Smith, C., Tucker, P., & Gilliland, J. A. (2018). Examining individual, interpersonal, and environmental influences on children's physical activity levels. *SSM- Population Health*, *4*, 76–85. https://doi.org/10.1016/j.ssmph.2017.11.004

Wilson, K., Clark, A. F., & Gilliland, J. A. (2018). Understanding child and parent perceptions of barriers influencing children's active school travel. *BMC Public Health*, *18*(1), 1–14. https://doi.org/10.1186/s12889-018-5874-y

Yousefian, A., Ziller, E., Swartz, J., & Hartley, D. (2009). Active living for rural youth:

addressing physical inactivity in rural communities. *Journal of Public Health Management and Practice : JPHMP*, *15*(3), 223–231. https://doi.org/10.1097/PHH.0b013e3181a11822

Chapter 3

3 Methods

3.1 Overview

The purpose of this chapter is to outline the methods of the Spatial Temporal Environment and Activity Monitoring (STEAM) project and describe the study areas to add geographical context to this dissertation.

3.2 Study Sample and Recruitment

This study uses data from the STEAM project. The STEAM project examines health behaviours in children in grades 4 to 8 (ages 8-14 years old) from 37 elementary schools in Ontario, Canada. The elementary schools were in two distinct geographical regions, 33 schools from Southern Ontario and four schools from Northern Ontario. Between 2009-2013 schools in Southern Ontario were selected from Middlesex, Elgin, Chatham-Kent, Essex, Huron, and Oxford counties in four publicly funded school boards (Thames Valley District School Board, London District Catholic School Board, Conseil Viamonde and Conseil Providence) and one private school. Schools were selected from groups of schools stratified by neighbourhood socio-economic status and urbanicity (e.g., urban, suburban, rural small town, rural). Across the four-year study period, there was 100% retention of schools. Recruitment presentations were made to 1394 students, of which 932 agreed to participate (66.9% participation rate). A total of 791 students (84.9%) in this group completed the data collection across both time points in the Southern Ontario cohorts.

In 2016, the study was replicated in Northern Ontario. Schools were selected from the towns of Nipigon, Red Rock, and Dorion, and included all schools from both publicly funded school boards (Superior Greenstone District School Board and Superior North Catholic District School Board) in these communities with grades 4-8. Across the study period, there was 100% retention of schools. Recruitment presentations were made to 194 students, of which 136 participated in data collection in the first round of the study (70.1% participation). A total of 125 students (91.2%) in this group completed the data

collection across both time points in the Northern Ontario cohort. The STEAM project was conducted with approval from the Non-Medical Research Ethics Board at the University of Western Ontario and all seven of the participating school boards (see Appendix A). Before participating in this study, children were made fully aware of all aspects of the study and required to obtain signed parental consent, as well as provide their own signed assent.

Students were invited to attend a presentation given by a member of the STEAM team where a brief presentation about the project was given (as shown in Figure 3.1). If the child was absent a team member told the child about the project, so they were not excluded. In Northern Ontario schools, information was sent out to parents via the school Facebook page before the presentation to the students. Data collection was conducted in all schools using an 8-day multi-tool procedure in two different seasons. A survey was used to collect information on their socio-demographics, PA, mobility, the perception of the environment, and other health behaviours. Children were asked to wear an Actical accelerometer on their hip for eight consecutive days and a global positioning system (GPS) device that passively logged locational data every second. Children were also asked to complete a daily activity diary where they recorded their activities school trips, sleep behaviour, and food purchases. Focus groups were held over lunch hours between data collection cycles.

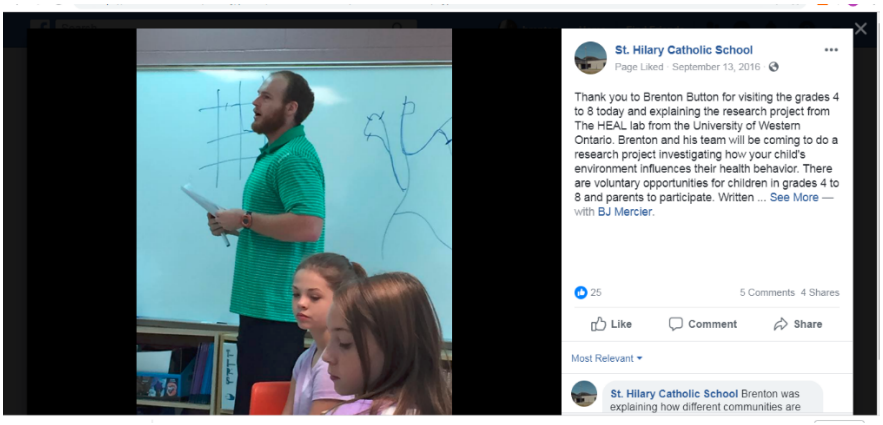


Figure 3.1 A member of the STEAM team presenting about the STEAM project

3.3 Multi-method Approach

One challenge that all researchers face is determining the most appropriate methods to collect data. Several methods have been used to quantitatively measure factors that influence children's MVPA, including surveys, geographic information system (GIS), and census data (Button et al., 2013; Loucaides et al., 2004; Mitchell et al., 2016). Although, these quantitative measures typically provide reliable and valid data, the results from these purely quantitative-based studies are limited in the type of information they can provide. To illustrate this point, a study by Mitchell et al. (2016) found that parks were important for children's PA, but this study only hypothesized why this feature was important. Studies that have attempted to understand PA at a deeper level using qualitative methods, such as focus groups or activity diaries, are usually limited as these studies do not provide quantifiable evidence that is necessary to justify the implementation of new programs (Moore et al., 2010; Wilson et al., 2005). For instance, a study by Wilson et al. (2005) found that boys' favourite activities were basketball, football, soccer, and baseball; whereas, girls rated their favourite activities as playing basketball, swimming, and roller-skating; and both genders reported that they would participate in activities if they were fun, provided a health benefit, and involved friends. However, there are no data from this study that suggest that building a program around these activities would increase PA levels (Wilson et al., 2005). When examining complex problems such as PA, combining objective measurements with rich contextual data has the potential to unlock beneficial information that could improve our understanding of children's PA and subsequently develop effective programming. STEAM projects have the same multi-method data collection protocol, collecting data longitudinally to understand better the potential causal relationships between the built environment and PA. The data collection tools include:

1) Geographic Information Systems (GIS);
2) Healthy Neighbourhood Surveys for Child and Parent;
3) Accelerometers;
4) Wearable Global Positioning Systems (GPS) loggers;
5) Activity diaries;
6) Meteorological data;

7) Focus groups; and
8) Positionality

3.3.1 Geographic Information Systems

A database with built-environment variables describing the opportunity structures for PA were created in GIS software. The opportunity structures that are included in the spatial database include recreation opportunity, park provisions, and infrastructure for active transport. There are also a series of other variables on social environment variables provided by the Canadian Census at the dissemination area level, which is the smallest geographical areal unit for which Statistics Canada releases socioeconomic data.

3.3.2 Healthy Neighbourhood Survey

Each round of the project began with child and parent versions of the Healthy Neighbourhood Survey. The survey included previously-validated or heavily used questions from widely used surveys (Neighbourhood Quality of Life Study, the Neighbourhood Environment Walkability Scale, the International PA Questionnaire for children, and the Pediatric Quality of Life Measurement Model) (Cerin et al., 2006; Janz et al., 2008; Varni et al., 1999), thereby allowing us to compare our results with other studies (Saelens et al., 2003). Copies of parents and child survey can be found in Appendix B. The survey primarily assessed children's perceptions of their local environments and potential barriers and enablers to PA. The parent version of the survey was used to discern how parents/guardians perceive neighbourhood features and safety concerning their children's activities. Socio-demographic information on the child and household were also gathered, such as age, gender, household income, household composition, parents' education, parents' employment status, and ethnicity, as well as parental attitudes/controls regarding children's activities (e.g., rules about playing on the street).

3.3.3 Accelerometers

The Actical accelerometers (Bio-Lynx Inc.) measure PA and active energy expenditure. The units are proven valid for children (Evenson et al., 2008). Each accelerometer was

calibrated for sex, objectively measured and recorded height and weight, date (synchronized to GPS time), and was set to record PA in one-second epochs by trained researchers (Puyau et al., 2002, 2004). Participants wore the accelerometers around the waist for all waking hours, except during water-based activities for one week. At the end of each study period, the accelerometer data were downloaded into Microsoft Excel and SPSS for processing.

3.3.4 Global Positioning System

The GPS units (Visiontac VGPS-900 or Columbus V-900 Bluetooth) are a reliable and accurate tool for objectively measuring the activity patterns of children outdoors. In the STEAM project, the children wore the GPS units on a lanyard around their neck to make them unobtrusive and easy to use. The units were set to record in 1-second intervals. The GPS continuously records data on time/date, speed, altitude, trip distance, and spatial location within 2.5 m (field verified). The GPS data were downloaded from the device during the team's daily visit to the schools and changed out if the battery was dead. At the conclusion of the study, the data were imported into GIS software for visual inspection and data cleaning.

3.3.5 Activity Diaries

Participating students self-completed an activity diary for each 8-day period that they wore the accelerometer and GPS. Each day, participants recorded what times they woke up and went to bed, the transport mode(s) they took to/from school (and elsewhere), activities they engaged in, and with whom they participated in activities and trips. In this way, the diary serves as a compliance log, as well as provides supplementary information on specific activities (Bates & Stone, 2015). The tool is based on a previously-validated activity diary and is moderately acceptable compared to objective measures (Sallis, 1991).

3.3.6 Meteorological Data

Meteorological data were obtained from the Environment Canada historical weather data website (Government of Canada, 2018) for the closest meteorological station for each specific day of the study.

3.3.7 Focus Groups

Semi-structured focus groups were completed with a subset of the STEAM sample. In order to be eligible to participate in the focus groups children had to provide assent and have parent consent that included an audio recording and the potential that anonymous direct quotes could be used in knowledge translation documents. The child focus groups took place at the child's school, lasted approximately 30-45 minutes outside class time (during lunch or recess periods). Question areas were grouped around two main topics PA and nature.

Research assistants from the HEAL lab visited each school every school day during the duration of the study to ensure that the children were wearing the equipment properly, uploading data and filling out their activity diary correctly.

Figure 3.2 STEAM team checking activity diaries and downloading GPS data

3.3.8 Positionality

When discussing this research project, I have been asked, “Why did you pick these communities in rural Northern Ontario?” The answer is simple: I grew up there! As a graduate student, I was tasked with reviewing the literature on the environment and health and identifying a gap that needed to be filled. After researching and reading article after article, I realized that people like myself were missing from the literature. The common discourse on the rural environment is generally focused on agricultural communities or on communities that are located near major centres. This focus on these specific types of rural communities marginalizes children from an already understudied type of rural (see below). With a located gap in the research, I approached my advisor about conducting a research project based on the original STEAM project in my hometown. Although the lab had many opportunities in London, he agreed to send me to my hometown with other graduate students to conduct this project.

I grew up in one of the small rural communities in this study. I spent most of my summers during university working for the township as a youth recreation programmer, and I worked as an occasional teacher in all the study schools before beginning my Ph.D. My parents still live in the same house I grew up in, and my sister lives down the street with her husband and two sons. Growing up, teaching in the study schools, and knowing some of the principals from my days as an elementary school student, I was able to obtain access to principals and teachers. I discussed with the principals any concerns they had, and they knew I would represent the community fairly. Being a part of the community, I was also able to put parents at ease, as most of them knew me or my mother, who worked at the local post office, or my father, an electrician in the mill before it closed. This trust was demonstrated during the study when I had a parent call my parents’ phone number (not listed in the letter of intent) regarding a piece of equipment. Furthermore, I had parents ask me more about the study after the men’s hockey night, and I had the arena attendant call me on multiple occasions as he found different equipment (accelerometer and GPS) in different places around the arena. Being part of the community allowed me to interpret the results based on a combination of my own memories growing up in similar circumstances, working in these communities, and via discussions with parents,

teachers, and principals while remaining grounded in the relevant literature. My unique insider knowledge, in a multi-method project, combined with strategic outsider co-authors, allowed us to interpret this research in a way that is based on local context but that still contributes to the field of health geography.

3.4 Study Areas

The STEAM project was conducted in Northern and Southern Ontario; below is a brief description of the study areas.

3.4.1 Northern Ontario

The primary study areas are situated in the heart of Northern Ontario about 120 km east of Thunder Bay, Ontario and 600 km West of Sault Ste. Marie, Ontario. Here one will find the rural small town of Nipigon (population 1,642), the rural Township of Red Rock (population 895), the rural Township of Dorion (population 316), the dispersed rural community of Hurkett (population 236) and the Lake Helen 53A Indian Reserve (population 303) (Statistics Canada, 2018), as shown in Figure 3.3. Almost every map of North America shows Lake Nipigon as a significant geographic feature. Lake Nipigon and the Nipigon River is the largest tributary to Lake Superior which borders most of the study region. The area is known for towering cliffs, distinctive red rocks, and a Lake Superior shoreline of elongated peninsulas, bays, and islands. The local communities are surrounded by forest with mostly spruce, jackpine, balsam fir, tamarack, cedar, aspen, poplar, and white birch (Hillmer & Bothwell, 2018). The combination of rugged wilderness and plentiful streams makes the area ideal for hunting and fishing. However, the dense and rugged forest that surrounds the local communities does provide potential danger as the bears and wolves will routinely come directly into the community and have been found on school playgrounds.

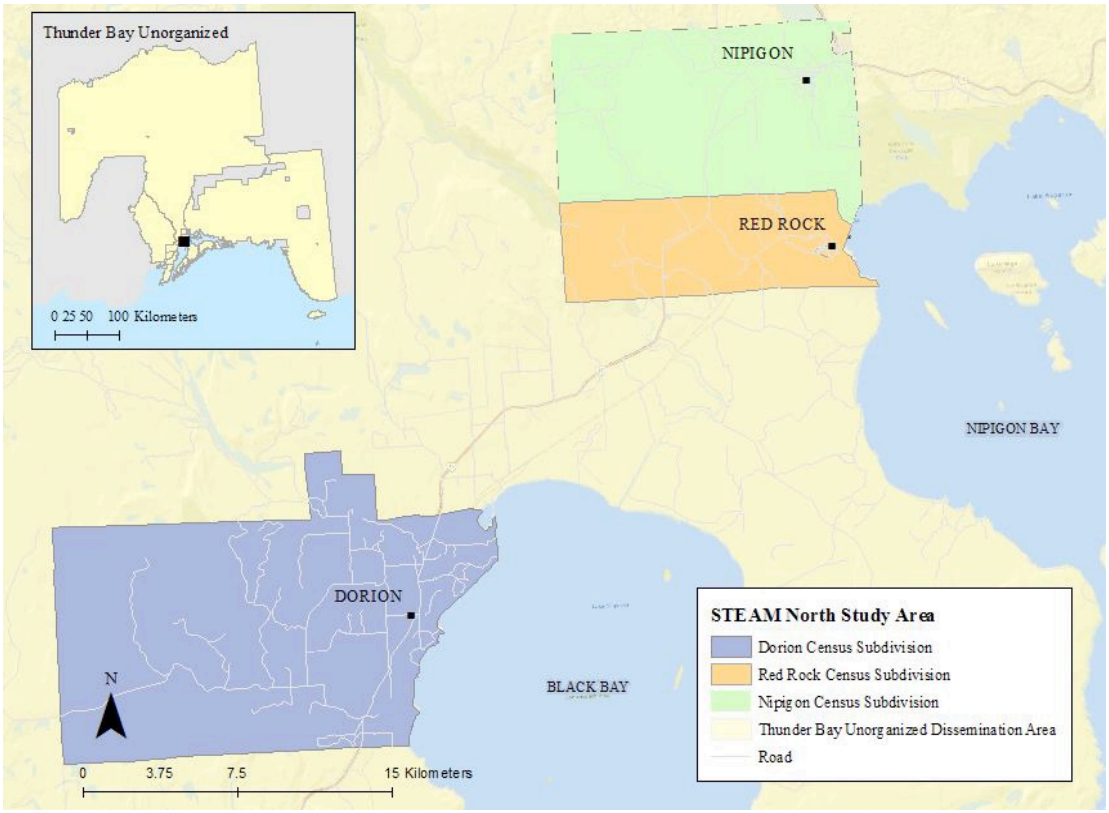


Figure 3.3 Map of study area of Northern Ontario

The Indigenous people were the first inhabitants of the area, but with the fur trade in the eighteenth and nineteenth centuries, then with the construction of the railway in the late-nineteenth century, Europeans came to the area, with each small town having its own ethno-cultural make-up (Hillmer & Bothwell, 2018). The area still maintains a large Indigenous population along with people of European ancestry. During the 1950s the forest industry was a major employer in the area (Brill, n.d.). However, due to unfavourable economic circumstances and devastating fire the local paper mills closed in 2007, and the area has been searching for a new major employer since the 2000s ("Nipigon mill fire a `devastating' loss," 2007).

In Nipigon, the largest population cohort is 55-59 years old, and the median age is 49 years. The median household income is about $57,000 CAD, almost $17,000 lower than the provincial average (Statistics Canada, 2018). Only 85 people in all of Nipigon claim to be immigrants to Canada and nearly 30% of the population claim aboriginal identity

(Statistics Canada, 2018). As shown in Figure 3.4, houses are located relatively close to each other, but once you leave the settled area, you are surrounded by vast forest. Nipigon has one recreation facility with a hockey arena (ice in winter, open in summer for general activities), a curling club, a seasonal outdoor pool (July and August), and two elementary schools. Both Nipigon and Red Rock have parks, basketball courts/tennis courts (all on the same cement pad), a grocery store, a variety store, and a couple of restaurants. Red Rock has one elementary school, the area high school, one recreation facility with a hockey arena (ice in winter closed in summer) and an indoor basketball court (closed in summer).

In contrast, Dorion only has a school that doubles as the community centre. It has one park and a basketball court, both on the school property, and almost all students need to be bused to the school. Dorion is a very low-density settlement; closest neighbours are often a few kilometres away. A few kilometres outside of Nipigon lies the Lake Helen Reserve which has an outdoor hockey rink, a few parks, and two convenience stores. The trans-Canada highway runs through, or acts as a boundary in Nipigon, Dorion, Hurkett, and the Lake Helen Reserve while Red Rock lies about eight kilometres off the highway.

Figure 3.4 Aerial photo of Nipigon, ON (Google, 2018)

3.4.2 Southern Ontario

In this section, characteristics of one of the communities from each level of urbanicity in Southern Ontario will be described to help add further context to the dissertation. Figure 3.5 shows a map of both STEAM North and STEAM South study areas. The largest group of students in the Southern Ontario sample is from the city of London, which is currently ranked as Canada's 11th largest metropolitan area (Population: 383,822) (Statistics Canada, 2018). The city of London lies approximately 200 km from both Toronto, Ontario (to the east) and Detroit, Michigan (to the West). In this study, Large Urban is defined as cities with a population greater than 100,000 (London). For analysis in this study, we refer to Urban neighbourhoods as the central part of the city of London, or the area of the city corresponding to the City of London boundaries in 1959 before widescale suburban development. Neighbourhoods in this urban area have a distinctively urban form, where there is more mixed land use, greater population densities, and more grid-like street networks. Suburban is defined as the remaining area within the current city limits of London, areas annexed between 1960 and 1992. These areas are characterized by more isolated residential zoning, lower population densities, and less permeable street networks. The City of London maintains 133 sports fields, 63 playgrounds, 255 parks and 21 recreation centres with plenty of different recreation options (HEAL, 2016). The most predominant age group in London is between 50-54 years old and the median age is 41 years. Almost 22% of people claim to be immigrants with less than 3% of the population claiming an aboriginal identity. For the most part, London's population still identifies with a European or Canadian origin. The median household income is about $62,000 CAD (Statistics Canada, 2018).

The urban small towns in the STEAM project include Chatham (Population: 44,676), Strathroy (Population: 14,401), and Tillsonburg (Population: 14,933). One town we will take a closer look at is Strathroy. The town of Strathroy is about 35 km from the city of London. The town of Strathroy has seven sports fields, six schools, three conservation areas, six parks, and four recreation centres. (HEAL, 2016) The median household income is $66,100 CAD. The median age is around 43, about 14% of the population is immigrants, and only 2% claim an aboriginal identity (Statistics Canada, 2018).

The rural small towns in the STEAM South study include Tilbury (Population: 4,765), Stoney Point (Population: 1,146) and Mount Brydges (Population: 1,834). The town of Tilbury is located about 130 km from London, but its closest major centre would be Windsor, Ontario located about 60 km east. The community has four schools, an arena, splash pad, skateboard park, tennis court, outdoor pool, and a baseball field (Municipality of Chatham-Kent, 2018). The median age is around 41 years, only 6% of people claim to be immigrants and 2% claim an aboriginal identity. The median household income is about $58,300 CAD (Statistics Canada, 2018). Other rural areas include Arva (Population: N/A), and St. Joachim (Population: N/A). Arva is located 10 km north of London and has one school, a park and a few local businesses; however, Arva is largely a bedroom community of London.

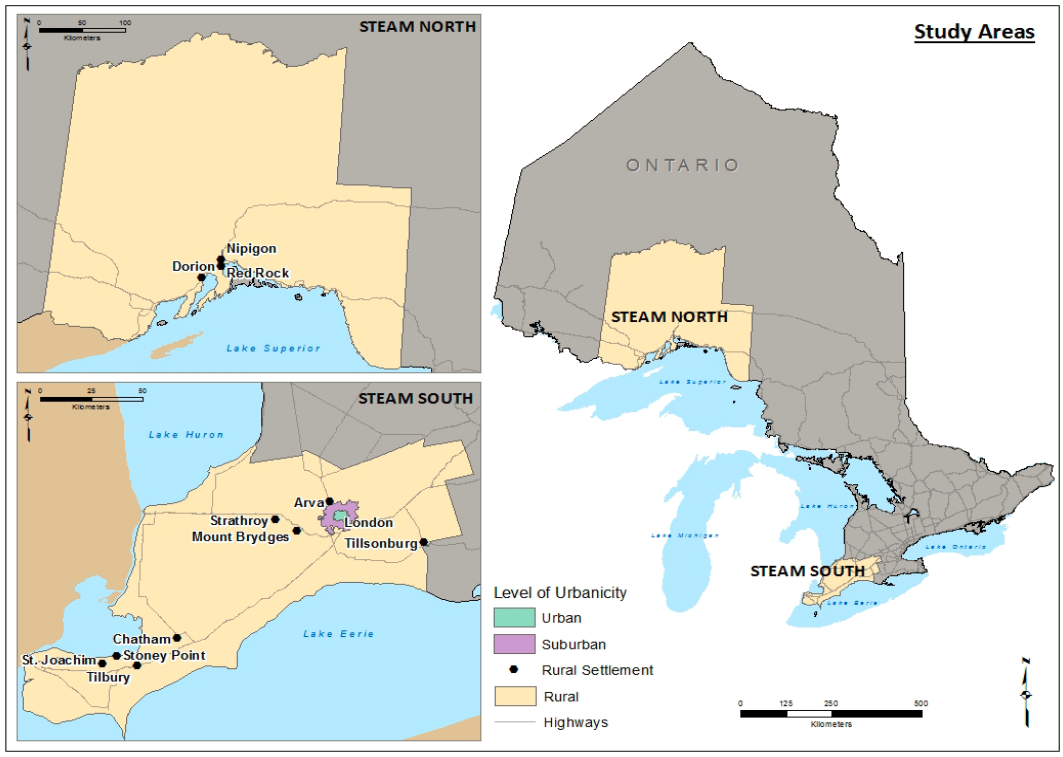


Figure 3.5 Map of STEAM Project Areas in Northern and Southern Ontario including levels of urbanicity

Examining the similarly defined rural small towns of Nipigon and Tilbury in Table 1 reveals that there are some similarities, as they both have a few schools, parks, outdoor arena, pool, and splash pads. There are critical geographical differences, however, as Nipigon is located over 100 km from its nearest metropolitan centre (Thunder Bay); whereas the rural small towns in Southern Ontario are much closer and therefore much more influenced by larger urban centres (London or Windsor). Nipigon also has a higher average age and lower median income.

Table 3.1 Comparison of similarly defined Nipigon (STEAM North) and Tilbury (STEAM South)

	Nipigon	Tilbury
Population	1,642	4,765
Closest Major Centre	110 km	60 km
Schools	2	4
Recreation Facilities	2	6
Median Household Income (CAD)	57,000	58,300
Median Age	59	41

3.5 Conclusion

The purpose of this chapter was to provide a more detailed description of the study protocol and study areas. The objective was to give the reader a comprehensive understanding of the STEAM project, a basic understanding of the research tools, and a contextual understanding of the study area. Having a basic understanding of the tools and study area provide a foundational knowledge for the dissertation.

3.6 References

Anonymous. (2007). Nipigon mill fire a `devastating' loss. *The Star*. Retrieved from https://www.thestar.com/news/2007/02/07/nipigon_mill_fire_a_devastating39_loss.html

Bates, B., & Stone, M. R. (2015). Measures of outdoor play and independent mobility in children and youth: a methodological review. *Journal of Science and Medicine in Sport*, *18*(5), 6–13. https://doi.org/10.1016/j.jsams.2014.07.006

Brill, B. (n.d.). Nipigon Museum the blog. Retrieved from http://nipigonmuseumtheblog.blogspot.com/

Button, B., Trites, S., & Janssen, I. (2013). Relations between the school physical environment and school social capital with student physical activity levels. *BMC Public Health*, *13*, 1191. https://doi.org/10.1186/1471-2458-13-1191

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood environment walkability scale: validity and development of a short form. *Medicine and Science in Sports and Exercise*, *38*(9), 1682–1691. https://doi.org/10.1249/01.mss.0000227639.83607.4d

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences ISSN:*, *0414*. https://doi.org/10.1080/02640410802334196

Google. (2018). Google Earth - Nipigon. Retrieved from https://earth.google.com/web/@49.01322545,-88.26734055,374.98103382a,3311.38403992d,35y,0h,45t,0r/data=ChMaEQoJL20vMDY2bmJ2GAIgASgCKAI

Government of Canada. (2018). Historical Climate Data. Retrieved from https://climate.weather.gc.ca/

HEAL. (2016). *Community Needs Assessment*. Retrieved from https://www.middlesex.ca/sites/default/files/hkcc/Middlesex_County_FINAL_forAccessibility.pdf

Hillmer, N., & Bothwell, R. (2018). Ontario in the Canadian encyclopedia. Retrieved from https://www.thecanadianencyclopedia.ca/en/article/ontario

Janz, K. F., Lutuchy, E. M., Wenthe, P., & Levy, S. M. (2008). Measuring activity in

children and adolescents using self-report: PAQ-C and PAQ-A. *Medicine and Science in Sports and Exercise*, *40*(4), 767–772. https://doi.org/10.1249/MSS.0b013e3181620ed1

Loucaides, C. A., Chedzoy, S. M., & Bennett, N. (2004). Differences in physical activity levels between urban and rural school children in Cyprus. *Health Education Research*, *19*(2), 138–147. https://doi.org/10.1093/her/cyg014

Mitchell, C., Clark, A., & Gilliland, J. (2016). Built environment influences of children's physical activity: examining differences by neighbourhood size and sex. *International Journal of Environmental Research and Public Health*, *13*(1), 130. https://doi.org/10.3390/ijerph13010130

Moore, J. B., Jilcott, S. B., Shores, K. A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010). A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Education Research*, *25*(2), 355–367. https://doi.org/10.1093/her/cyq004

Municipality of Chatham-Kent. (2018). Tilbury. Retrieved from https://www.chatham-kent.ca/Newcomers/choose-chatham-kent/thats-livingck/our-communities/tilbury

Puyau, M. R., Adolph, A. L., Vohra, F. A., & Butte, N. F. (2002). Validation and calibration of physical activity monitors in children. *Obesity Research*, *10*(3)

Puyau, M. R., Adolph, A. L., Vohra, F. A., Zakeri, I., & Butte, N. F. (2004). Prediction of activity energy expenditure using accelerometers in children. *Medicine and Science in Sports and Exercise*, *36*(9), 1625–1631. https://doi.org/10.1249/01.MSS.0000139898.30804.60

Saelens, B. E., Sallis, J. F., Black, J. B., & Chen, D. (2003). Neighborhood-based differences in physical activity: an environmental scale evaluation. *American Journal of Public Health*, *93*(9), 1552–1558. https://doi.org/10.2105/ajph.93.9.1552

Sallis, J. (1991). Self-report measures of children's physical activity. *Journal of School Health*, *61*(5), 215–219.

Statistics Canada. (2018). Census Profile, 2016 Census. Retrieved October 29, 2018, from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

Varni, J., Seid, M., & Rode, C. (1999). The PedsQL: measurement model for the

pediatric quality of life inventory. *Medical Care*, *37*(2).

Wilson, D., Williams, J., Evans, A., Mixon, G., & Rheaume, C. (2005). Brief report: a qualitative study of gender preferences and motivational factors for physical activity in underserved adolescents. *Journal of Pediatric Psychology*, *30*(3), 293–297.

Chapter 4

4 Understanding factors associated with children achieving recommended amount of MVPA on weekdays and weekend days

Brenton L. G. Button MSc

Andrew F. Clark PhD

Jason A. Gilliland PhD

4.1 Abstract

Introduction: Low levels of moderate-to-vigorous physical activity (MVPA) are consistently reported for children living in industrialized countries. These perennially inadequate levels of MVPA have been linked to increased risk for chronic disease. Little research uses a comprehensive approach to examine how correlates of PA differ for children on weekdays versus weekends. The purpose of this research is to examine the factors that influence whether children achieve 60 minutes of MVPA on weekdays compared to weekend days.

Methods: Children (n = 532) ages 8 to 14 years from Southern and Northern Ontario, Canada participated in the study between 2009-2013 and 2016 and data were analyzed in 2019. Children's MVPA was measured using an Actical accelerometer, environmental features measured with a geographic information system (GIS), and demographic data from child/parent surveys. A forward selection method was used to build the model for variables from a socio-ecological model on children meeting or not meeting the PA guidelines.

Results: During the week, boys were more active than girls (OR = 4.153 $p < 0.001$) and as age increased children were less likely to reach the MVPA guidelines (OR = 0.716 $p = 0.001$). On weekends boys were still more likely to meet the guidelines (OR = 1.706 $p = 0.011$) and children living in rural Northern Ontario were significantly more likely to reach the MVPA guidelines compared to all groups in Southern Ontario.

Conclusions: The findings indicate that different variables influence whether children meet the MVPA guidelines on weekdays compared to weekends. Comparing weekdays and weekends provides more useful information for creating effective PA interventions.

Keywords: rural population, urban population, children, physical activity, weekday, weekend

4.2 Introduction

Low levels of physical activity (PA) is a major health problem in industrialized countries around the world (Hallal et al., 2012). In North America, less than 35% of children and youth are achieving the recommended 60 minutes of moderate-to-vigorous PA (MVPA) (Barnes et al., 2018; National Physical Activity Plan Alliance, 2018). This figure has remained consistent over the past 10 years (Colley et al., 2011; National Physical Activity Plan Alliance, 2018). Increasing the proportion of children meeting the MVPA guidelines of 60 minutes of MVPA per day is imperative, as higher levels of MVPA are linked to a decrease in chronic disease risk factors, such as obesity, high blood pressure, and waist circumference (Carson et al., 2013, 2014; Janssen & Leblanc, 2010).

Previous research has identified that children are highly active during the school day with many children getting at least half of their 60 minutes of MVPA while at school (Clark et al., 2019). On the weekends, there is typically a significant decline in MVPA levels (Comte et al., 2013), as children do not have the structure of school to provide programmed opportunities for MVPA. Researchers have examined differences in MVPA levels between weekdays and weekend days (Fairclough et al., 2012), but there is little research that takes a comprehensive approach to examining MVPA on weekdays and weekend days that includes geographically separate places. This paper will address this gap by using the socio-ecological model (SEM) to examine the factors that influence children's ability to achieve their recommended minutes of MVPA on weekdays compared to weekend days.

Health researchers have used the SEM to help develop an understanding of the factors that influence children's MVPA (Martins et al., 2017; Sallis et al., 2008). The SEM provides the framework to understand how the complex interactions of the intrapersonal, interpersonal, physical environment, and policy factors interact to influence behaviour. At the intrapersonal level, age has an inverse relationship with PA (Sallis et al., 2000; Biddle et al., 2011), boys are more active than girls (Biddle et al., 2011; Kavanaugh et al., 2015; Sallis et al., 2000), ethnicity can influence PA (Singh et al., 2008), and research related to how children perceive their ability to do certain activities has a positive

relationship with PA (Belanger et al., 2018; Biddle et al., 2011). At the interpersonal level children's perceptions of barriers in their neighbourhood can have an inverse relationship with PA (Sallis et al., 2000; Taylor et al., 2018a), children from a two-parent household are more likely to participate in sports compared to other households (McMillan et al., 2016), parental support has a positive association on PA (Biddle et al., 2011; Dowda et al., 2011; Sallis et al., 2000; Wilk et al., 2018), and socioeconomic status (SES) can impact PA levels. SES has been measured through parental employment (Estabrooks et al., 2003; Lasheras et al., 2001) and median household income (Mitchell et al., 2016; Shearer et al., 2012). At the policy level, girls who attend a school with a balanced school day are more active (Clark et al., 2019).

Physical environment variables which have shown positive association with PA are normally based on accessibility to features, such as distance to recreation facility (Davison & Lawson, 2006; Ding et al., 2011; Tucker et al., 2009), distance to school (Davison & Lawson, 2006; Ding et al., 2011; Larsen et al., 2009; Wilson et al., 2018), and if a park is near you house (Davison & Lawson, 2006; Ding et al., 2011; Mitchell et al., 2016). One part of the physical environment that research often overlooks is the general type of environment in which a child lives, specifically measured as the level of urbanicity. Urbanicity attempts to capture the characteristics of different environments including built forms and social norms that are inherent to different urbanicities. Traditionally, research is either confined to a single city (Mitra et al., 2017), an urban, suburban, rural dichotomy or trichotomy (Katapally et al., 2015; Rainham et al., 2012), or combines the data from urban, suburban, and rural into a larger analysis, e.g. analyses conducted for large national level reports (Barnes et al., 2018). These three methods miss nuances that could exist between different levels of urbanicity and varying geographical areas (Gilliland, 2010). Using more discrete measures of urbanicity can provide a more precise representation of how the general environment influences health-related outcomes (Sandercock et al., 2010; Taylor et al., 2018b; Tillmann et al., 2018).

There are two main gaps in the literature this paper is trying to address. First, there is a lack of understanding as to the factors that are related to children getting 60 minutes of

MVPA on weekdays and weekend days using a comprehensive approach. Second, most researchers treat children living in urban, suburban, urban small towns, and rural areas the same, while research has shown that there are differences in the environments and the lives of children in these various urbanicities (Gilliland, 2010; Moore et al., 2010). To address these gaps in the literature, this paper will address two research questions:

(1) What factors at the intrapersonal, interpersonal, physical environment, and policy levels influence children's ability to get 60 minutes of MVPA on a weekday?
(2) What factors at the intrapersonal, interpersonal, and physical environment levels influence children's ability to get 60 minutes of MVPA on a weekend day?

By addressing these questions, this paper will be able to inform researchers and health promoters to create more targeted policies and direct intervention development to increase MVPA among children in different geographic settings on both weekdays and weekend days.

4.3 Methods

Data were collected as part of the Spatial Temporal Environment and Activity Monitoring (STEAM) project. A full description of the STEAM project is available elsewhere (Mitchell et al., 2016). The STEAM project examines health behaviours of 1,068 children in grades 4 to 8 (ages 8-14 years) from 33 elementary schools in Ontario, Canada. The elementary schools were located in two distinct geographical regions: 29 schools from Southern Ontario and four schools from Northern Ontario. The schools in Southern Ontario were selected from groups of schools stratified by neighbourhood SES and urbanicity. The schools in Northern Ontario included four schools that were in a rural region of the Thunder Bay District. This study was conducted with approval from the Non-Medical Research Ethics Board at the University of Western Ontario and all seven of the participating school boards. Before participating in this study, children were required to obtain parental consent and sign their own assent form.

Data were collected on individual and family characteristics, PA, perceptions of the physical environment, and other health behaviours. Data for this study was collected over

an eight-day period. Child participants and parents completed a survey with questions about demographics, PA, health-related quality of life, and perceptions of their neighbourhood environments. These survey questions were based on the Neighbourhood Environment and Walkability Survey (Cerin et al., 2006), Pediatric Quality of Life Measurement Model (PedsQL) (Varni et al., 1999), and other highly used surveys (Mitchell et al., 2016). Immediately after children completed the surveys, they were outfitted with a hip-worn accelerometer and a passive-GPS data logger that they wore for the duration of the study.

The STEAM project was completed in two phases. The cross-sectional sample for this study includes the spring season from Southern Ontario (2009-2013) schools and the fall season of the Northern Ontario schools (2016) to control for weather differences. The original sample of 1,068 children, was reduced after eliminating participants who did not meet the following inclusion criteria: 1) meet an accelerometer wear-time minimum of 10-hours per day (see Dependent Variable); 2) completed the child survey; and 3) have a valid home location identified by GPS. The final sample consisted of n = 532 cases.

4.3.1 Dependent Variable: PA

This study has two dependent variables derived from objective measures of PA using an accelerometer: (1) a binary measure of whether a child had an average of at least 60 minutes of MVPA per day on weekdays; and (2) a binary measure of whether a child had an average of at least 60 minutes of MVPA per day on weekend days. MVPA was measured using an Actical® Z Accelerometer (Philips Respironics, Murrysville, PA, USA), a device worn around the hips sitting on either hipbone. The accelerometers measured PA in 30-second epochs, which is an epoch length used in this age group (Sanders et al., 2014). The accelerometer records movement made by each participant in all directions, summed over one minute (counts per minute, or CPM). If the device had zero counts for 60 consecutive minutes that hour was considered invalid (Aadland et al., 2018) and these methods have been used in other studies (Mitchell et al., 2016).

A valid day was considered six hundred minutes of valid wear time (or 10 hours) (Mitchell et al., 2016; Rich et al., 2013). MVPA was considered to be at least 1,500 counts per minute (Orme et al., 2014; Puyau et al., 2002). For this study, children were included in the weekday analysis if they had two valid weekdays of 10 hours or more and included in the weekend day analysis if they had at least one valid weekend day. An average of children's valid weekdays and weekend days were used to determine if children met the PA guidelines. These criteria allowed us to maintain a large enough sample size for parametric statistics.

4.3.2 Independent Variables

The independent variables used in this paper are fully described in Table 4.1. Independent variables for the analyses came from those that are found significant in past research on PA of children, including factors at the intrapersonal, interpersonal, physical environment, and policy levels. Intrapersonal factors used in this model include age, gender, ethnicity, and physical functioning as measured using the PedsQL with all of these variables from self-reported questions on the child survey. Missing data from the child survey on child age, gender, and ethnicity were derived from the parent survey. Interpersonal factors in this paper include children's perceptions of barriers and parental support from the child survey, maternal employment, paternal employment, and family composition, all from the parent survey, as well as the median household income of the child's neighbourhood, which was derived from 2011 Census of Canada data at the Dissemination Area level, which is a common proxy for neighbourhood SES. In cases where missing data could not be derived from the parent survey a separate category for missing data were created. The physical environment factors are represented by four variables, computed based on the child's precise home location: accessibility to a park, accessibility to a child's school, accessibility to a recreation centre, and urbanicity. Urbanicity was created by the research team using information from Statistics Canada and city plans. Urban large city (geographic areas with more than 100,000 people residing in defined city limits), suburban large city (surrounding larger geographic regions with more than 100,000 residents), urban small town (regions with a population of 10,000 – 99,999), and rural (population fewer than 9,999). Finally, the policy factors

are measured by the type of recess schedule at a child's school: traditional (two 15-minute recesses and a 30-minute lunch recess) or balanced (two 20-minute recesses).

Table 4.1 Variables associated with children's PA by the level of the SEM

Variable	Source	Description
Intrapersonal		
Age	Child survey (continuous)	Age in years (Biddle et al., 2011; Sallis et al., 2000)
Gender	Child survey (categorical) (boy/girl)	Self-reported gender as boy or girl (Biddle et al., 2011; Kavanaugh et al., 2015; Sallis et al., 2000)
Ethnicity	Child survey (categorical) (Caucasian/other)	Ethnicity coded as either Caucasian or other (Singh et al., 2008)
Physical functioning	Child survey PedsQL (categorical) (high/low)	A categorical variable based on face validity from four questions based on how hard it was to do physical tasks (Belanger et al., 2018; Biddle et al., 2011)
Interpersonal		
Social barrier	Child survey (composite score)	Composite score of social barrier questions (Taylor et al., 2018b)
Neighbourhood barrier	Child survey (composite score)	Composite score of neighbourhood barrier questions (Taylor et al., 2018b)
Safety barrier	Child survey (composite score)	Composite score of safety barrier questions (Taylor et al., 2018b)
Census average median household income (continuous) was taken from the 2011 census	Census 2011 (continuous)	Census average median household income (continuous) was taken from the 2011 census (Mitchell et al., 2016; Shearer et al., 2012)
Maternal employment	Parent survey (categorical) (unemployed/employed)	Mother's employment (Estabrooks et al., 2003; Lasheras et al., 2001)
Paternal employment	Parent survey (categorical) (unemployed/employed)	Father's employment (Estabrooks et al., 2003; Lasheras et al., 2001)
Family composition	Child survey (categorical) (two parent/lone parent)	Number of parents in the main household (McMillan et al., 2016)
Parental support	Child survey (categorical) (agree/disagree)	A categorical variable based on if children agree or disagree that their parents take part in activities

		with them (Biddle et al., 2011; Dowda et al., 2011; Sallis et al., 2000; Wilk et al., 2018)
Environment		
Park in 500m buffer	GIS (yes/no)	If any section of a park was within a 500m buffer of a child's home based on GPS (Davison & Lawson, 2006; Ding et al., 2011; Mitchell et al., 2016)
Home school	GIS (continuous)	Shortest distance along the street network between each child's home and the school they attended (Davison & Lawson, 2006; Ding et al., 2011; Larsen et al., 2009; Wilson et al., 2018)
Recreation facility	GIS (continuous)	Shortest distance along the street network between each child's home and the nearest arena or public/private recreational facility (Davison & Lawson, 2006; Ding et al., 2011; Tucker et al., 2009)
Urbanicity	GIS (categorical) (urban large city, suburban large city, urban small town, rural south, and rural north)	Categorical variable on different levels of urbanicity (Moore et al., 2014; Rainham et al., 2012; Veugelers et al., 2008)
Policy		
School day	School recruitment (categorical) (balanced/traditional)	Variable based on school policy (Clark et al., 2019)

4.3.3 Statistical Analyses

Analyses were performed in STATA version 14 (StataCorp, College Station, TX, USA) in 2019. Two logistic regression models were specified in this paper to answer the research questions: (1) children having an average of 60 minutes of MVPA on weekdays; and (2) children having an average of 60 minutes of MVPA on weekend days. Variables at the intrapersonal, interpersonal, physical environment, and policy levels (e.g., only included during the weekday to account for school day differences) were entered into the model using forward selection, as there were too many variables to include in backwards deletion or block-wise regression. Variables were maintained in the model if significant at a .10 level and the variable improved the model fit (Heinze et al., 2018).

4.4 Results

Descriptive statistics are presented in Table 4.2. The sample had more girls (58%) than boys, the average age was 11 years, and around 75% of children were Caucasian. About one quarter of the children had a park within a 500 m buffer of home, on average their school was about 5 km away from home, and the average distance to the nearest recreation facility from a child's home was 5 km. During the week, nearly half the sample met the PA guideline (51%), while on the weekend only about one quarter of the children met the PA guideline (25%).

The first model addressing research question 1 (Table 4.3) examines the factors from the SEM that influences the odds of a child getting the recommended 60-minutes of MVPA on weekdays. The results of this analysis find that only three intrapersonal variables are significant: gender, age, and physical functioning. The results show that the odds of boys meeting the recommendations on weekdays are 4.153 times that of girls ($p < 0.001$). Age is also found significant, with each additional year of age decreasing the odds of getting the recommended amount of PA by 0.716 ($p = 0.001$). Finally, children with high self-reported physical functioning are 2.457 ($p < 0.001$) times more likely of getting the recommended amount of PA as compared to children with low physical functioning.

The second model addressing research question 2 is presented in Table 4.4, examines the factors from the SEM that influence the odds of a child getting 60-minutes of MVPA on weekend days. The results of this analysis find variables at both intrapersonal and physical environment levels of the SEM are related to children meeting the recommendations on weekend days. The only significant intrapersonal variable was gender, which found that the odds of boys meeting the recommendations are 1.706 that of girls ($p = 0.011$). The other significant variable is urbanicity. The urbanicity measures find that children living in the rural Northern Ontario are significantly more likely to meet the MVPA guidelines on weekends than children living in urban areas (OR = 0.327, $p = 0.019$), suburban areas (OR = 0.389, $p = 0.005$), urban small towns (OR = 0.373, $p = 0.030$), or in rural Southern Ontario (OR = 0.363, $p = 0.004$).

Table 4.2 Descriptive statistics of the variables of the child participants STEAM project

Variable	n	%
Intrapersonal		
Gender		
Boys	223	41.9
Girls	309	58.1
Ethnicity		
Caucasian	395	74.2
Other	137	25.8
Physical functioning, *mean (std dev)*	85.6	15.7
Age, *mean (std dev)*	11.2	1.1
Interpersonal		
Parents take part*		
Agree	292	54.9
Disagree	221	41.5
Maternal employment*		
Unemployed	82	15.4
Employed	334	62.8
Paternal employment*		
Unemployed	35	6.6
Employed	364	68.4
Family composition		
Two-parent household	377	70.9
Lone parent household	155	29.1
Social score, *mean (std dev)*	-0.7	0.7
Safety score, *mean (std dev)*	-1.0	0.9
Neighbourhood score, *mean (std dev)*	-0.9	0.7
Environment		
Urbanicity		
Urban large city	53	10.0
Suburban large city	236	44.4
Urban small town	51	9.6
Rural south	136	25.6
Rural north	56	10.5
Park in 500m buffer		
Yes	135	25.4
No	397	74.6
Home School (km) *mean (std dev)*	5.3	8.3
Closest Rec. (km) *mean (std dev)*	5.0	7.2
Neighbourhood Income per 10 000 *mean (std dev)*	6.9	2.7
Organizational		
School day*		
Balanced	298	56.0
Traditional	225	42.3
Outcome		

MVPA weekday		
Meet recommendations	269	50.6
Do not meet recommendations	263	49.4
MVPA weekend		
Meet recommendations	131	24.6
Do not meet recommendations	401	75.4

* Does not add up to 100% to account for missing data

Table 4.3 Logistic regression of the association between SEM variables in children on weekday MVPA

Variable	**Odds Ratio**	***p***	**95% Confidence Interval**	
Intrapersonal				
Boys (ref: girls)	4.153	****<0.001**	2.836	6.082
Age	0.716	***0.001**	0.585	0.874
Physical functioning – high (ref: low)	2.457	****<0.001**	1.673	3.609

Boldface indicates statistical significance (*p < 0.01, **p < 0.001)

Table 4.4 Logistic regression of the association between SEM variables in children on weekend day MVPA

Variable	**Odds Ratio**	***p***	**95% Confidence Interval**	
Intrapersonal				
Boys (ref: girls)	1.706	***0.011**	1.129	2.579
Age	0.880	0.175	0.731	1.056
Physical functioning – high (ref: low)	1.362	0.157	0.889	2.089
Physical environment				
Urbanicity (ref: Rural North)				
Urban	0.327	***0.019**	0.128	0.750
Suburban	0.389	****0.005**	0.202	0.750
Urban small town	0.373	***0.030**	0.154	0.908
Rural south	0.363	****0.004**	0.184	0.721
Closest rec. (km)	1.025	0.103	0.995	1.056

Boldface indicates statistical significance (*p < 0.05, **p < 0.01)

4.5 Discussion

The purpose of this paper was to use the SEM to examine what factors influence whether children achieve the recommended minutes of MVPA on weekdays and weekend days. This was done by using two logistic regression models, one to represent the weekday and one to represent the weekend days. Previous research has indicated that PA levels differ from weekday to weekend day and this paper contributes to the literature by identifying

what specific factors influence the odds of meeting MVPA guidelines on weekdays and weekends days (Comte et al., 2013). Researchers also identified that few studies included geographical setting variables that go beyond an urban/rural dichotomy/trichotomy or include geographically distant places (Katapally et al., 2015; Mitchell et al., 2016; Mitra et al., 2017; Rainham et al., 2012). This led to one major finding as children living in rural Northern Ontario communities were more likely to meet the MVPA guidelines on weekends when compared to children from Southern Ontario in differing levels of urbanicity.

The results of this study found that boys were more likely than girls to meet the MVPA guidelines on both weekdays and weekends, but the odds dropped from 4.153 on weekdays to 1.706 on weekends. The decrease in odds can likely be explained by the influence of school, as boys accumulate significantly more MVPA during the school day compared to girls (Clark et al., 2019). On weekends the MVPA gender-gap decreases, as both boys and girls are less active on weekends, accounting for the smaller odds ratio (Comte et al., 2013). As is found in some research, age was a significant predictor of MVPA (Sallis et al., 2000; Biddle et al., 2011), but this study found that age was only significant on weekdays. This difference could once again be explained by the school environment. As younger children are more active than older children at school (Lau et al., 2015).

On weekdays the children who reported high physical functioning were more likely to meet the MVPA guidelines. The physical functioning variable was based on four questions that asked children how difficult it is to walk, run, participate in sports, or lift something heavy essentially their perceived competence in different domains of PA. Previous research has shown that psychological variables based on competence have been positively related to PA (Belanger et al., 2018; Biddle et al., 2011). In this study we found that this variable was only significant during the weekday. Previous research also suggests that certain psychological correlates of PA are context specific (Ommundsen et al., 2007). This suggests that there is something about children who scored higher on this scale and the weekday context that makes them more active. Researchers need to further

explore this relationship as it could lend insight to MVPA differences between children with higher and lower physical functioning scores during the weekday.

No variables at the interpersonal level influenced whether children met the MVPA guidelines. This is contradictory to past research, which found associations between PA and children's perceptions of barriers (Taylor et al., 2018a), parent support (Dowda et al., 2011), and SES (Mitchell et al., 2016). In all of these examples, PA was measured as a continuous variable measuring minutes of MVPA, suggesting a lack of significance in the interpersonal factors is a result of using a binary outcome variable (e.g., 60 minutes of MVPA). This is an important contribution to policy, as individual and physical environment factors seem to be more influential in children achieving their recommended 60 minutes of MVPA.

At the physical environment level, children from rural Northern Ontario were more likely to meet the MVPA guidelines on the weekend compared to suburban, urban, small town, and rural children from Southern Ontario. This suggests that there is something about the North that increases the chances of children getting the recommended amount of MVPA on weekends. As research has only touched on rural children's PA, especially rural children in a northern setting, it is difficult to determine why these differences exist (Meyer et al., 2016; Nykiforuk et al., 2018). One potential explanation is that our Northern Ontario study area is more geographically isolated providing children more freedom to explore their environment and be active. With a substantial portion of the North America population living in rural areas, it is essential to study the variables that influence PA in rural children in different geographic areas (Statistics Canada, 2018; U S Census Bureau, 2016).

4.6 Limitations

A limitation of this study is that two weekdays and one weekend day were used as inclusion criteria. Some other researchers have used a minimum of four valid days (Colley et al., 2017). Using more valid days could help improve the overall accuracy of

the model as more days used helps capture a better overall average estimate of a child's PA levels.

4.7 Conclusion

This paper identified that different factors of the intrapersonal and physical environment influence whether children meet the MVPA guidelines on weekdays compared to weekends. Conceptually, this study has important implications for how researchers think about the predictors of PA. If researchers use an average value which lumps together weekdays and weekend days, some nuances are lost, and there is a possibility that factors that influence MVPA during the weekday are driving the overall significance of that variable. For example, this study found that during the week the odds that boys meet the MVPA guidelines compared to girls is much higher on weekdays compared to weekend days. This suggests that weekday policies and programs need to be created to focus on increasing MVPA among girls specifically (Clark et al., 2019). Similarly, this study also found that children in Northern Ontario were significantly more likely to meet the MVPA recommendations than those in Southern Ontario on weekend days. Research needs to further investigate these regional differences in MVPA, especially on weekends when the school day does not dictate how children spend their time. Allowing program leaders to focus their efforts on smaller time points and specific regions could lead to more efficient and cost-effective interventions for improving children's PA levels.

4.8 References

Aadland, E., Andersen, L. B., Anderssen, S. A., & Resaland, G. K. (2018). A comparison of 10 accelerometer non-wear time criteria and logbooks in children. *BMC Public Health*, 1–9.

Barnes, J. D., Cameron, C., Carson, V., Chaput, J.-P., Colley, R. C., Faulker, G., Janssen, I., Kramers, R., Saunders, T., Spence, J., Tucker, T., Vanderloo, L., & Tremblay, M. (2018). Results from Canada's 2018 report card on physical activity for children and youth. *Journal of Physical Activity and Health*, *15*(S2), S402–S403. https://doi.org/10.1123/jpah.2018-0516

Belanger, K., Barnes, J. D., Longmuir, P. E., Anderson, K. D., Bruner, B., Copeland, J. L., Gregg, M. J., Hall, N., Kolen, A. M., Lane, K. N., Law, B., Macdonald, D. J., Martin, L. J., Saunders, T. J., Sheehan, D., Stone, M., Woodruff, S. J., & Tremblay, M. S. (2018). The relationship between physical literacy scores and adherence to Canadian physical activity and sedentary behaviour guidelines. *BMC Public Health*, *18*(Suppl 2).

Biddle, S. J. H., Atkin, A. J., Cavill, N., & Foster, C. (2011). Correlates of physical activity in youth: a review of quantitative systematic reviews. *International Review of Sport and Exercise Psychology*, *4*(1), 25–49. https://doi.org/10.1080/1750984X.2010.548528

Carson, V., Ridgers, N. D., Howard, B. J., Winkler, E. A. H., Healy, G. N., Owen, N., Dunstan, D. W., & Salmon, J. (2013). Light-intensity physical activity and cardiometabolic biomarkers in US adolescents. *PLoS ONE*, *8*(8). https://doi.org/10.1371/journal.pone.0071417

Carson, V., Rinaldi, R. L., Torrance, B., Maximova, K., Ball, G. D. C., Majumdar, S. R., Plotnikoff, R. C., Veugelers, P., Boulé, N. G., Wozny, P., McCargar, L., Downs, S., Daymont, C., Lewanczuk, R., & McGavock, J. (2014). Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. *International Journal of Obesity (2005)*, *38*(1), 16–21. https://doi.org/10.1038/ijo.2013.135

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood environment walkability scale: validity and development of a short form. *Medicine and Science in*

Sports and Exercise, *38*(9), 1682–1691. https://doi.org/10.1249/01.mss.0000227639.83607.4d

Clark, A. F., Campbell, J., Tucker, P., Wilk, P., & Gilliland, J. A. (2019). If you make it free, will they come? Using a physical activity accessibility model to understand the use of a free children's recreation pass. *Journal of Physical Activity and Health*, 31–34.

Clark, A. F., Wilk, P., & Gilliland, J. (2019). Comparing physical activity behavior of children during school between balanced and traditional school day schedules. *Journal of School Health*, *89*(2), 129–135. https://doi.org/10.1111/josh.12722

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C., & Tremblay, M. S. (2017). Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports*, *28*(10), 8–16. https://doi.org/October 2017

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, *22*(1), 15–23. https://doi.org/10.1016/j.yspm.2011.03.006

Comte, M., Hobin, E., Majumdar, S. R., Plotnikoff, R. C., Ball, G. D. C., McGavock, J. & MIPASS and Healthy Hearts Investigators Teams (2013). Patterns of weekday and weekend physical activity in youth in 2 Canadian provinces. *Applied Physiology, Nutrition, and Metabolism*, *38*(2), 115–119. https://doi.org/10.1139/apnm-2012-0100

Davison, K. K., & Lawson, C. T. (2006). Do attributes in the physical environment influence children's physical activity? A review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, 3(1), 19 https://doi.org/10.1186/1479-Received

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth: a review. *American Journal of Preventive Medicine*, *41*(4), 442–455. https://doi.org/10.1016/j.amepre.2011.06.036

Dowda, M., Pfeiffer, K. A., Brown, W. H., Mitchell, J. A., Byun, W., & Pate, R. R. (2011). Parental and environmental correlates of physical activity of children attending preschool. *Archives of Pediatrics and Adolescent Medicine*, *165*(10).

https://doi.org/10.1001/archpediatrics.2011.84

Estabrooks, P., Lee, R., & Gyurcsik, N. (2003). Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Annals of Behavioural Medicine*, *25*(2), 80–91. https://doi.org/10.1207/S15324796ABM2502

Fairclough, S. J., Ridgers, N. D., & Welk, G. (2012). Correlates of children's moderate and vigorous physical activity during weekdays and weekends. *Journal of Physical Activity and Health*, *9*(1), 129–137. https://doi.org/10.1123/jpah.9.1.129

Gilliland, J. (2010). The built environment and obesity: trimming waistlines through neighbourhood design. In T. Bunting, P. Filion, & R. Walker (Eds.), *Canadian cities in transition: new directions in the twenty-first century* (Fourth, pp. 391–410). Oxford University Press

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U., & Lancet Physical Activity Series Working Group. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet*, *380*(9838), 247–257. https://doi.org/10.1016/S0140-6736(12)60646-1

Heinze, G., Wallisch, C., & Dunkler, D. (2018). Variable selection – a review and recommendations for the practicing statistician. *Biometrical Journal*, *60*(3), 431–449. https://doi.org/10.1002/bimj.201700067

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*, 40. https://doi.org/10.1186/1479-5868-7-40

Katapally, T. R., Rainham, D., & Muhajarine, N. (2015). Factoring in weather variation to capture the influence of urban design and built environment on globally recommended levels of moderate to vigorous physical activity in children. *BMJ Open*, 1–10. https://doi.org/10.1136/bmjopen-2015-009045

Kavanaugh, K., Moore, J. B., Hibbet, L. H., & Kaczynski, A. T. (2015). Correlates of subjectively and objectively measured physical activity in young adolescents. *Journal of Sport and Health Science*, *4*(3), 222–227. https://doi.org/10.1016/j.jshs.2014.03.015

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., & He, M. (2009). The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. *American Journal of Public Health*, *99*(3), 520–526. https://doi.org/10.2105/AJPH.2008.135319

Lasheras, L., Aznar, S., Merino, B., & López, E. G. (2001). Factors associated with physical activity among Spanish youth through the National Health Survey. *Preventive Medicine*, *32*(6), 455–464. https://doi.org/10.1006/pmed.2001.0843

Lau, E., Dowda, M., McIver, K., & Pate, R. (2015). Changes in physical activity in the school, afterschool, and evening periods during the transition from elementary to middle school. *Journal of School Health*, *20*(2), 163–178. https://doi.org/10.1007/s10741-014-9462-7.Natural

Martins, J., Marques, A., Peralta, M., Palmeira, A., & Carreiro Da Costa, F. (2017). Correlates of physical activity in young people: a narrative review of reviews. Implications for physical education based on a socio-ecological approach. *Retos*, *31*, 292–299. https://doi.org/Recuperado de https://recyt.fecyt.es/index.php/retos/article/view/53505

McMillan, R., McIsaac, M., & Janssen, I. (2016). Family structure as a correlate of organized sport participation among youth. *PLoS ONE*, *11*(2), 1–12. https://doi.org/10.1371/journal.pone.0147403

Meyer, M. R. U., Moore, J. B., Abildso, C., Edwards, M. B., Gamble, A., & Baskin, M. L. (2016). Rural active living: a call to action. *Journal of Public Health Management and Practice*, *22*(5), E11–E20. https://doi.org/10.1097/PHH.0000000000000333

Mitchell, C., Clark, A., & Gilliland, J. (2016). Built environment influences of children's physical activity: examining differences by neighbourhood size and sex. *International Journal of Environmental Research and Public Health*, *13*(1), 130. https://doi.org/10.3390/ijerph13010130

Mitra, R., Cantello, I. D., Buliung, R. N., & Faulkner, G. E. J. (2017). Children's activity-transportation lifestyles, physical activity levels and social-ecological correlates in Toronto, Canada. *Journal of Transport and Health*, *6*, 289–298. https://doi.org/10.1016/j.jth.2017.03.010

Moore, J. B., Beets, M. W., Morris, S. F., & Kolbe, M. B. (2014). Comparison of objectively measured physical activity levels of rural, suburban, and urban youth. *American Journal of Preventive Medicine*, *46*(3), 289–292. https://doi.org/10.1016/j.amepre.2013.11.001

Moore, J. B., Jilcott, S. B., Shores, K. A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010). A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Education Research*, *25*(2), 355–367. https://doi.org/10.1093/her/cyq004

National Physical Activity Plan Alliance. (2018). *The 2018 United States report card on physical activity for children and youth*.

Nykiforuk, C. I. J., Atkey, K., Brown, S., Caldwell, W., Galloway, T., Gilliland, J., Kongats, K., McGavock, J., & Raine, K. D. (2018). Promotion of physical activity in rural, remote and northern settings: a Canadian call to action. *Health Promotion and Chronic Disease Prevention in Canada*, *38*(11), 419–435. https://doi.org/10.24095/hpcdp.38.11.03

Ommundsen, Y., Klasson-Heggebø, L., & Anderssen, S. (2006). Psycho-social and environmental correlates of location-specific physical activity among 9- and 15-year-old Norwegian boys and girls: the European Youth Heart Study. *International Journal of Behavioral Nutrition and Physical Activity*, *13*, 0–9. https://doi.org/10.1186/1479-Received

Orme, M., Wijndaele, K., Sharp, S. J., Westgate, K., Ekelund, U., & Brage, S. (2014). Combined influence of epoch length, cut-point and bout duration on accelerometry-derived physical activity. *International Journal of Behavioral Nutrition and Physical Activity*, *11*(1), 1–8. https://doi.org/10.1186/1479-5868-11-34

Puyau, M. R., Adolph, A. L., Vohra, F. A., & Butte, N. F. (2002). Validation and calibration of physical activity monitors in children. *Obesity Research*, *10*(3).

Rainham, D. G., Bates, C. J., Blanchard, C. M., Dummer, T. J., Kirk, S. F., & Shearer, C. L. (2012). Spatial classification of youth physical activity patterns. *American Journal of Preventive Medicine*, *42*(5), e87–e96. https://doi.org/10.1016/j.amepre.2012.02.011

Rich, C., Geraci, M., Griffiths, L., Sera, F., Dezateux, C., & Cortina-Borja, M. (2013).

Quality control methods in accelerometer data processing: defining minimum wear time. *PLoS ONE*, *8*(6), 1–8. https://doi.org/10.1371/journal.pone.0067206

Sallis, J., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: theory, research, and practice, 4th edition* (Fourth, pp. 465–485). Jossey-Basshttps://doi.org/10.7326/0003-4819-116-4-350_1

Sallis, J., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical of children and adolescents activity. *Medicine & Science in Sports & Exercise*, *32*(5), 963–975.

Sandercock, G., Angus, C., & Barton, J. (2010). Physical activity levels of children living in different built environments. *Preventive Medicine*, *50*(4), 193–198. https://doi.org/10.1016/j.ypmed.2010.01.005

Sanders, T., Cliff, D. P., & Lonsdale, C. (2014). Measuring adolescent boys' physical activity: bout length and the influence of accelerometer epoch length. *PLoS ONE*, *9*(3). https://doi.org/10.1371/journal.pone.0092040

Shearer, C., Blanchard, C., Kirk, S., Lyons, R., Dummer, T., Pitter, R., Rainham, D., Rehman, L., Shields, C., & Sim, M. (2012). Physical activity and nutrition among youth in rural, suburban and urban neighbourhood types. *Canadian Journal of Public Health*, 55–60.

Singh, G., Yu, S., Siahpush, M., & Kogan, M. (2008). High levels of physical inactivity and sedentary behaviors among US immigrant children and adolescents. *Archives of Pediatrics and Adolescent Medicine*, *162*(8), 756–763. https://doi.org/http://dx.doi.org/10.1001/archpedi.162.8.756

Statistics Canada. (2018). 2016 Census of Population. Retrieved from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

Taylor, L., Clark, A., Wilk, P., Button, B., & Gilliland, J. (2018a). Exploring the effect of perceptions on children's physical activity in varying geographic contexts: using a structural equation modelling approach to examine a cross-sectional dataset. *Children*, *5*(12), 159. https://doi.org/10.3390/children5120159

Taylor, L., Clark, A. F., & Gilliland, J. A. (2018b). Context matters: examining children's

perceived barriers to physical activity across varying Canadian environments. *Health & Place,* 54, 221–228. https://doi.org/10.1016/j.healthplace.2018.10.002

Tillmann, S., Clark, A. F., & Gilliland, J. A. (2018). Children and nature: linking accessibility of natural environments and children's health-related quality of life. *International Journal of Environmental Research and Public Health*, *15*(6). https://doi.org/10.3390/ijerph15061072

Tucker, P., Irwin, J. D., Gilliland, J., He, M., Larsen, K., & Hess, P. (2009). Environmental influences on physical activity levels in youth. *Health & Place*, *15*(1), 357–363. https://doi.org/10.1016/j.healthplace.2008.07.001

U S Census Bureau. (2016). *Measuring America: Our Changing Landscape*.

Varni, J., Seid, M., & Rode, C. (1999). The PedsQL: measurement model for the pediatric quality of life inventory. *Medical Care*, *37*(2).

Veugelers, P., Sithole, F., Zhang, S., & Muhajarine, N. (2008). Neighborhood characteristics in relation to diet, physical activity and overweight of Canadian children. *International Journal of Pediatric Obesity*, *3*, 152–159. https://doi.org/10.1080/17477160801970278

Wilk, P., Clark, A. F., Maltby, A., Smith, C., Tucker, P., & Gilliland, J. A. (2018). Examining individual, interpersonal, and environmental influences on children's physical activity levels. *SSM-Population Health*, *4*, 76–85. https://doi.org/10.1016/j.ssmph.2017.11.004

Wilson, K., Clark, A. F., & Gilliland, J. A. (2018). Understanding child and parent perceptions of barriers influencing children's active school travel. *BMC Public Health*, *18*(1), 1–14. https://doi.org/10.1186/s12889-018-5874-y

Chapter 5

5 Examining weather-related factors on moderate to vigorous physical activity levels of children from rural communities

Brenton L. G. Button, OCT, MSc

Tayyab I. Shah, PhD

Andrew F. Clark, PhD

Piotr Wilk, PhD

Jason A. Gilliland, PhD

5.1 Abstract

Objective: The objective of this study was to examine the influence of weather on moderate-to-vigorous physical activity (MVPA) levels of children aged 8-14 years from rural communities, an understudied Canadian population.

Methods: Children (n = 90) from four communities in rural Northern Ontario participated in this study between September and December 2016. Children's MVPA were measured using an Actical accelerometer and demographic data came from surveys of children and their parents. Weather data were collected from the closest weather station. Cross-classified regression models were used to assess the relationship between weather and children's MVPA.

Results: In total 41% of children were averaging over 60 minutes of MVPA. This study indicated that boys accumulated more MVPA than girls (b = 26.38 $p < 0.01$), children were more active on weekdays compared to weekends (b = -16.23 $p < 0.01$), children were less active on days with precipitation (b = -22.88 $p < 0.01$), and higher temperature led to a significant increase in MVPA (b = 1.33 $p < 0.01$)

Conclusion: The findings of this study indicate that weather (temperature and precipitation) influences rural children's MVPA levels. Future research is necessary to incorporate these findings into interventions to increase rural children's MVPA and improve their overall health.

Keywords: rural, child, physical activity, weather, north, temperature

5.2 Introduction

Canadian children are not getting enough physical activity (PA) for optimal growth and development. Approximately 35% of Canadian children aged 5-17 years achieve a 60-minute average of daily moderate to vigorous PA (MVPA) as recommended in the Canadian 24-Hour Movement Guidelines for Children and Youth (Colley et al., 2017). These participation rates are disturbing, as regular MVPA has been shown to prevent non-communicable diseases and lower cardiometabolic risk factors (Janssen & Leblanc, 2010).

Previous research has identified numerous demographic factors which influence children's PA levels, including gender (Biddle et al., 2011), age (Biddle et al., 2011), and ethnicity (Tremblay et al., 2006). Additionally, children's PA is influenced by parental socio-economic status (SES) (Estabrooks et al., 2003), children's perceptions of PA ability (Belanger et al., 2018; Biddle et al., 2011), and support of PA either from parents (Biddle et al., 2011) or peers (Biddle et al., 2011). A growing body of research has shown that the environment in which children live can also influence their PA participation through having access to resources, such as parks and recreation centres (Oliveira et al., 2014), or the walkability of their neighbourhood (Larsen et al., 2012).

One understudied factor in Canada related to MVPA participation that has differing impacts in different areas is the influence of the weather. Across Canada, there are large variations in temperature, precipitation, and the number of daylight hours throughout the year, but little is known about how these fluctuating weather patterns influence PA levels in different areas across Canada. Previous systematic reviews by Tucker and Gilliland (2007) and Rich et al. (2012) found that season had a relationship with subjective (parent report, child report) and objective (accelerometer, pedometer) measures of PA. Recently, there has been a shift in how people are studying seasonal changes. The shift has moved from examining large scale seasonal difference (e.g., spring to winter) in PA to specifically examining how daily weather patterns influence PA within and across seasons (e.g., rain and temperature) (Remmers et al., 2017).

Previously published studies examining season and weather highlight a major limitation: most research is conducted in large urban centers and does not mention if children from rural areas were included. For example, Canadian studies have been conducted in Ottawa (Lewis et al., 2016) and Toronto (Mitra & Faulkner, 2012). In urban areas during poor weather, children can use one of the many recreation facilities available to be active. However, in rural areas during poor weather, these facilities may not exist or, if they do, children may face the additional barrier of distance and transportation (Yousefian et al., 2009). This highlights the need to focus on PA among rural children. With Canada still maintaining a large rural population, it is imperative that researchers better understand these rural communities.

There are two main gaps in the literature that this study will address. First, there is a lack of literature examining the influence of weather on daily changes in children's MVPA in rural areas. Second, little is known about rural children's MVPA. This study will address these two gaps by answering the following research question: How does weather influence daily MVPA levels of children who live within rural communities, while accounting for child and day-level factors?

5.3 Methods

5.3.1 Study Design and Data Collection

Data were collected as part of the Spatial Temporal Environment and Activity Monitoring project and additional details are described elsewhere (Taylor et al., 2018). Ethics approval was granted by the University's Non-Medical Research Ethics Board (NMREB: 108029), the two local school boards, and done in accordance with the 1964 Helsinki declaration. The study was conducted in four elementary schools in rural Northern Ontario. The research team presented the details of the study to all children in grades 4-8 (ages 8-14 years). Children were provided with a package to take home to their parents, including a letter of information and parental consent form. Once the children had returned a signed parental consent form and provided their own assent, they could participate in the study.

Data for this study were collected over two eight-day periods, with the first round of data collection occurring between September 19 and October 4 of 2016 and the second round of data collection occurring between November 22 and December 7 of 2016. Child participants and parents completed a survey with questions about demographics, PA, health-related quality of life, and perceptions of their neighbourhood environments. These survey questions were based on other highly used surveys (Cerin et al., 2006; Varni et al., 1999). Children were also outfitted with a hip-worn accelerometer and a passive-GPS unit that they wore for the duration of the study.

The four schools had 194 students from grades 4-8, of which 134 students agreed to participate in this study. This represents almost 70% of all students in grades 4-8. This sample was further reduced for analysis based on the following criteria: a) child was required to meet accelerometer wear-time criteria described in the following section; b) child or parent completed relevant questions on the survey; and c) child home location identified by GPS. After applying all four inclusion criteria, a final sample of 90 children with a total of 663 valid days of data were available for further analysis.

5.3.2 Dependent Variable: Moderate-to-Vigorous Physical Activity (MVPA)

The dependent variable used in this study is the number of minutes of MVPA per day. MVPA was measured using an Actical® Z Accelerometer (Philips Respironics, Murrysville, PA, USA), an omni-directional device worn around the waist, sitting on either hipbone. The accelerometers measured PA in 30-second epochs, which is an appropriate epoch length used for this age group (Edwardson & Gorely, 2010; Sanders et al., 2014). The accelerometer was set to record movements made by each participant in all directions, summed over a one-minute period (counts per minute, or CPM). If the device had zero counts for 60 consecutive minutes that hour was considered invalid (Aadland et al., 2018). A valid day was considered six hundred minutes of valid wear time (or 10 hours), a threshold used in previous studies (Taylor et al., 2018). MVPA was considered to be at least 1,500 counts per minute (Puyau et al., 2002). A child had to have at least one valid day in each of the seasons to be included in the study, which is appropriate as the dependent variable is included in the models at the day-level.

5.3.3 Independent Variables

Variables used in the analysis were informed by previous PA research and intended to either describe a day on which the data were collected (e.g., day-level variables) or measure characteristics of a child (e.g., child-level variables).

Day-level variables included weather factors (e.g., precipitation and temperature) and day type (weekday vs weekend). All data for weather variables were downloaded from Environment and Natural Resource Canada's Historical Climate Data website. Two binary variables were used to measure precipitation: snow (snow vs no snow) or rain (rain vs no rain). These two variables were chosen as snow offers different affordances for PA compared to rain, and rain was identified as a binary variable as even small amounts of rain could prevent children from playing. Maximum temperature is a continuous variable measuring the temperature around the time that children have free time to play outside (Lewis et al., 2016). Day type was measured for each valid day, based on whether the MVPA data were from a weekday or weekend day (Comte et al., 2013).

Child-level variables derived from the child survey included age (continuous) (Biddle et al., 2011), gender (girl vs boy) (Biddle et al., 2011), ethnicity (Caucasian/white vs Indigenous or visible minority), parental support (agree vs disagree if a parent takes part in activities with you) (Biddle et al., 2011), perceptions of physical functioning (categorical) (Belanger et al., 2018; Biddle et al., 2011), and social, neighbourhood, and safety barriers (continuous). One categorical factor assessing if the child lived directly in the settled community of Nipigon or Red Rock or in the more rural surrounding areas was created using home location from the GPS data (rural small-town vs rural). The perception of physical functioning measure was developed through four 5-point Likert scale questions from the PedsQL that pertain to how hard it is for the child to move (Varni et al., 1999) and is based on face validity. The Likert scale questions were scored from 0 to 100 in increments of 25 and averaged creating an overall score. Once an average was established, the median was used to dichotomize a child as having high or low (above or below the median) physical functioning. The social, neighbourhood, and safety barriers for PA variables were based on a composite score that was developed by

computing the average of four-point Likert-scale questions used to represent a child's perception of social, neighbourhood, and safety barriers to PA based on previous research (Taylor et al., 2018). The score ranges from -2 to 2 for the perception that the barriers influence PA. Child-level variables derived from the parent survey included mother's education (high school or below vs college or above) (Estabrooks et al., 2003) and family composition (two parent household vs one parent household) (McMillan et al., 2016). Only maternal education had missing data, with less than 10% of cases missing. Data were imputed using a mode fill.

5.3.4 Statistical Analyses

A cross-classified model was fitted to examine the variation in children's daily MVPA levels. A cross-classified model was selected because there are two independent sets of clusters in which daily MVPA values are nested. Daily values of MVPA are clustered within each child and, at the same time, they are nested within the specific dates during which the data were collected. For example, all MVPA data collected on a given date are more alike than data from other dates, and all MVPA data collected from a given child are more alike than data from other children. The cross-classified model allows us to account for this complex data structure. These models are becoming more common in children's health research (Wilk et al., 2018). To confirm that a cross-classified model is appropriate to address the research question, two preliminary models were tested: a date model and a child model. The results of these models suggested a significant level of clustering of daily MVPA values within dates ($p < 0.01$) and children ($p < 0.01$), justifying the use of the cross-classified model.

The cross-classified analysis was conducted as a stepwise process, with five models being tested. First, a null model provided an estimate of the variance at daily MVPA values across children and across dates. Second, the child-level variables were added to the null model to assess how they influence MVPA. Third, the day type variable (weekday vs weekend) was entered on its own to the null model. Fourth, weather factors were added to the null model to understand how weather patterns on each date influence daily values of MVPA. Finally, the child-level and day-level factors were added together

to assess how the two types influence daily values of MVPA, while accounting for each other. All data analysis was conducted in SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

5.4 Results

Table 5.1 presents the descriptive statistics for the continuous variables and frequency for categorical variables included in the analysis. A total of 90 children contributed 663 daily MVPA values. Using an average of all valid days 41% of children met the MVPA guidelines and on average, children were getting about 58.6 minutes of MVPA per day. The average age was 10.6 years, there are more girls (61%) than boys (39%) in the sample, and 57% of people reported being Caucasian/white and 43% reported being Indigenous or a visible minority. The average daily maximum temperature during the study was around 10^{O}C, but daily maximum temperature ranged from -2.9^{O}C to 22.7^{O}C. Sixteen days had no precipitation, seven days had snow, and four days had rain.

The first model is a null model where only variances were estimated. The interclass correlation coefficient (ICC) value related to variation in daily MVPA between children is 0.29 while the ICC for variation between days on which data were collected is 0.19 suggesting that child and day-level characteristics account for 29% and 19% of the total variance in daily MVPA values.

The results from the second model containing all the child-level characteristics (see Table 5.2). indicate that, gender and maternal education were significantly associated with daily MVPA. On average, boys were getting 26.49 more minutes of MVPA (b = 26.49 $p <$ 0.01) than girls and children who had mothers with a high school education were getting 12.19 (b = -12.19 $p = 0.03$) more minutes of MVPA compared to children with mother's who had college or above education. The residual ICC value for the child-level variance 0.20.

The results from the third model suggest that addition of a single day-level variable, day type, did not significantly reduce the day-level ICC (ICC = 0.18) as the effect of the variable on daily MVPA was not statistically significant. The results from the fourth

model, which included all weather factors indicate that maximum temperature and rain have a significant effect on daily MVPA. On average for each 1-degree Celsius increase in temperature across dates children were getting 1.18 more minutes of MVPA (b = 1.18 $p < 0.01$). Regarding precipitation, children were getting, on average, 24.38 minutes less of MVPA on days with rain (b = -24.38 $p < 0.01$). Weather-level variables had a residual ICC of 0.10.

Finally, the results from the fourth model with both child and day-level variables posit that boys were getting on average 26.38 more minutes of MVPA per day as compared to girls (b = 26.38 $p < 0.01$) and children with mothers who had a high school education were getting 12.20 more minutes of MVPA compared to children with mothers who had a college education (b = -12.20 $p = 0.03$). Children were less active during weekends compared to weekdays; on average, they were getting 16.23 fewer minutes of MVPA (b = -16.23 $p < 0.01$) on weekends. Comparing to days without rain or snow, children were getting on average 22.88 minutes less of MVPA (b = -22.88 $p < 0.01$) on days with rain. For each increase in one degree Celsius, there was on average 1.33 minutes (b = 1.33 $p < 0.01$) increase in MVPA. Comparing to the null model, child-level variance was reduced by 40% (residual ICC 0.23) while the day-level variance was reduced by 64% (residual ICC 0.09).

Table 5.1 Descriptive statistics for the 663 days of data from 90 children

Dependent Variable	Mean and SD
MVPA	58.6 (40.4)
Child-level	Count and %
Gender	
Boys	35 (38.9)
Girls	55 (61.1)
Ethnicity	
Caucasian	51 (56.7)
Indigenous or visible minority	39 (43.3)
Age *mean (sd)*	10.6 (1.4)
Physical functioning *mean (sd)*	88.8 (15.9)
Parents take part	
Agree	50 (55.6)
Disagree	40 (44.4)

Mother's education	
High school and below	20 (22.2)
College and above	70 (77.8)
Family composition	
One-parent household	12 (13.3)
Two-parent household	78 (86.7)
Social barrier *mean (sd)*	-0.6 (0.7)
Neighbourhood barrier *mean (sd)*	-0.8 (0.6)
Safety barrier *mean (sd)*	-1.2 (0.7)
Physical environment	
Rural small Town	45 (50.0)
Rural	45 (50.0)
Day-level	Count and %
No rain or snow	16 (59.3)
Cases of rain	4 (14.8)
Cases of snow	7 (25.9)
Maximum temperature *mean (sd)*	10.0 (9.5)
Daylight minutes *mean (sd)*	619.1 (102.4)
Weekdays	19 (70.4)
Weekend days	8 (29.6)

Table 5.2 The cross-classified model assessing the relationship between child's MVPA and child variables (Model 1), day type (Model 2) weather variables (Model 3), and child and day-level variables (Model 4)

Variable	Category	Model 1			Model 2			Model 3			Model 4		
		Est	SE	p-value	Est	SE	p-value	Est	SE	p-value	Est	SE	p-value
Intercept		57.63	9.70		58.07	4.90		47.09	6.52		53.05	10.49	
Gender (*ref: Girls*)	Boys	26.49	4.73	<0.01*							26.38	4.71	<0.01*
Age	Years	-2.01	1.61	0.21							-2.07	1.61	0.20
Ethnicity (*ref: Caucasian*)	Indigenous and visible minority	-1.20	4.91	0.81							-1.21	4.90	0.80
Physical functioning (*ref: Low*)	High	7.02	5.00	0.16							7.03	4.97	0.16
Parents take part in activities (*ref: Disagree*)	Agree	-6.42	4.82	0.18							-6.41	4.80	0.18
Number of parents (*ref: Two*)	One	-1.87	7.01	0.79							-1.51	6.99	0.83
Mother's education (*ref: High school or below*)	College or above	-12.19	5.56	0.03*							-12.20	5.54	0.03*
Social barrier		-1.39	3.41	0.68							-1.38	3.40	0.69
Safety barrier		1.94	3.08	0.53							1.97	3.07	0.52
Neighbourhood barrier		3.70	3.59	0.30							3.75	3.56	0.29
Physical environment (*ref: Rural small-town*)	Rural	-1.07	6.82	0.88							0.11	5.96	0.98
Day Type (*ref: Weekday*)	Weekend day				-13.55	7.15	0.06				-16.23	5.36	<0.01*
Rain Days (*ref: No*)	Yes							-24.38	8.35	<0.01*	-22.88	7.73	<0.01*
Snow Days (*ref: No*)	Yes							-4.99	8.08	0.54	-4.26	7.46	0.57
Maximum Temperature								1.18	0.37	<0.01*	1.33	0.35	<0.01*

Italics indicates reference group

*p value < 0.05

5.5 Discussion

The purpose of this paper was to examine how weather influences daily MVPA levels of children who live within rural communities, while accounting for child and day-level factors. This was done using a cross-classified linear regression. Previous research has indicated that season, and more specifically, temperature has an influence on MVPA (Lewis et al., 2016; Rich et al., 2012; Tucker & Gilliland, 2007); however, little has been written about the impact of weather and seasonality on rural children's MVPA. This paper helps fill that gap in the literature by examining the impact of weather on children's MVPA in a rural setting. The findings indicate that both temperature and rain had a significant effect on children's daily MVPA, but not snow. It is imperative for researchers, policymakers, and recreation programmers to understand the factors that influence MVPA for rural populations, as previous research has shown that children's MVPA levels differ in rural compared to urban areas (McCormack & Meendering, 2016).

The results of this study found that boys achieved significantly more MVPA than girls (e.g., 25 more minutes on average), which is consistent with previous research (Telford et al., 2016). Numerous reasons have been hypothesized for this difference, including individual factors such as lower cardiorespiratory fitness and lower hand-eye coordination among girls (Telford et al., 2016). Although this finding is similar to other contexts, it is important to bring to the attention of stakeholders in rural communities. In rural communities, children are often limited in activities that they can participate in due to lack of accessible opportunities (Walia & Leipert, 2012). Rural community leaders need to connect with girls and build programs around what activities interest them.

Interestingly, maternal education had a significant impact on MVPA. In this paper, maternal education was a proxy for SES and research is not always conclusive on SES (Biddle et al., 2011), but some research suggests that higher levels of maternal education lead to more sedentary time and less LPA (Sherar et al., 2016). A possible explanation for this finding is in rural communities' parents with higher SES might be more willing to travel to the nearest city for their child to participate in organized activities, and all of the travel might be having a negative impact on children's PA levels.

During weekend days, children were getting about 15 fewer minutes of MVPA than on weekdays. Previous research based in urban environments has also indicated that children are more active during the week (Comte et al., 2013). A potential reason is that on school days, children normally have access to the indoor gymnasium for daily health and physical education classes, and they have two or three activity breaks where they are encouraged to be physically active and can play with schoolmates and school equipment. On the weekend, rural children typically do not have easy access to the structures and supportive features of the school. To help combat the lower levels of PA among rural children on weekends, local stakeholders could offer more youth-based programming with transportation supports, or other incentives such as free programming or rewards programs to encourage children to be more physically active (Clark et al., 2018).

Previous studies have shown that daily MVPA levels are positively correlated with daily temperatures (Rich et al., 2012; Tucker & Gilliland, 2007). Likewise, in this study, PA levels increased as temperature increased; each extra degree increase in temperature was related to about an 80 second increase in daily MVPA. With temperatures ranging from around -3^{O} Celsius to 23^{O} Celsius in our study area, this is an average increase of about thirty-five-minutes in MVPA from the coldest to warmest days. Thirty-five minutes is a significant amount of MVPA and needs to be considered when designing programs in Northern rural communities. With winter temperatures in this area reaching average lows of -30^{O} Celsius most years, this could have an even larger impact on PA; however, it is important to note that most studies show that the change in PA is not linear (Remmers et al., 2017). In rural communities, the influence of temperature could be stronger because rural children do not have easy access to places to play indoors when it gets too cold outdoors. A potential way to combat weather-related drops in MVPA is to transform spaces in public facilities (e.g. libraries) so they can accommodate children's free play.

This study also found that rain days had a significant negative influence on children's daily MVPA. A study comparing children aged 9-11 years in Australia and Canada found that rainfall was negatively associated with MVPA in Australia, but not Canada (Lewis et al., 2016). In this study focused on Northern Ontario, however, rain had a larger impact, with almost a 25-minute decrease in MVPA between days that it rained compared to days

that it did not rain or snow. Giving children an indoor opportunity has been shown to help prevent a decline in children's PA during poor weather (Harrison et al., 2011). In rural and remote areas, however, indoor recreation facilities may be too far from children's homes to offer a convenient opportunity for MVPA. In such cases, the negative influence of rain would be stronger in rural than urban areas. In contrast to rain, snow does not significantly influence total MVPA. A potential explanation is that snow is more fun for children than rain as it affords certain additional opportunities for PA, such as skiing, sledding, sliding, building snow structures, and general play in the snow. A potential solution may be to provide access to schools after normal school hours, so that children have a comfortable place to play in the colder months or on rainy days.

A limitation of this study is the sample size as only 90 children met the inclusion criteria, but this number still represents a significant proportion of all grade 4-8 children in the communities. Another limitation is this study did not examine spring or summer MVPA when temperatures are the hottest. It is possible that MVPA starts to decrease when temperatures reach above, 22^{O}C (Remmers et al., 2017). Nevertheless, the times were chosen with principals requested that preliminary data could be shared with the students before graduation and could be used for the following year school improvement plan.

5.6 Conclusion

Very little research has been conducted on children's MVPA in rural communities in Canada. The findings of this study indicate that weather (temperature and precipitation), gender, maternal education, and day type were significant in influencing MVPA. This research suggests rural children need opportunities to play inside in the presence of bad weather to increase MVPA. Given its impact on PA, future research might examine how the weather impacts other important health-related behaviours.

5.7 References

Aadland, E., Andersen, L. B., Anderssen, S. A., & Resaland, G. K. (2018). A comparison of 10 accelerometer non-wear time criteria and logbooks in children. *BMC Public Health*, 1–9.

Belanger, K., Barnes, J. D., Longmuir, P. E., Anderson, K. D., Bruner, B., Copeland, J. L., Gregg, M. J., Hall, N., Kolen, A. M., Lane, K. N., Law, B., Macdonald, D. J., Martin, L. J., Saunders, T. J., Sheehan, D., Stone, M., Woodruff, S. J., & Tremblay, M. S. (2018). The relationship between physical literacy scores and adherence to Canadian physical activity and sedentary behaviour guidelines. *BMC Public Health*, *18*(Suppl 2).

Biddle, S. J. H., Atkin, A. J., Cavill, N., & Foster, C. (2011). Correlates of physical activity in youth: a review of quantitative systematic reviews. *International Review of Sport and Exercise Psychology*, *4*(1), 25–49. https://doi.org/10.1080/1750984X.2010.548528

Cerin, E., Saelens, B. E., Sallis, J. F., & Frank, L. D. (2006). Neighborhood environment walkability scale: validity and development of a short form. *Medicine and Science in Sports and Exercise*, *38*(9), 1682–1691. https://doi.org/10.1249/01.mss.0000227639.83607.4d

Clark, A. F., Wilk, P., Mitchell, C. A., Smith, C., Archer, J., & Gilliland, J. A. (2018). Examining how neighborhood socioeconomic status, geographic accessibility, and informational accessibility fnfluence the uptake of a free population-level physical activity intervention for children. *American Journal of Health Promotion*, *32*(2), 315–324. https://doi.org/10.1177/0890117117718433

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C., & Tremblay, M. S. (2017). Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports*, *28*(10), 8–16. https://doi.org/October 2017

Comte, M., Hobin, E., Majumdar, S. R., Plotnikoff, R. C., Ball, G. D. C., McGavock, J. & MIPASS and Healthy Hearts Investigators Teams (2013). Patterns of weekday and weekend physical activity in youth in 2 Canadian provinces. *Applied Physiology, Nutrition, and Metabolism*, *38*(2), 115–119. https://doi.org/10.1139/apnm-2012-0100

Edwardson, C. L., & Gorely, T. (2010). Epoch length and its effect on physical activity intensity. *Medicine & Science in Sports & Exercise*, 928–934. https://doi.org/10.1249/MSS.0b013e3181c301f5

Estabrooks, P., Lee, R., & Gyurcsik, N. (2003). Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status? *Annals of Behavioural Medicine*, *25*(2), 80–91. https://doi.org/10.1207/S15324796ABM2502

Harrison, F., Jones, A. P., Bentham, G., Sluijs, E. M. F. Van, Cassidy, A., & Griffin, S. J. (2011). The impact of rainfall and school break time policies on physical activity in 9-10 year old British children: a repeated measures study. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 47. https://doi.org/10.1186/1479-5868-8-47

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*, 40. https://doi.org/10.1186/1479-5868-7-40

Larsen, K., Gilliland, J., & Hess, P. M. (2012). Route-based analysis to capture the environmental influences on a child's mode of travel between home and school route-based analysis to capture the environmental influences on a child's mode of travel between home and school. *Annals of the Association of American Geographers ISSN:*, *5608*. https://doi.org/10.1080/00045608.2011.627059

Lewis, L. K., Maher, C., Belanger, K., Tremblay, M., Chaput, J., & Olds, T. (2016). At the mercy of the gods: associations between weather, physical activity, and sedentary time in children. *Pediatric Exercise Science*, 152–163.

McCormack, L. A., & Meendering, J. (2016). Diet and physical activity in rural vs urban children and adolescents in the United States: a narrative review. *Journal of the Academy of Nutrition and Dietetics*, *116*(3), 467–480. https://doi.org/10.1016/j.jand.2015.10.024

McMillan, R., McIsaac, M., & Janssen, I. (2016). Family structure as a correlate of organized sport participation among youth. *PLoS ONE*, *11*(2), 1–12.

https://doi.org/10.1371/journal.pone.0147403

Mitra, R., & Faulkner, G. (2012). There's no such thing as bad weather, just the wrong clothing: climate, weather and active school transportation in Toronto, Canada. *Canadian Journal of Public Health*, *103*(SUPPL. 3), 35–41.

Oliveira, A. F., Moreira, C., Abreu, S., Mota, J., & Santos, R. (2014). Environmental determinants of physical activity in children: a systematic review. *Archives of Exercise in Health and Disease*, *4*(2), 254–261.

Puyau, M. R., Adolph, A. L., Vohra, F. A., Butte, N. F. (2002). Validation and calibration of physical activity monitors in children. *Obesity Resarch*, *10*(3).

Remmers, T., Thijs, C., Timperio, A., Salmon, J., Veitch, J., Kremers, S., & Ridgers, N. (2017). Daily weather and children's physical activity patterns. *Medicine & Science in Sports & Exercise*, (25), 922–929.

Rich, C., Griffiths, L. J., & Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 49. https://doi.org/10.1186/1479-5868-9-49

Sanders, T., Cliff, D. P., & Lonsdale, C. (2014). Measuring adolescent boys' physical activity: bout length and the influence of accelerometer epoch length. *PLoS ONE*, *9*(3). https://doi.org/10.1371/journal.pone.0092040

Sherar, L. B., Griffin, T. P., Ekelund, U., Cooper, A. R., Esliger, D. W., van Sluijs, E. M. F., Andersen, L. B., Cardon, G., Davey, R., Froberg, K., Hallal, P. C., Janz, K. F., Kordas, K., Kriemler, S., Pate, R. R., Puder, J. J., Sardinha, L. B., Timperio, A. F., & Page, A. S. (2016). Association between maternal education and objectively measured physical activity and sedentary time in adolescents. *Journal of Epidemiology and Community Health*, *70*(6), 541–548. https://doi.org/10.1136/jech-2015-205763

Taylor, L., Clark, A., Wilk, P., Button, B., & Gilliland, J. (2018). Exploring the effect of perceptions on children's physical activity in varying geographic contexts: using a structural equation modelling approach to examine a cross-sectional dataset. *Children*, *5*(12), 159. https://doi.org/10.3390/children5120159

Telford, R. M., Telford, R. D., Olive, L. S., Cochrane, T., & Davey, R. (2016). Why are

girls less physically active than boys? Findings from the LOOK longitudinal study. *PLoS ONE*, *11*(3), 1–11. https://doi.org/10.1371/journal.pone.0150041

Tremblay, M., Bryan, S., Perez, C., Ardern, C., & Katzmarzyk, P. (2006). Physical activity and immigrant status: Evidence from the Canadian community health survey. *Canadian Journal of Public Health*, *97*(4), 277–282. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed7&NEWS=N&AN=2006433348

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909–922. https://doi.org/10.1016/j.puhe.2007.04.009

Varni, J., Seid, M., & Rode, C. (1999). The PedsQL: measurement model for the pediatric quality of life inventory. *Medical Care*, *37*(2).

Walia, S., & Leipert, B. (2012). Perceived facilitators and barriers to physical activity for rural youth: an exploratory study using photovoice. *Rural Remote Health*, *12*, 1842. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22283830

Wilk, P., Clark, A. F., Maltby, A., Smith, C., Tucker, P., & Gilliland, J. A. (2018). Examining individual, interpersonal, and environmental influences on children's physical activity levels. *SSM-Population Health*, *4*, 76–85. https://doi.org/10.1016/j.ssmph.2017.11.004

Yousefian, A., Ziller, E., Swartz, J., & Hartley, D. (2009). Active living for rural youth: addressing physical inactivity in rural communities. *Journal of Public Health Management and Practice : JPHMP*, *15*(3), 223–231. https://doi.org/10.1097/PHH.0b013e3181a11822

Chapter 6

6 Exploring children's perceptions of barriers and facilitators to physical activity in a rural Northern community

Brenton L. G. Button MSc

Suzanne Tillmann MSc

Jason A. Gilliland PhD

6.1 Abstract

Researchers rarely explore children's perspectives of barriers and facilitators to physical activity (PA) in a rural environment. To explore rural children's perceptions 84 children in grades 4-8, in rural Northern Ontario participated in focus groups to discuss barriers and facilitators to PA. Three key themes were identified: environment, social environment, and perceptions of safety. Environmental features included weather and the built environment. Social environment included the role of friends and adults to either facilitate or restrict children's play. The fear of wildlife was pervasive across all focus groups and resulted in restricted independent mobility and PA. Rural children are typically under-represented in PA research. The findings suggest that researchers need to understand contextual nuances on the rural environment.

Keywords: rural, focus group, physical activity, children, north

6.2 Introduction

Low levels of physical activity (PA) among children are a major public health concern, as PA has physical (Ferrari et al., 2015; Herman et al., 2015), cognitive (McIsaac et al., 2015), and emotional benefits (Biddle & Asare, 2011; Larun et al., 2006). Previous research has identified a wide range of correlates of children's PA, ranging from individual-level variables such as age (Biddle et al., 2011; Sallis et al., 2000), to interpersonal variables such as relationships with others (Biddle et al., 2011; Sallis et al., 2000), to environmental variables such living in close proximity to a park (Ding et al., 2011; Mitchell et al., 2016; Tucker et al., 2009). Much of what we have learned about the determinants of children's PA is based on research in urban settings; meanwhile, there is a scarcity of evidence on the factors that influence PA among rural children, and even less is known about children in remote or Northern communities (Meyer et al., 2016; Nykiforuk et al., 2018).

Previous quantitative research has shown that less than half of the children in a rural Northern Ontario area were meeting the recommended 60 minutes of moderate-to-vigorous PA (MVPA) per day, as objectively measured using accelerometry (Button et al., 2019). Additionally, analysis based on a cross-classified linear regression revealed that weather, gender, maternal education, and day type (weekday/weekend) had the most significant impact on MVPA levels. Children were more active on weekdays, when temperatures were warmer, and on days without rain; additionally, boys were more active than girls, and children who had a mother with lower educational attainment were more active. In that study of children from rural Northern Ontario, the usual correlates at the interpersonal level (e.g., parental encouragement, perceptions of barriers related to safety, neighbourhood, or social features) and environmental level (e.g., living in a settled area with a higher population density, better access to recreation facilities, and potentially living within walking distance to school or living in a dispersed area with lower population density, decreased access to facilities, and not living within walking distance to school) did not have a significant influence on MVPA (Button et al., 2019). Despite the important findings of that quantitative analysis, researchers are still lacking a comprehensive understanding of the barriers and facilitators to children's PA in this rural setting.

Qualitative research with rural children using an ecological systems theory has highlighted common barriers to PA, such as lack of opportunities, distance, school policies, programs and procedure, and other safety concerns to be important factors (Moore et al., 2010; Yousefian et al., 2009). For example, researchers in Maine US held six focus groups with 84 rural adolescents (aged 10-18 years) and identified that a shortage of outdoor amenities, inadequate transportation, and distance to large shopping centers with box stores were all barriers to PA (Yousefian et al., 2009). Additionally, Moore et al. (2010) held three focus groups with 22 rural youth in North Carolina US and found certain barriers that prevented children from being active. Examples of these barriers included children in grade eight no longer having recess, perceived danger related to hunting like being fearful of gunshots in the backyard, and neighbourhood disorder. Facilitators of PA in this study were built environment features such as having access to sports equipment and fields during recess and gym class (Moore et al., 2010). These studies provide valuable information, but the rural research body is limited, as the combination of studies still give a very narrow perspective on rural environments and are not necessarily transferable given the diverse make-up of rural areas (Meyer et al., 2016; Nykiforuk et al., 2018).

There is a critical lack of qualitative research highlighting children's perspectives on the contextual factors influencing facilitators and barriers to rural children's PA. This gap poses challenges for health policymakers, recreation programmers, and municipal decision-makers to assess applicable facilitators and barriers. Based on the ecological systems theory which posits that a child's behaviour is influenced by factors in their immediate environment (e.g., friends, family), the more indirect environment (e.g., distance to school, availability of recreation opportunities), and the connection between the environments (Brofenbrenner, 1979). The purpose of this article is to use children's perspectives to provide contextual information on the facilitators and barriers of rural children's PA in small rural northern communities.

6.3 Methods

6.3.1 Study Area

The term *rural* is highly contested, and no definition adequately captures the heterogeneity of all rural environments (Coburn et al., 2007; du Plessis et al., 2001). Rather than simply use a definition of rural based on population thresholds, which has been done in previous rural research (Joens-Matre et al., 2008; Moore et al., 2010), in this article we decided to describe the geographic context of the study areas, enabling future researchers to determine the applicability and context of the research.

Situated in the heart of Northern Ontario, the study area has a mixture of rugged boreal forests, plentiful lakes, and a diverse range of animals (e.g., bears, moose, deer, lynx, wolves, coyotes, foxes, porcupines, beavers, and a variety of birds). The area is ideal for hunting, fishing, and birding. Living in proximity to such pristine wilderness comes at a cost to safety, however, as dangerous wild animals often travel into town, with many sightings of black bears and wolves occurring on township streets and playgrounds. In 2014, the spring bear hunt was re-introduced as a pilot program with one of the aims being to control the bear population (Ministry of Natural Resources and Forestry, 2016).

The original inhabitants of the area were Indigenous people, but the development of the fur trade and later the railway introduced Europeans to the area in the eighteenth and nineteenth centuries, thus creating a unique socio-cultural milieu. Approximately 30% of people currently living in the area identify as Indigenous, while the rest of the population is predominantly individuals of European ancestry (Statistics Canada, 2018). The area had a prosperous forest industry for many years, but due to unfavourable economic circumstances, residents have been searching for a new major employer since the early 2000s.

Currently, there are three distinct townships (Nipigon, Red Rock, and Dorion), one dispersed rural community (Hurkett), and one Indigenous reserve (Lake Helen Reserve 53A). The study took place in all four elementary schools in the region. Nipigon (Township population 1,642) and Red Rock (Township population 895) are similar in that they both have distinct settled areas, a few parks, one major sports field, one splash

pad, various recreation trails, and an arena. Nipigon has two elementary schools and a seasonal outdoor pool (June-August). Red Rock has one elementary school and one high school serving approximately 250 students from across the entire district, with some children being bused from up to 45 minutes away. During the winter, ice hockey is offered in Nipigon, and depending on interest, Red Rock also offers hockey to boys and girls. However, in certain years, girls have not had a team of their own and played with the boys or travelled to the nearest major city about 100 km (62 miles) away. Hockey season typically runs from early October to early April. In the past, and based on registration, figure skating and curling may be offered. During the spring, an age-appropriate baseball and soccer league is offered for about six weeks if enough children are registered.

In comparison, Dorion (Township population 316) has one school, and almost all students take the bus to attend. The school doubles as a community centre and has a typical school playground (e.g., monkey bars, slides), basketball court, and a baseball field. Children in these communities must to travel to either Nipigon, Red Rock, or Thunder Bay to partake in organized sport. Just outside Nipigon sits the Lake Helen Reserve (Reserve population 303). The reserve has a community centre, outdoor hockey rink, park, baseball field. All the reserve's students are bused into Nipigon to attend one of the elementary schools. Hurkett (Area population 236) is a dispersed rural community with no amenities and children are bused to Dorion for school. Nipigon, Dorion, Hurkett, and Lake Helen Reserve have the trans-Canada highway run through the community or act as a boundary to the local community while Red Rock is about eight kilometres from the highway.

The climate in the region is cold and temperate. The average annual temperature in the region is 1.8 degrees Celsius (35 degrees Fahrenheit), with average temperature in January (winter) of -16.4^{O}C (2.5^{O}F), and average temperature in July (summer) of 17.1^{O}C (63^{O}F). The average annual rainfall is 770 mm (30 inches), and it snows, on average, 80 days per year (Government of Canada, 2018).

6.3.2 Methodological Approach

For this study, the researchers used focus groups to encourage children to voice their thoughts and perspectives without being confined by pre-selected survey options. This child-centred approach treats children as co-researchers, where they are provided an opportunity to explore their own ideas and perceptions of what factors act as barriers and facilitators of their own PA participation in a free-flowing nature (Morgan et al., 2002; O.Nyumba et al., 2018). It is important to recognize that the goal of a focus group is not to gain a consensus from the children but to develop a database (Krueger & Casey, 2009). Therefore, saturation was not the goal and focus groups were conducted with all children who had parental consent and gave their own assent, but after the 14th focus group code saturation was reached (Krueger & Casey, 2009).

As suggested by Barker and Weller (2003), researchers must consider the existing power dynamics between themselves and the participants (Barker & Weller, 2003). In the context of the present study, several steps were taken to address the power imbalance. A local male (lead author) was deliberately selected to moderate all focus groups given that he was a community insider with a strong understanding of regional customs and norms. This individual was a well-known teacher and recreation programmer in the area and had experience working with children of all ages. He understood the ethics of working with children, knew all the children by name, and encouraged children to refer to him using his first name thus fostering a conversational tone. While these efforts and precautions were taken to reduce the power imbalance perceived by children, it is acknowledged that he still possessed a level of authority.

Another potential concern in focus groups is children answering to stay socially relevant, as children could provide answers that reflect what they think the moderator or their peers want to hear rather than their true thoughts and feelings (Morgan et al., 2002). To reduce the risk of social desirability bias, children were randomly assigned groups within specific age ranges, and the moderator took a few moments to explain to the students that there are no wrong answers; and everyone is entitled to an opinion, and researchers were interested in hearing everyone’s opinions.

6.3.3 Data Collection

Data were collected as part of a larger project called the Spatial Temporal Environment and Activity Monitoring (STEAM) project, the details of which can be found elsewhere (Coen, et al., 2019; HEAL, n.d.; Tillmann et al., 2018). The focus group data for the present study were collected from a subset of this larger study. Data were collected from October to December 2016 from students in four elementary schools in rural Northern Ontario. A member of the research team gave a presentation to grade 4-8 classes from all participating schools. Prior to participation in the study, students also received a package to take home and return with signed consent from their parents/guardians. Children also had to provide their own assent to participate in focus groups. Both parents and children provided consent to participation in focus groups that included audio recording, and permission to use anonymous direct quotes in any presentation of the results that was separate from the consent to participate in the rest of the STEAM project. The final recruitment included 194 students from the four regional elementary schools, with 84 of those students obtaining parental consent and providing child assent to participate in the focus groups. These 84 students represent just below 50% of all grade 4-8 students in the entire study area. Twenty focus groups, with 3–7 participants per group occurred during nutrition breaks of about 30-45 minutes through six weeks in the fall (October, November, and December) of 2016.

A semi-structured focus group guide was developed to prompt discussion about children's health behaviours including PA, healthy eating, and understanding of nature. The guide was based on a combination of a literature review, findings from previous STEAM focus groups, and local area knowledge. For this article, only the questions regarding PA were analysed; this represents 12-15 minutes of the entire focus group which lasted around 30-45 minutes depending on student participation. The questions that specifically related to PA were designed to obtain a deeper understanding of facilitators and barriers for PA and were broadly based on the socio-ecological model as a way of presenting potential factors (Moore et al., 2010; Yousefian et al., 2009). Example questions included, are there places that make you want to play? What do they look like? Are there places you don't want to play?" and, "If you could change one thing about your environment to make you more active what would it be?" The moderator followed the

focus group guidebook, but also allowed flexibility in the students' interpretation of and responses to the questions as well as encouraged the discussion to flow based on children's perspectives. All focus groups were audio recorded, transcribed verbatim, and verified for accuracy. Once the transcript had been verified, they were anonymized. Immediately after each focus group, the moderator made field notes describing his initial reactions, quality of data, and other general feelings from the focus group. These notes helped contextualize some of the responses and discussion. For example, in one case, a child said *we can't go over there* and pointed outside, so the moderator made notes that the child pointed to the parts of the outdoor equipment.

6.3.4 Ethics Approval

Ethics approval was granted by the University's Non-Medical Research Ethics Board (NM-REB #108029) and the two local school boards.

6.4 Analysis

A thematic analysis was conducted based on the six-phase process suggested by Braun and Clarke (2006). These steps are: (1) familiarization; (2) coding; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; and (6) writing a report (Braun & Clarke, 2006). During familiarization, the researcher, who was also the moderator, listened to and read every transcript, not just to become familiar with the data, but also to have in-depth knowledge of the focus groups as a complete dataset. For coding, researchers used NVivo Pro (Version 11) to categorize data as either facilitators or barriers to coincide with the overarching research question. Once separated, the main researcher proceeded to develop semantic codes and sub-themes through the individual datasets. The primary author has experience with qualitative research and an extensive knowledge of the local area. During steps 1-5 another researcher familiar with the study and study area confirmed the codes and final themes. During this process the researchers used the process of critical friends where each researcher challenges each other to encourage reflexivity on the data (Smith & McGannon, 2018). Several measures (e.g., credibility, transferability, dependability, and confirmability) were taken to enhance the rigour and trustworthiness of the data throughout the data collection and analysis process (Table 6.1)(Guba & Lincoln, 1989).

Table 6.1 Measures to ensure data trustworthiness

Criteria	
Credibility	Moderator had lived and taught in all schools in the study area, had experience conducting focus groups, took accurate field notes, and when any thought or answer was presented the moderator ensured that he understood the answer provided. For example, when a child mentioned they liked to ride a trike, the moderator confirmed this was a three-wheeled all-terrain vehicle.
Confirmability	Another coder that had spent a time in the rural study location and was familiar to the local context reviewed the initial and confirmed final semantic codes to ensure nothing was missed in the primary analysis.
Transferability	The data is unique as the sample was everyone willing to participate. The study had almost the same characteristics to the larger STEAM sample. The community was described in detail allowing researchers to determine if results would transfer to other similar communities.
Dependability	The lead author practiced reflexivity on how the analysis was shaped by his views on what it was like growing up in a rural community and how he determined meaningfulness of data as someone who had similar experiences as the children in the community and working as a teacher in the community. The work was completed with another author who understands but is not from the area helped confer dependability.

(adapted from Irwin et al., 2005; Tucker et al., 2007, 2008)

6.5 Results

Table 6.2 presents the demographic characteristics of the children in the focus groups. There were slightly more girls (51.2%) compared to boys (48.8%). The largest grade group was grade 4, making up about 26% of the sample. Caucasian children made up a little over half of the focus groups (51.2%), while Indigenous children made up about around 43%, and the remaining 6% are other ethnicities.

Table 6.2 Demographic characteristics of the sample in the STEAM focus group.

Demographics	STEAM Focus Group	
	n	%
Gender		
Female	43	51.2
Male	41	48.8
Grade		
4	22	26.2
5	20	23.8
6	17	20.2
7	16	19.0
8	9	10.7
Ethnicity		
Caucasian	43	51.2
Indigenous	36	42.9
Other	5	6.0

Most of the children's conversations were centered on barriers to PA as compared to facilitators. Three themes were identified and include environment (e.g., distance, skate parks, splash pads, indoor facilities, and weather), social environment (e.g., relationship with peers, teachers, and adults), and perceptions of safety (e.g., water, forest, and animals). The final themes and illustrative examples are discussed in greater detail below.

Environment

The environment theme was based on features of the environment that were acting as facilitators or barriers. It was largely centered on four built environment codes (e.g., distance, skate parks, splash pads, and indoor facilities) and weather.

Barrier:

Children described feeling confined by distance; as one girl in grade 8 said, “Your parents usually don't want to drive you cause my friend lives, like, a long way's away.” Similar sentiments were discussed when it came to travel to and from school or extracurricular activities. For example, one boy in grade 5 stated, “Well I don’t walk to school because it takes me, like, 30 minutes.” Another girl who had to travel over 120 km just to play competitive hockey said, “Um, I play hockey in Thunder Bay, too, so I’m not going to walk.” (girl grade 6)

Children’s perceptions of the built environment barriers seemed focused on splash pads and weather. The older children in grades 6 and 7 discussed how they thought the splash pad was intended for younger children

Girl 1: “Well, it’s [the splash pad] kind of, I don’t know how to say this, but it’s kind of, like, kiddy.” (girl grade 7)

Girl 2: “I like swimming so whenever I'm hot, I'll either, I'm, I've probably gone to the splash pad twice, but I've - don't think I've gone in either times, but if it's hot, I'll either ask my mom to take me to Loftquist [Lake], or I'll just sit inside.” (girl grade 6)

One environmental variable that is understudied but of growing interest in children’s PA literature is the influence of weather. When students were asked about active transportation, one boy mentioned he took the bus and walked, and when probed further, he said, “I walk like after school that’s why I said both because in the morning it's too cold.*”* (boy grade 7) Another boy shared his feelings about walking in the winter and the lack of properly maintained sidewalks or sidewalks in general

> When it's winter, and you're trying to walk around, and you don't got no sidewalks you have to walk up snowbanks sometimes you're in slush from the vehicles driving by sometimes you're too close, and it's just a hassle. (boy grade 8)

Facilitator:

Children discussed wanting a place to go and do activities after school as a facilitator with both the environment and social environment components. As one student explained, “There should be like more stuff to do like people just coming and doing activities there.” (boy grade 4) Another child expanded on the idea further with more specific points like,

> I guess what I was thinking a club where like any sports could be played there so like if you want to play volleyball or basketball you can go over there and it can be like local, you just grab your stuff and go play that sport for an hour. (boy grade 7)

Another potential facilitator were skate parks. They were mentioned in every focus group and the conversations were succinct, as a boy in grade 4 said, “maybe like a skate park would be pretty cool” or another boy in a grade 7 “I wish, I wish there was a skate park and more people.”

Social Environment

Children’s social environment refers to immediate context where a child lives and the relationships they have with other people in these contexts. These relationships were focused on relationships with adults and peers.

Barrier:

Children described how adults were responsible for creating barriers to PA. It was most frequently discussed in the context of the school environment. For example, one student expressed his frustration with school rules, which he felt were inhibiting PA, “We can’t play football now because people were fighting and, (pause), and, like, nothing to do.*”* (boy grade 5) Students acknowledged that rules were in place for a reason, but continued to emphasize how rules prevented them from being active, “So, like you could probably bring back foursquare, even though there are some poor sports, umm, but, there are poor sports in life, so you need to deal with it.*”* (girl grade 5) Another student stated, *“*We have pretty much not very many options to do in winter because we can’t throw

snowballs, can't slide on ice, and I can see why but maybe more wintery activities*."* (girl grade 5)

Facilitator:

When children were asked what would make them more active after school, many kids reported that having better access to their friends or having more people would make them more active. A girl in grade 6 said *"*Um, if there was, like, more people because, cause like, when I was, like, younger, me and my brother's friends would play, like, capture the flag or something, but they're like, all live in Thunder Bay or most of them really, don't really do anything anymore, so, yeah, more people*."* Another girl in the same grade living in a different part of the community had similar sentiments, "Say if there was more people, like, living on my street then yeah, I'd go outside because there's like, mostly old peopl*e."* (girl grade 6)

Another important facilitator that came up was the role of adults in organizing activities at school. One girl explained that intramurals were fun, and she wanted more, "Mr [X] should start it [intramurals] right at the start of the year so that we could play more sports*."* (girl grade 6) A girl in a different school thought that adults or even peers could facilitate activities, *"*If maybe the soccer games were organized, and we had teams beforehand we wouldn't waste so much of our recess picking teams." (girl grade 6)

Perceptions of Safety

An important theme that came up through all focus groups was child's perception of safety. Children's fear stemmed from living in proximity to large bodies of water, dense hilly forest, but mostly it was about the fear of animals

Barrier:

Across all focus groups, children consistently identified wildlife as a barrier to PA. In some cases, wildlife referred to common domestic/household loose dogs running around, but the most common fear came from bears. One child explained quite simply, "There's a lot of bears everywhere" (boy grade 4), which prevented him from playing in certain areas of the community. The fear of bears was mentioned as something parents were

fearful of, as a girl in grade 6 said, “Um, not really but I don't think my mom would want me to go in the bush later, like at six, seven or eight because there's been a bear around.” The fear of bears was also mentioned without reference to a parent as one girl in grade 4 said she cannot go in her backyard, “Because there’s been lots of bears and there’s a creek in my backyard.” Regardless of where the fear stemmed from, wildlife seemed to act as a potential barrier.

6.6 Discussion

The purpose of this study was to explore children’s perceptions of the facilitators and barriers of PA in rural northern communities. Rural children identified and provided contextual information on numerous barriers and some facilitators to their PA. These facilitators and barriers were grouped into three themes: environment, social environment, and perceptions of safety. The contextual understanding and applied nature of these themes can help create more successful interventions in similar rural areas.

Similar to other research in the rural settings, children mentioned distance was a barrier to being active (Moore et al., 2010). Friends’ houses, schools, or recreation facilities were too far from children’s houses, meaning they needed a ride from a parent. This similar finding across rural areas suggests that there is some generalizability from heterogeneous rural contexts (Moore et al., 2010; Yousefian et al., 2009). Distance is an accepted part of rural living. To counteract this barrier to physical activity, children should be taught games or activities during school to facilitate their own physical activity when confined to their homes.

Two built environment features that were prominently discussed included skate parks and splash pads. Children mentioned that a skate park would be a “cool” feature as they are common in the closest major city, but all communities lacked anything resembling a skate park and local streets are paved with a mix of asphalt and larger aggregate making it extremely difficult to skateboard on. The other feature that children mentioned and discussed was the splash pad. Two of the towns recently had splash pads built in the last five years, and they were the most recent built environment additions in these communities. The older children criticized them as being for little children and sometimes suggested that there was nothing age appropriate for them. In a more urban

area, a study based on interviews with parents indicated that parents were willing to travel further for features like splash pads (Tucker et al. 2007). This suggests that park design needs to incorporate children of all ages, as differently aged children and parents have different perspectives on what is important in a park. The problem of declining park usage by age is not isolated to rural areas as other urban studies find decrease park usage in adolescence (Veitch et al., 2007), but designing parks for children of all ages is more critical in rural areas because these children only have one or two parks in their whole communities. If older children feel like features are "kiddy" that space is no longer a recreational opportunity for them, causing them to go hang out in other areas that are potentially less conducive to PA. Research on older adolescents have found that children placed importance on long steep slides, absence of graffiti, presence of swings, walking/cycling paths, and BMX tracks and skate bowls (Veitch et al., 2017). These could be explored in this rural area.

Another common environmental feature that was discussed is the impact of the weather. Since a single moderator conducted all the focus groups, the period for focus groups extended almost six weeks starting in late October (mean temperature = 15^{O}C [59^{O}F]) and ending in early December (mean temperature = -10^{O}C [14^{O}F]) with snow covering the ground (Government of Canada, 2019). When examining the focus groups chronologically, a temporal pattern exists, as the barriers related to the environment become more pronounced as the seasons changed. Specifically, some children mentioned that they would get rides rather than walk because of the cold. The subtle difference between active and inactive transportation can impact children's overall PA (Faulkner et al., 2009). In one focus group, a child noted, that in winter you do not have sidewalks because the snow covers them. This finding demonstrates that the weather changes how children interact with their environment. This is an important finding as it could suggest that weather could be acting as a moderator of the built environment and PA relationship. Further research is necessary to understand this complex relationship between the built environment, weather, and PA (Tucker & Gilliland, 2007).

Children who participated in this study want access to more scheduled, or at least loosely organized, activities. In the fall season in these rural areas, there are no community or

club-organized PA opportunities for children; in the winter months, children can either play on a hockey team with practices 3-4 times a week, or a curling program that runs about once a week. Previous research has suggested that after-school programs can be beneficial in increasing children's MVPA (Mears & Jago, 2016). A potential solution is creating an after-school drop-in program with an adult to help organize different games some days and free play on others as children discussed the want for both structured and unstructured play. This type of program could also help prevent weather-related declines in PA as children are given the opportunity to play indoors. In rural areas, other community groups might need to be targeted in taking a more active role in promoting PA, as most rural areas lack the resources to employ a recreation programmer to run after-school programs.

Research has found that children's social environments are important for PA (Martins et al., 2017). In this study, children mentioned the social environment at school. Specifically discussing teacher-led or organized activities as potential facilitators to PA, and school rules as barriers. Schools are an important setting for PA; in fact children get over half of their total MVPA during the school day (Clark et al., 2019). In rural areas, the school environment is an important place to understand because children have access to friends, equipment, and other built environment features that they might not have access to at other parts of the day (Meyer et al., 2016). With rural children having more limited access to PA facilitators it is important that their school-based PA is understood and maximized. However, schools are a complex environment with many diverse stakeholders including principals, teachers, educational support staff, parents, and students. Collaborative partnerships between these stakeholders are necessary to create child-friendly PA environments where all stakeholders feel safe and comfortable. One way these environments can be achieved is through strong collaborations between student-led school councils that include teachers and principals where they discuss ways they can work together to promote PA in the school community (Griebler & Nowak, 2012).

In all focus groups, children discussed perceptions of safety caused by fear of wildlife as something that prevented children from being active by limiting areas they could or

explore. The importance of wildlife is a significant consideration, as it would have less of an influence in an urban area. In this rural area, it seemed as if there was a culture of fear. Children perceived the fear stemmed from family, friends, and the natural environment. This threat is also visualized as one school had recently put in a fence to keep wild animals out. It is difficult to disentangle the legitimacy of these fears as wild animals do come into the community searching for food, but very rarely have they ever attacked a human in this area. This threat has a major implication on rural children as fear can shape their "mental maps", having a negative influence on their independent mobility and environmental competence. Other instances besides wildlife were also present as some children described that their parents feared the child hanging out near waterbodies or climbing the "mountains". Children may avoid playing in certain areas that are perceived as threatening or have been told is threatening by adults or friends (England & Simon, 2010). Understanding what this culture of fear stems from is crucial as it could be combated with wildlife education.

6.7 Limitations

One key limitation of this study is that, like other studies, it is context specific. We argue that most previous studies offer limited understanding of the determinants of rural children's PA because they have largely taken place in urban settings. However, it can also be said of this article that being focused on a particular type of rural environment (in Northern Ontario), that some of the findings may not be relevant to other rural settings, particularly those with higher population densities and in greater proximity to major urban centres. Another limitation of this study is that it only offers the child's perspective. To fully understand the influence of different facilitators and barriers to children's PA researchers also need the opinions of other stakeholders including parents, teachers, and community leaders. With the collective opinions from all groups researchers can make more accurate policy recommendations. Finally, the term "play" and "active" became conflated as it was easier for some children to understand the term play. Future research needs to disentangle these two terms to improve the understanding of each variable.

6.8 Conclusion

Findings from this study suggest that PA is a complex behaviour that is influenced by many different factors. The ecological system theory embraces the complexity of children's PA behaviour. Based on the ecological systems theory, the socio-ecological model has become widely used by public health researchers for understanding PA and other health behaviours and the basic idea of the model is that children's PA is influenced by characteristics of the specific child (e.g., gender, age), the child's interpersonal factors (e.g., relationship with friends and adults) and, the physical environment (e.g., park amenities) (Brofenbrenner, 1979; Humbert et al., 2008; Mehtälä et al., 2014; Sallis et al., 2008). In these focus groups children discussed factors from these different levels such as their relationships with teachers (interpersonal) or wanting a place to play afterschool (physical environment). While conceptual models like the socio-ecological model can help us better understand PA behaviours, it is also imperative that researchers better understand the environmental context in which they are working and properly conceptualize and measure variables that are context specific.

In this Northern Ontario study area, it would be helpful for recreation providers to establish contacts with other similar rural communities to determine what they are doing differently and if different ideas could be helpful in their region. Given the perspectives of children from this area, it is recommended that local recreation personnel contact other communities to see how skate parks and after-school programs have been implemented and evaluated in other communities. Further research needs to continue to engage with rural children, to help uncover how their own unique environmental contexts influences not only their PA levels, but also their overall health and well-being.

6.9 References

Barker, J., & Weller, S. (2003). “Is it fun?” developing children centred research methods. *International Journal of Sociology and Social Policy*. 23(1-2), 33-58

Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine*, *45*(11), 886–895. https://doi.org/10.1136/bjsports-2011-090185

Biddle, S. J. H., Atkin, A. J., Cavill, N., & Foster, C. (2011). Correlates of physical activity in youth: a review of quantitative systematic reviews. *International Review of Sport and Exercise Psychology*, *4*(1), 25–49. https://doi.org/10.1080/1750984X.2010.548528

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.

Brofenbrenner, U. (1979). *The ecology of human development: experiments by nature and design*. Cambridge, Mass: Harvard University Press.

Button, B. L. G., Clark, A. F., Shah, T., Wilk, P., & Gilliland, J. A. (2019). Examining weather-related factors on physical activity levels of children from rural communities. *Manuscript in Preperation*.

Clark, A., Wilk, P., & Gilliland, J. (2019). Comparing physical activity behavior of children during school between balanced and traditional school day schedules. *Journal of School Health*, *89*(2), 129–135. https://doi.org/10.1111/josh.12722

Coburn, A. F., C, M., McBride, T., Mueller, K., Slifkin, R., & Wakefield, M. (2007). *Choosing rural definitions: implications for health policy*.

Coen, S. E., Mitchell, C. A., Tillmann, S., & Gilliland, J. A. (2019). ‘I like the “outernet” stuff:’ girls’ perspectives on physical activity and their environments. *Qualitative Research in Sport, Exercise and Health*, *11*(5), 599–617. https://doi.org/10.1080/2159676X.2018.1561500

du Plessis, V., Beshiri, R., Bollman, D., & Clemenson, H. (2001). *Definitions of rural* (Vol. 3).

Ding, D., Sallis, J. F., Kerr, J., Lee, S., & Rosenberg, D. E. (2011). Neighborhood environment and physical activity among youth. *American Journal of Preventive Medicine*, *41*(4), 442–455. https://doi.org/10.1016/j.amepre.2011.06.036

England, M. R., & Simon, S. (2010). Scary cities: urban geographies of fear, difference and belonging. *Social & Cultural Geography*, *11*(3), 201–207. https://doi.org/10.1080/14649361003650722

Faulkner, G. E. J., Buliung, R. N., Flora, P. K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Preventive Medicine*, *48*(1), 3–8. https://doi.org/10.1016/j.ypmed.2008.10.017

Ferrari, G. L., Oliveira, L. C., Araujo, T. L., Matsudo, V., Barreira, T. V, Tudor-Locke, C., & Katzmarzyk, P. (2015). Moderate-to-vigorous physical activity and sedentary behavior: independent associations with body composition variables in Brazilian children. *Pediatric Exercise Science*, *27*(3), 380–389. https://doi.org/10.1123/pes.2014-0150

Government of Canada. (2018). Historical Climate Data. Retrieved from https://climate.weather.gc.ca/

Government of Canada. (2019). Canadian Weather. Retrieved from https://weather.gc.ca/canada_e.html

Griebler, U., & Nowak, P. (2012). Student councils: a tool for health promoting schools? Characteristics and effects. *Health Education*. https://doi.org/10.1108/09654281211203402

Guba, E., & Lincoln, Y. (1989). *Fourth Generation Evaluation*. Newbury Park, California: SAGE Publications, Inc.

HEAL. (n.d.). Spatial Temporal Environmental and Activity Monitoring. Retrieved from http://theheal.ca/projects/spatial-temporal-environment-and-activity-monitoring/

Herman, K. M., Chaput, J.-P., Sabiston, C. M., Mathieu, M.-E., Tremblay, A., & Paradis, G. (2015). Combined physical activity/sedentary behavior associations with indices of adiposity in 8- to 10-year-old children. *Journal of Physical Activity and Health*, *12*(1), 20–29. https://doi.org/10.1123/jpah.2013-0019

Humbert, M. L., Chad, K. E., Bruner, M. W., Spink, K. S., Muhajarine, N., Anderson, K. D., Girolami, T. M., Odnokon, P., & Gryba, C. R. (2008). Using a naturalistic ecological approach to examine the factors influencing youth physical activity across grades 7 to 12. *Health Education & Behavior*, *35*, 158–173.

https://doi.org/10.1177/1090198106287451

Irwin, JD., He, M., Bouck, LMS., Tucker, P., & Pollett, G. (2005). Preschoolers' physical activity behaviours: parents' perspectives *Canadian Journal of Public Health*, *96*(4), 299–303.

Joens-Matre, R. R., Welk, G. J., Calabro, M. A., Russell, D. W., Nicklay, E., & Hensley, L. D. (2008). Rural – urban differences in physical activity, physical fitness, and overweight prevalence of children. *The Journal of Rural Health*, *24*(1), 49–54.

Krueger, R., & Casey, M. A. (2009). *Focus groups: a practical guide for applied research* (3rd ed.). SAGE PublicationsSage CA: Los Angeles, CA.

Larun, L., Nordheim, L. V, Ekeland, E., Hagen, K. B., & Heian, F. (2006). Exercise in prevention and treatment of anxiety and depression among children and young people. *Cochrane.Database.Syst.Rev.*, *3*, CD004691-. https://doi.org/10.1002/14651858.CD004691.pub2

Martins, J., Marques, A., Peralta, M., Palmeira, A., & Carreiro Da Costa, F. (2017). Correlates of physical activity in young people: a narrative review of reviews. Implications for physical education based on a socio-ecological approach. *Retos*, *31*, 292–299. https://doi.org/Recuperado de https://recyt.fecyt.es/index.php/retos/article/view/53505

McIsaac, J.-L., Kirk, S., & Kuhle, S. (2015). The association between health behaviours and academic performance in Canadian elementary school students: a cross-sectional study. *International Journal of Environmental Research and Public Health*, *12*(11), 14857–14871. https://doi.org/10.3390/ijerph121114857

Mears, R., & Jago, R. (2016). Effectiveness of after-school interventions at increasing moderate-to-vigorous physical activity levels in 5- to 18-year olds: a systematic review and meta-analysis. *British Journal of Sports Medicine*, https://doi.org/10.1136/bjsports-2015-094976

Mehtälä, M. A. K., Sääkslahti, A. K., Inkinen, M. E., & Poskiparta, M. E. H. (2014). A socio-ecological approach to physical activity interventions in childcare: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *11*(1). https://doi.org/10.1186/1479-5868-11-22

Meyer, M. R. U., Moore, J. B., Abildso, C., Edwards, M. B., Gamble, A., & Baskin, M.

L. (2016). Rural active living: a call to action. *Journal of Public Health Management and Practice*, *22*(5), E11–E20. https://doi.org/10.1097/PHH.0000000000000333

Ministry of Natural Resources and Forestry. (2016). Ontario to expand black bear hunting pilot. Retrieved from https://news.ontario.ca/mnr/en/2016/02/ontario-to-expand-black-bear-hunting-pilot.html

Mitchell, C., Clark, A., & Gilliland, J. (2016). Built environment influences of children's physical activity: examining differences by neighbourhood size and sex. *International Journal of Environmental Research and Public Health*, *13*(1), 130. https://doi.org/10.3390/ijerph13010130

Moore, J. B., Jilcott, S. B., Shores, K. A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010). A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Education Research*, *25*(2), 355–367. https://doi.org/10.1093/her/cyq004

Morgan, M., Gibbs, S., Maxwell, K., & Britten, N. (2002). Hearing children's voices: methodological issues in conducting focus groups with children aged 7–11 years. *Qualitative Research*.

Nykiforuk, C. I. J., Atkey, K., Brown, S., Caldwell, W., Galloway, T., Gilliland, J., Kongats, K., McGavock, J., & Raine, K. D. (2018). Promotion of physical activity in rural, remote and northern settings: a Canadian call to action. *Health Promotion and Chronic Disease Prevention in Canada*, *38*(11), 419–435. https://doi.org/10.24095/hpcdp.38.11.03

O.Nyumba, T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Sallis, J. F., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: theory, research, and practice, 4th edition* (Fourth, pp. 465–485). Jossey-Basshttps://doi.org/10.7326/0003-4819-116-4-350_1

Sallis, J., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical

activity of children and adolescents. *Medicine & Science in Sports & Exercise*, *32*(5), 963–975.

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology*, *11*(1), 101–121. https://doi.org/10.1080/1750984X.2017.1317357

Statistics Canada. (2018). Census Profile, 2016 Census. Retrieved October 29, 2018, from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E

Tillmann, S., Button, B., Coen, S. E., & Gilliland, J. A. (2018). "Nature makes people happy, that's what it sort of means:" children's definitions and perceptions of nature in rural Northwestern Ontario. *Children's Geographies*, *17(6), 705-718* https://doi.org/10.1080/14733285.2018.1550572

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health*, *121*(12), 909–922. https://doi.org/10.1016/j.puhe.2007.04.009

Tucker, P., Gilliland, J., & Irwin, J. (2007). Splashpads, swings, and shade: parents' preferences for neighbourhood parks. *Canadian Journal of Public Health*, *98*(3), 198–202.

Tucker, P., Irwin, J. D., Gilliland, J., & He, M. (2008). Adolescents' perspectives of home, school and neighborhood environmental influences on physical activity and dietary behaviors. *Children Youth and Environments 18*(2), 12–35.

Tucker, P., Irwin, J. D., Gilliland, J., He, M., Larsen, K., & Hess, P. (2009). Environmental influences on physical activity levels in youth. *Health & Place*, *15*(1), 357–363. https://doi.org/10.1016/j.healthplace.2008.07.001

Veitch, J., Salmon, J., & Ball, K. (2007). Children's perceptions of the use of public open spaces for active free-play. *Children's Geographies*. 5(4), 409-422.https://doi.org/10.1080/14733280701631874

Veitch, J., Salmon, J., Deforche, B., Ghekiere, A.,Van Cauwenberg, J. Van, Bangay, S., & Timperio, A. (2017). Landscape and urban planning park attributes that encourage park visitation among adolescents: a conjoint analysis. *Landscape and Urban*

Planning, *161*, 52–58. https://doi.org/10.1016/j.landurbplan.2016.12.004

Yousefian, A., Ziller, E., Swartz, J., & Hartley, D. (2009). Active living for rural youth: addressing physical inactivity in rural communities. *Journal of Public Health Management and Practice : JPHMP*, *15*(3), 223–231. https://doi.org/10.1097/PHH.0b013e3181a11822

Chapter 7

7 Discussion

7.1 Overview

Despite the overwhelming amount of evidence on the relationship between the urban environment and children's physical activity (PA), comparatively few studies have explored the links between rural environments and children's PA. The overall purpose of this dissertation was to partly fill this knowledge gap by addressing the research question: *What are the environmental influences on physical activity among children in rural Northern Ontario?* A multi-method approach was used to answer this question over three chapters, each with its own research objective. The theory and literature review presented in Chapter 2, combined with the data collection methods presented in Chapter 3, informed the three studies reported in Chapters 4-6. This chapter presents a summary of the key findings of this dissertation, identifies limitations of the research, presents future research directions, and describes potential policy implications.

7.2 Summary of Key Findings and Research Contributions

To address the overarching research question, this dissertation used a multi-method approach and presented three related studies, each addressing a key research objective. The objective of Chapter 4 was to examine what factors influence whether children achieve their recommended minutes of moderate-to-vigorous PA (MVPA) on weekdays and weekend days. Previous research has suggested that there is a difference in children's PA levels on weekdays versus weekend days, but researchers regularly combine both weekdays and weekend days in their analyses of PA levels and PA determinants (Colley et al., 2017). This approach is problematic for understanding what factors influence PA as it fails to recognize the importance that different day types can have on such factors. Our data suggest that there are different factors that influence children's ability to meet the MVPA guidelines on weekdays and weekend days. The study used logistic regressions to determine what variables influenced whether children met the MVPA guidelines of 60 minutes of MVPA on weekdays and weekends in 532 children aged 8 to 14 years old

from Southern and Northern Ontario. The results of this analysis found that, on weekdays, three intrapersonal variables were related to meeting the MVPA guidelines: gender, age, and physical functioning. On weekends, one variable each at both the intrapersonal and physical environment levels were related to children meeting the MVPA recommendations. At the intrapersonal level, gender was significant, as the odds of boys meeting the recommendations were greater than girls doing so, but there was a decrease in the magnitude of difference. At the physical environment level, a common strategy when choosing a referent group is to use the "normative group," so most researchers would pick the urban group as a referent group. However, by selecting rural Northern Ontario as the referent group, we highlighted rural children. Children living in rural Northern Ontario were significantly more likely to meet the MVPA guidelines on weekends than children living in urban areas, suburban areas, urban small towns, or in rural Southern Ontario. The regional differences provided a justification to examine the rural Northern Ontario sample exclusively. In conclusion, this study indicates that different factors influence children's ability to meet the MVPA guidelines on weekdays versus weekend days. While other studies have also found there are differences by day type (Comte et al., 2013; Fairclough et al., 2012), few, if any, studies have also incorporated regional variations into their analyses. Chapters 5 and 6 considered the environmental influences of rural northern children's PA in greater depth.

The objective of Chapter 5 was to examine the influences of seasonality and weather on rural children's PA. This study uses cross-classified regression models to determine how weather influences day-to-day MVPA levels of children who live in rural Northern Ontario communities. The study population included 90 individual children with a total of 663 valid days of monitoring data, and the analysis included factors at the intrapersonal, interpersonal, and physical environment levels. Methodologically, the cross-classified model allowed for flexibility in examining correlated data, so researchers could use day-level weather data, which help move the literature beyond examining more large-scale seasonal influences (Seltman, 2014). The results from this study indicate that boys were more active than girls, children were more active on weekdays and days without rain, and for each increase in one degree Celsius, there was 1.33 minutes ($p <$ 0.01) increase in MVPA, on average. This paper indicates that certain weather variables

and temporal differences can significantly impact rural children's MVPA, and this should not be ignored by PA researchers. These findings are contrary to Lewis et al. (2016), who found that rain did not significantly impact MVPA of Canadian children in urban areas. This difference suggests that weather has differing impacts in urban and rural regions. The primary goal of this study was to focus on the influence of day-to-day weather changes on MVPA; however, there is still an absence of information on other environmental variables that might influence rural children's PA. In response, Chapter 6 used focus group data to explore rural children's perceptions of facilitators and barriers to their PA.

The objective of Chapter 6 was to explore more deeply the facilitators and barriers to rural children's PA. This aim was accomplished through 20 focus groups with 84 children in grades 4 to 8. The focus groups allowed rural children to express their perceptions of barriers and facilitators without being confined by options from surveys. The focus groups used a general guideline for questioning but were largely open for children to discuss their thoughts and ideas. Using thematic analysis, three themes were identified: environment, social environment, and perceptions of safety. Environmental features that were discussed include the built environment (e.g., splash pads, school playgrounds, skate parks, indoor facilities) and the impact of weather on PA. The children explained that friends and adults could either facilitate or restrain their play. Finally, fear of wildlife was pervasive, as children's fears or parents' fears seemed to restrict the children's independent mobility in some respects. Consistent with other studies, the rural children identified variables that are similar to urban and other rural environments (Moore et al., 2010), but the children in this study also identified variables that are unique to this context. This study has advanced the research body by using a large sample from a geographically isolated rural community. These findings suggest that researchers can use urban- or rural-based literature to create potential hypotheses but need to use methods that allow them to collect data on the uniqueness of the specific rural environment.

Using a multi-method approach was a complex process requiring both quantitative, qualitative, and methodological expertise. However, this approach was necessary as the

combination of methods is stronger than any single method. This approach provided richer data and greater credibility than previous studies by offering complementary and confirmatory insights (Johnson & Onwuegbuzie, 2004), as illustrated in Chapters 5 and 6. Chapter 5 quantitatively demonstrated the impact of temperature and rain, and Chapter 6 added explanations for these findings.

Overall, the major contribution of this dissertation lies in its contribution to knowledge of rural children's PA. However, the combined results have created important methodological and theoretical considerations. First, the results reveal the importance of the temporal environment on children's PA. In most children's PA research, the temporal realm is either omitted or inadequately explained (Spence & Lee, 2003). In Figure 7.1, two models are presented, one to represent the weekdays and one to represent the weekend days. This approach was taken in Chapter 4, in which the two models were constructed. In Chapter 5, we conceptually thought of it as one model and included temporal variables (e.g., day type and weather) and both significantly impacted MVPA. This finding cannot be understated, as most children's PA researchers aggregate as much data as possible to create a "representative" picture of children's PA. The price of aggregation and confidence in a measure is the potential loss of understanding nuances, such as temporal differences. When trying to understand human behaviour, the loss of detail or nuance can be drastic, as this may include information that is critical for planning effective interventions (Pollet et al., 2015). Most applications of the socio-ecological theoretical framework in the health-promotion literature tend not to include temporal dimensions (Moore et al., 2010; Sallis et al., 2006), even though this was part of Bronfenbrenner's early conceptualization (Brofenbrenner, 1979). The findings of this dissertation clearly show that it is important that researchers not overlook temporal aspects (e.g., day type, seasons) when theorizing or conceptualizing children's PA behaviours. Second, this research demonstrates the significance of having a contextual understanding of the environment of the study area, recognizing that a child's PA behaviour is partially formed by their environment. A good fit between the individual and the environment can lead to positive health-related changes (Spence & Lee, 2003). There is a need for researchers to have a more comprehensive understanding of the environment and children's actions within their environment. This research found that none of the

commonly studied environmental variables (e.g., accessibility to recreation facilities, perceptions of the neighbourhood) were significant in influencing MVPA in the quantitative papers. I further explored the environment using qualitative measures. The qualitative findings suggest that some children were scared to play in certain places because of wildlife, that children liked teacher-supported activities, and that the park was not an inviting place for children to play, indicating that context-specific variables need to be included when examining children's PA. In this specific area, a variable of perceptions of safety from wildlife or a variable of teacher support could be important, as seen in Figure 7.1. It is, therefore, imperative that researchers and policymakers understand the synergy between the individual and the environment. One of the only ways to reach this level of understanding is through a multi-method approach.

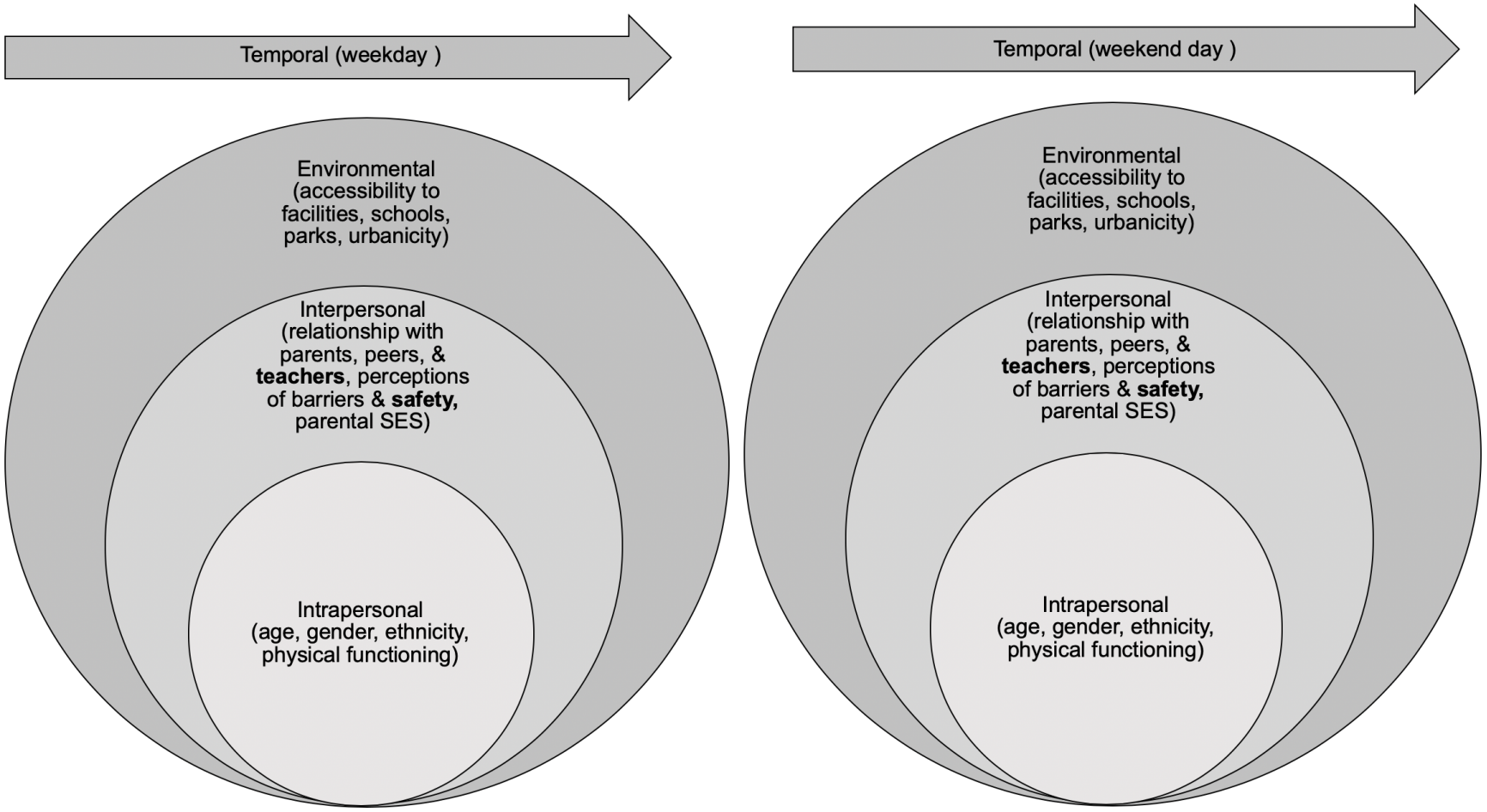


Figure 7.1 Socio-ecological model for children's physical activity on weekdays and weekend days with different levels and potential variables, including rural specific variables in bold adapted from Sallis et al. (2008)

7.3 Limitations

Despite the contributions to understanding rural children's PA, this dissertation is subject to certain limitations. First, the entire STEAM North study was conducted over a four-month period, which somewhat limits the generalizability of the results as we were unable to capture the full range of temporal differences that could potentially influence children's MVPA. This timeframe also influences the multi-method approach, as the data were gathered concurrently rather than sequentially. Thus, we could not use the findings from the first round of data collection to inform the focus groups, nor use the focus groups to inform the second round of data collection. However, these dates were specifically chosen in consultation with the school principals, so preliminary data could be shared with the school community and students before graduation and could be used for the school improvement plan. Second, efforts were made throughout the data collection process to maintain the largest possible sample size from fall to winter. Unfortunately, fewer students completed the full data-collection cycles in the winter, and fewer students participated in the focus groups (44%), potentially making some of the results less transferable to the wider population. Third, I used the socio-ecological model as a framework for this dissertation. One of the main disadvantages of any ecological model is the challenge to evaluate all components. I used all available data to construct the most comprehensive models but was still limited regarding some of the constructs I could measure. Specifically, the construct "social capital" has been cited as an important variable in improving children's PA (Button et al., 2013), but this was outside the focus of this dissertation.

There are other important characteristics of working with rural communities that are important to recognize as they impact data analyses. When working in rural regions, researchers may be somewhat limited in sample size selection and environmental variability. In this study, every child in the area was recruited, but, in some instances, we were unable to build a multi-variable model due to small numbers, despite high participation rates. This problem cannot be circumvented by recruiting more children because this could potentially bias the sample, as you would need to add other communities. Another concern when working in rural areas is the lack of environmental

variability. When conducting regression analysis, a lack of variability in predictor variables can lead to a less-precise model (Marill, 2004).

7.4 Future Direction

The STEAM project started as a pilot project in 2009 and has now been built into a distinct database of health information on a geographically diverse group of children. At the individual manuscript level, each study can be extended to enhance our knowledge of the research area. Study 1 could lead to two directions in future research. First, Study 1 suggested that different variables influenced MVPA on weekdays and weekends. This finding is similar to ideas put forth by Sallis et al. (2006) in their four domains of active living research, in which they suggest that research needs to be domain specific, so accurate models can be constructed (Sallis et al., 2006). This domain-specific modelling is evident in active transportation literature (Larsen et al., 2009) and in temporal domains such as recess (Woods et al., 2015), but is limited in other domains of children's MVPA. Second, more geographically distinct areas need to be researched or publicized to determine whether a difference exists that is similar to the difference between rural Northern Ontario and different urbanicities in Southern Ontario. Researchers need to determine whether different areas display differences in MVPA, or whether a global model is accurate. Currently, most Canadian MVPA literature tends to cite an analysis based on data from the Canadian Health Measures Survey (Roberts et al., 2017; ParticipACTION, 2018), but we have little support to suggest that these results are valid in all different Canadian communities.

Study 2: In Canada, weather temperatures can change drastically from summer to winter, and these weather changes differ from Southern Canada to Northern Canada. It is likely that children are more active in warmer months than in colder months, but brief cross-sectional snapshots confound our understanding of weather-related changes in PA as few studies have examined children's PA throughout the entire year (Rich et al., 2012). A more intensive full-year study needs to be done to understand better how weather influences PA and how built environments potentially moderate the relationship between weather and PA.

Study 3 was limited by the time constraints of a school lunch period and had the goal of capturing a breadth of data rather than a depth of data. Future research should spend longer with children, probe them more deeply about their answers, and attempt to use more innovative research methods, such as photovoice or participatory mapping exercises (Wilson, et al., 2019). Using more innovative methods could help improve data quality, as drawing, mappings, diaries, and storytelling might allow children to communicate in ways that are more suited to their understanding of the environment (Barker & Weller, 2003). These approaches allow for a richness in data that can potentially help understand PA behaviours in context. Additionally, physical inactivity is a multi-faceted problem, and researchers should conduct focus groups and interviews with people that the children mention, including parents, teachers, and recreation officials, as congruence among these groups could lead to improved PA interventions (Gillies, 1998).

Overall, each study has its potential direction for future research, which will help improve the surveillance level of data and contribute to the body of knowledge. One large-scale method shift that could potentially aid in future research is using ecological momentary assessment, which involves repeated sampling of subjects' current behaviours and experiences, in real-time, in subjects' natural environments (Dunton, 2018). Although a contentious approach, it could help gather specific temporal data that could potentially help understand PA behaviour during a specific timeframe and during a specific activity, which could lead to a better understanding of rural children's PA and create better interventions.

If researchers are focused on creating interventions, they may want to adopt a modified community-based participatory research approach. In this approach, a research team would work with a specific community throughout the entire research process, from defining a problem and collecting data, to creating and carrying out an action plan (Holkup et al., 2009; Kenny et al., 2013). This approach would be beneficial as it could leverage contextual knowledge to create more successful and community-supported environmental interventions than exist at present.

7.5 Policy Implications

Overall, the policy implications are presented at the community level and the provincial and federal level. At the provincial and federal level, I suggest two separate considerations that are important for rural children's PA and rural health in general.

One of the driving forces behind the aforementioned timelines of this dissertation came as a direct request from the principals of the participating schools. The school principals wanted information, so that their graduating students could see the preliminary results, as a research project is a real-life example of inquiry-based learning. The principals also wanted to complete school improvement-plans based on the preliminary data (see Appendix C). Thus, we have already helped educate children, parents, and school boards about the health behaviours of their children. Having community-level data is important as a lack of appropriate data has been cited as an issue when working with rural communities (Ministry of Health and Long-Term Care, 2017). Furthermore, since the completion of this study, some schools and communities have made important health-related changes. For example, one of the schools in the study was recently recognized as one of 274 schools across Ontario that holds a silver Ontario Health and Physical Education Association certificate as a Healthy School. The school implemented a family wellness fair, a healthy snacks initiative, and personal health workshops. Another example is the formation of an "after-school" boys and girls club in one of the communities. However, in these rural communities, it is difficult to create change as there is limited human capital (Meyer et al., 2016).

At the provincial and federal level, there is a continuous awareness of the importance of PA (Ministry of Health Promotion, 2010; Public Health Agency of Canada, 2018). However, rural areas are often neglected or superficially treated in any plans. Federal and provincial policies tend to treat rural areas as a single entity for several reasons. First, the political process often requires that a significant coalition be formed to pass rural-related legislation, and it is more expedient to lump than to divide. Second, policymakers and legislators often do not understand rural variability and diversity or the methods for making these distinctions (Hart et al., 2005). Third, policymakers tend to focus on access to healthcare services rather than individual community well-being (Smith et al., 2008).

These three factors miss the contextual nuances of living in the rural environment. This point was further highlighted when a group of 28 rural experts discussed that rural communities need to be involved when determining policies and programs given the heterogeneity of rural communities (Nykiforuk et al., 2018). Currently, under the Ontario Conservative government, there are plans to amalgamate the 36 local public health agencies into 14 (Ministry of Health and Long-Term Care, 2017). The Chief Medical Officer for the Northern Health Unit, the neighbouring health unit to the Thunder Bay Health Unit, which includes the communities of Nipigon, Red Rock, Dorion, and Hurkett, has already expressed their concerns about local voices being lost in the amalgamation (Jeffords, 2019). In these small rural communities, the loss of the district health units could lead to the concerns of rural communities being ignored.

More broadly, another policy consideration centres around the community in general. In rural areas, communities play a vital role in the health and well-being of their members. Some rural areas in Canada rely on the richness of their natural resources (Ministerial Advisory Council on Rural Health, 2002). This reliance creates devastating boom-and-bust cycles. The communities of Nipigon, Red Rock, Dorion, and Hurkett are still searching for a major employer since the loss of their paper mills. The combination of boom-and-bust economies, increased migration of youth to cities, the aging of the population, chronic high unemployment, and downturns in economic activity has important implications for rural communities and, consequently, for children's PA (Lawrie et al., 2011; Moazzami, 2015; Rothwell, 2002; Singh, 2002). For example, when Red Rock lost its paper mill, taxes increased, and the community had to make layoffs, and consequently they no longer employ a full-time recreation programmer. Overall, the lack of investment in keeping rural communities alive not only negatively impacts the PA levels of children, but also the health of the entire community (Shandro et al., 2011; Sherman, 2009). Therefore, the government needs to invest in these communities to keep them healthy. If more money is available for recreation projects, the information from this dissertation could be used to help direct those investments because park design, places to play in bad weather, and community-based programs seem to have the potential to increase children's PA.

7.6 Conclusion

Over the past decade, children's PA has been an important public health and academic concern. Gaining a better understanding of how the environment (built and natural) influences PA has become a research priority. Nevertheless, the current research body is dominated by studies of urban environments, leaving a major gap in understanding environmental influences on rural children's PA. A multi-method approach, based on the socio-ecological model was used to examine the environmental influences of rural children's PA. This dissertation presents both quantitative and qualitative results regarding rural children's PA that are crucial for PA researchers, policymakers, and recreation officials.

7.7 References

Barker, J., & Weller, S. (2003). “Is it fun?” developing children centred research methods. *International Journal of Sociology and Social Policy*. 23(1-2), 33-58

Brofenbrenner, U. (1979). *The ecology of human development: experiments by nature and design*. Cambridge, Mass: Harvard University Press.

Button, B., Trites, S., & Janssen, I. (2013). Relations between the school physical environment and school social capital with student physical activity levels. *BMC Public Health*, *13*, 1191. https://doi.org/10.1186/1471-2458-13-1191

Colley, R. C., Carson, V., Garriguet, D., Janssen, I., Roberts, K. C., & Tremblay, M. S. (2017). Physical activity of Canadian children and youth, 2007 to 2015. *Health Reports*, *28*(10), 8–16. https://doi.org/October 2017

Dunton, G. F. (2018). Ecological momentary assessment in physical activity research. *Exercise and Sport Science Review*, *45*(1), 48–54. https://doi.org/10.1249/JES.0000000000000092.Ecological

Gillies, P. (1998). Effectiveness of alliances and partnerships for health promotion. *Health Promotion International*, *13*(2), 99–120. https://doi.org/10.1093/heapro/13.2.99

Hart, L. G., Larson, E. H., & Lishner, D. M. (2005). Rural definitions for health policy and research. *American Journal of Public Health*, *95*(7), 1149–1155. https://doi.org/10.2105/AJPH.2004.042432

Holkup, P., Tripp-Reimer, T., Salois, E., & Weinert, C. (2009). Community-based participatory research: an approach to intervention research with a native american community. *Annals of Advanced Nursing Science*, *6*, 247–253. https://doi.org/10.1111/j.1743-6109.2008.01122.x.Endothelial

Jeffords, S. (2019, May 19). Health units worried about province’s plans to consolidate 35 agencies into 10. *The Canadian Press*. Retrieved from https://www.cbc.ca/news/canada/toronto/public-health-units-ford-government-1.5142217

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: a research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26. https://doi.org/10.3102/0013189X033007014

Kenny, A., Hyett, N., Sawtell, J., Dickson-Swift, V., Farmer, J., & Meara, P. O. (2013). Community participation in rural health: a scoping review. *BMC Health Services Research*.

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., & He, M. (2009). The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. *American Journal of Public Health*, *99*(3), 520–526. https://doi.org/10.2105/AJPH.2008.135319

Lawrie, M., Tonts, M., & Plummer, P. (2011). Boomtowns, resource dependence and socio-economic well-being. *Australian Geographer*, *42*(2), 139–164. https://doi.org/10.1080/00049182.2011.569985

Marill, K. A. (2004). Advanced statistics: linear regression, part I: simple linear regression. *Academic Emergency Medicine*, *11*(1). https://doi.org/10.1197/S1069-6563(03)00600-6

Meyer, M. R. U., Moore, J. B., Abildso, C., Edwards, M. B., Gamble, A., & Baskin, M. L. (2016). Rural active living: a call to action. *Journal of Public Health Management and Practice*, *22*(5), E11–E20. https://doi.org/10.1097/PHH.0000000000000333

Ministerial Advisory Council on Rural Health. (2002). *Rural health in rural hands strategic directions for rural, remote, northern and aboriginal Communities*.

Ministry of Health and Long-Term Care. (2017). 3.10 Public health: chronic disease prevention. Retrieved from http://www.auditor.on.ca/en/content/annualreports/arreports/en17/v1_310en17.pdf

Ministry of Health Promotion. (2010). *Ontario's sport and physical activity strategy*.

Moazzami, B. (2015). *Strengthening rural Canada: fewer & older: the coming demographic crisis in rural Ontario*. Retrieved from https://books.google.ca/books/about/Strengthening_Rural_Canada.html?id=dciIrgEACAAJ&pgis=1

Moore, J. B., Jilcott, S. B., Shores, K. A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010). A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Education Research*, *25*(2), 355–367. https://doi.org/10.1093/her/cyq004

Nykiforuk, C. I. J., Atkey, K., Brown, S., Caldwell, W., Galloway, T., Gilliland, J., Kongats, K., McGavock, J., & Raine, K. D. (2018). Promotion of physical activity in rural, remote and northern settings: a Canadian call to action. *Health Promotion and Chronic Disease Prevention in Canada*, *38*(11), 419–435. https://doi.org/10.24095/hpcdp.38.11.03

ParticipACTION. (2018). *The Brain + Body Equation: Canadian kids need active bodies to build their best brains. The 2018 ParticipACTION report card on physical activity for children and youth*. Toronto. ParticipACTION; 2018

Pollet, T. V., Stulp, G., Henzi, S. P., & Barrett, L. (2015). Taking the aggravation out of data aggregation: a conceptual guide to dealing with statistical issues related to the pooling of individual-level observational data. *American Journal of Primatology*, *77*(7), 727–740. https://doi.org/10.1002/ajp.22405

Public Health Agency of Canada. (2018). *A common vision for increasing physical activity and reducing sedentary living in Canada: Let's get moving*.

Rich, C., Griffiths, L. J., & Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 49. https://doi.org/10.1186/1479-5868-9-49

Roberts, K. C., Yao, X., Carson, V., Chaput, J. P., Janssen, I., & Tremblay, M. S. (2017). Meeting the Canadian 24-hour movement guidelines for children and youth. *Health Reports*, 28(10), 3-7.

Rothwell, N. (2002). *Employment in rural and small town Canada: an update to 2000*. *Rural and Small Town Canada Analysis Bulletin* (Vol. 3). Retrieved from http://www.statcan.ca/english/freepub/21-006-XIE/21-006-XIE01004.pdf

Sallis, J., Cervero, R., Ascher, W., Henderson, K., Kraft, K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health*, *27*, 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100

Seltman, H. J. (2014). *Chapter 15 mixed models*. *Experimental design and analysis*. https://www.stat.cmu.edu/~hseltman/309/Book/chapter15.pdf

Shandro, J. A., Veiga, M. M., Shoveller, J., Scoble, M., & Koehoorn, M. (2011). Perspectives on community health issues and the mining boom – bust cycle.

Resources Policy, *36*(2), 178–186. https://doi.org/10.1016/j.resourpol.2011.01.004

Sherman, J. (2009). Bend to avoid breaking: job loss, gender norms, and family stability in rural America. *Social Problems*, 56(4), 599–620. https://doi.org/10.1525/sp.2009.56.4.599.600

Singh, V. (2002). *Rural income disparities in Canada: a comparison across the provinces* (Vol. 3). Ottawa.

Smith, K. B., Humphreys, J. S., & Wilson, M. G. A. (2008). Addressing the health disadvantage of rural population: how does epidemiological evidence inform rural health policies and research ? *Australian Journal of Rural Health*, 56–66. https://doi.org/10.1111/j.1440-1584.2008.00953.x

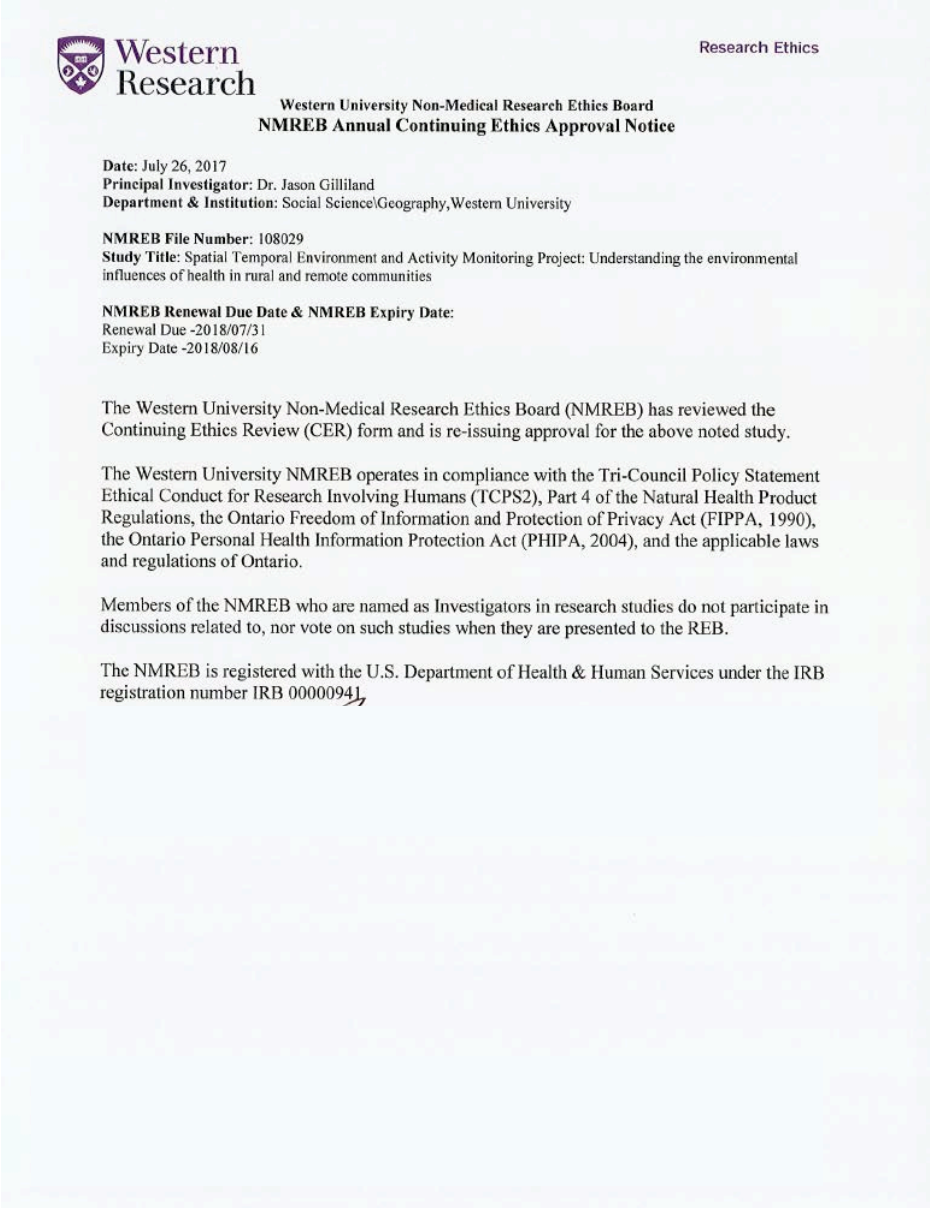
Spence, J. C., & Lee, R. E. (2003). Toward a comprehensive model of physical activity. *Psychology of Sport and Exercise*, *4*(1), 7–24. https://doi.org/10.1016/S1469-0292(02)00014-6

Wilson, K., Coen, S. E., Piaskoski, A., & Gilliland, J. A. (2019). Children's perspectives on neighbourhood barriers and enablers to active school travel: a participatory mapping study. *Canadian Geographer*, *63*(1), 112–128. https://doi.org/10.1111/cag.12488

Woods, A. M., Graber, K. C., Daum, D. N., & Gentry, C. (2015). Young school children's recess physical activity: movement patterns and preferences. *Journal of Teaching in Physical Education*, 496–516.

Appendices

Appendix A: Ethics Approval



Western Research

Research Ethics

Western University Non-Medical Research Ethics Board
NMREB Annual Continuing Ethics Approval Notice

Date: July 26, 2017
Principal Investigator: Dr. Jason Gilliland
Department & Institution: Social Science\Geography,Western University

NMREB File Number: 108029
Study Title: Spatial Temporal Environment and Activity Monitoring Project: Understanding the environmental influences of health in rural and remote communities

NMREB Renewal Due Date & NMREB Expiry Date:
Renewal Due -2018/07/31
Expiry Date -2018/08/16

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed the Continuing Ethics Review (CER) form and is re-issuing approval for the above noted study.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), Part 4 of the Natural Health Product Regulations, the Ontario Freedom of Information and Protection of Privacy Act (FIPPA, 1990), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 0000094[illegible]

Appendix B: Relevant STEAM documents

Parent letter of information

Examining the Influence of the Neighbourhood Environment on Children's Health and Well-Being

Principal Investigator: Dr. Jason Gilliland, Dept. of Geography, University of Western Ontario

Dear parent or guardian,

We would like to invite you and your child to participate in a study aimed at understanding how the neighbourhood environment around your child's school affects his or her health. The study is being conducted with grade 4 to 8 classes at various elementary schools across North Western Ontario.

What is being studied?

Our research team is conducting a project which will study the various places or facilities in your neighbourhood that your child uses (or intentionally don't use) on a regular basis for recreational or physical activity, including how they typically travel to these places – for example, how they travel to and from school each day. We are also interested in examining their dietary patterns, in particular, the locations in the neighbourhood at which they typically eat or purchase food. In addition, we'd like to learn more about how children perceive and feel about their local environments, and how this may influence their neighbourhood activities or travel.

What will happen in this study?

If you and your child agree to participate, **your child will be asked to:**

1. Complete the *Healthy Neighbourhoods Survey for Youth* (typically takes 30 minutes to write) about their perception and use of their neighbourhood environment and its facilities for activities and/or food consumption. Surveys will be filled out by all participating students in their classroom at a time made available by their teacher. Members of the research team will be on hand to help children fill out their surveys and to answer questions. All children will be given as much time as needed to complete the survey.

2. Wear two small pieces of equipment - a lightweight GPS logger and a loonie-sized accelerometer – each day during their waking hours for two 7 day periods – once in the Fall (September or October) of this and again in the winter (November or December) of the same year. The GPS logger, worn on an armband or collapsible neck lanyard, only maps the general places the child visited in the neighbourhood and the routes taken to get there - it has no display or orienteering capabilities and the data cannot be seen in 'real time'. The tiny accelerometer, worn on an unobtrusive elastic belt around his or her waist (can be worn underneath clothes), is similar to a pedometer but instead measures intensity of activity (e.g. running is registered as a more intense activity than walking or sitting). These tools will help us to understand children's travel and activity patterns within their neighbourhoods. By having children participate for 2 periods approximately 2 months apart we can also better understand how children's behaviours and activities change with the weather. Researchers will be coming into the schools on a daily basis during school hours to make sure the equipment is functioning and study procedures are being followed .

3. Complete a short activity diary for each day they wear the 2 pieces of equipment, briefly outlining their activities that day.

4. Participating children will also be given the opportunity to meet with the researchers in a focus group to discuss their feelings about their neighbourhood and to help clarify how the built environment of the neighbourhood helps or hinders their ability to engage in various recreational activities, to eat healthy foods, or to travel easily to the places they would like, such as parks. The focus group will typically involve 4-6 youth, will take place either at lunch recess or outside of school time, last about 30-60 minutes, and will be held at the school or another community facility. Participation in the focus group is completely voluntary; a child can decide not to participate in a focus group and still be allowed to participate in the rest of the study. All focus groups are audio-recorded and transcribed verbatim, as it is not possible to audio-record some participants and not others. Therefore, if you do not wish your child to be audio-recorded they will not be able to participate in the focus groups. We as researchers cannot guarantee what is said in the focus group won't be shared by classmates, but we always remind all students not to share what they have heard.

5. Children are welcome to participate in any of the 4 stages of the study. We only ask that if they did not participate in the survey AND the GPS/accelerometer/activity diary portions they do not participate in the focus groups, as we would like to link the findings.

As the child's parent/guardian, **you will be asked to:**

1. Complete the *Healthy Neighbourhoods Survey for Parents* (takes 20-25 minutes to write) about household demographics as well as parent/guardian perceptions about your neighbourhood. The survey will be used to understand the various types of households participating within each school neighbourhood, as well as local parents' perceptions of the neighbourhood and their child's use of this environment. The Parent Survey is completely voluntary and doesn't disqualify your child from participating in the study themselves, but provides us with valuable information from parents' perspectives. We would greatly appreciate your participation.

2. Parents of participating children will also be given the opportunity to participate in a parents' focus group with the same aims as those with the children. The focus group will take place outside of school time, last approximately 45-60 minutes, and will be held at the school or another nearby community facility. Participation in the focus group is completely voluntary; a parent can decide not to participate in a focus group and their child will still be eligible to participate in the study as outlined above. All focus groups are audio-recorded and transcribed verbatim, as it is not possible to audio-record some participants and not others. Therefore, if you do not wish to be audio-recorded you will not be able to participate in the focus groups. We as researchers cannot guarantee what is said in the focus group won't be shared by other parents but we always remind all participants not to share what they have heard.

Do we have to participate in this study?

Your participation in this study is completely voluntary. You and your child are under no obligation to participate, you can refuse to answer any questions, and can choose to withdraw from the study at any time. Your decision will not affect your child's academic standing in any way.

What are the benefits and risks if my child participates?

Recent research has shown that our health is not only related to our personal lifestyle, such as the food we eat or physical activity we undertake, but also to the characteristics of the neighbourhood(s) within which we conduct our daily activities. Reviewing the information collected from this study will help us to better understand the links between our neighbourhood environments, our activities, and our health. The study results may be useful for local municipal and school board planners and decision makers who require input on how best to plan design healthy communities.

There are no costs to you or your child for participating in this study. However, each participant will earn $2/day for each day they are enrolled in the study and $3 for returning the equipment in each season. If children do not wear the GPS or return the diary for any given day, the $2 will be withheld until the following day when they are able produce their GPS and diary.

The equipment in this study is easy to use, and the research team will spend time with your child to make sure he or she understands how to use and care for the equipment. However, if any pieces of equipment break or become lost during the time they are in their possession, we will immediately provide them with a replacement unit without any cost or consequence to you or your child.

There may be risks to your child if he/she participates in this study; fatigue or disinterest on the part of the child in continuing with the study for the full 7 days are considered the largest risks. However, each piece of equipment weighs less than 60g (0.12 pounds). The height and weight of each participating child will also need to be collected, strictly to properly set up the accelerometer. Measurements will be taken in a private area at the child's school in the presence of a trusted adult (e.g. school nurse or teacher); no other children or persons outside of the research team will be present. The equipment used to measure a child's weight has no visible display; measurements are sent wirelessly to a nearby laptop and therefore will not be visible to anyone except research team members.

There is no risk that you or your child will be identified or identifiable in any study materials or publications. All of the information collected in this study will remain strictly confidential. Anonymity will be assured by assigning you and your child a unique identification code so that names or personal information will not appear on any survey or data file. Also, completed surveys, focus group transcripts (audio and written), and any detailed maps created from the GPS data, will only be viewed by members of the research team and will be stored in a locked filing cabinet or on a password protected computer in a secure room at the University of Western Ontario. Teachers and other students do not have access to ANY of this information and it is only made available to the participant themselves and the research team. Focus group members are asked to keep everything they hear confidential and not to discuss it outside of the meeting. However, we cannot guarantee that confidentiality will be maintained by group members. Participating children will be able to review maps of their individual travel patterns on request for authentication purposes and to modify any information that they feel does not accurately reflect their experience. However, to ensure participation while protecting the privacy of each child, data or maps made from GPS units will not be made available to parents or guardians. We will inform the participants that the GPS unit is equipped with an "on/off" button and they can turn off the unit if ever there is an occasion where they wish not to be recorded. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law we have a duty to report.

If you or your child chooses to withdraw from the study at any time, up to 30 days after the completion of the project, any of your/their personal data collected to date will be immediately destroyed and excluded from the study analysis.

You do not waive any legal rights by signing this consent form

Who do I contact if I have any other questions?
Should you have any questions or concerns about participating in this project, you can contact the lead researcher
email Information Withheld

Representatives of The University of Western Ontario's Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. If you have any further questions regarding your rights as a study participant, please contact the Office of Research Ethics

Research Team
Dr. Jason Gilliland, Department of Geography, University of Western Ontario
Dr. Piotr Wilk, Department of Epidemiology, University of Western Ontario
Brenton Button, Department of Geography, University of Western Ontario

This letter is for you to keep. Please return the attached Parent/Guardian consent form. You will also be given a copy of the consent form once it has been signed.

Western

HEAL
HUMAN ENVIRONMENTS ANALYSIS LABORATORY

Examining the Influence of the Neighbourhood Environment on Children's Health and Well-Being
Parent / Guardian Consent Form

Principal Investigator: Dr. Jason Gilliland, Dept. of Geography, University of Western Ontario

Regardless of whether you are consenting to let your child to participate in this study, we would ask that you return this form to school with your child, sealed in the envelope provided. Envelopes will be collected by your child's teacher. Thank you!

A. Parent Involvement

Consent: I, _____ ***(name of parent/guardian- please print)***, have read this letter and have been given the opportunity to ask questions. Any questions have been answered to my satisfaction.

☐ I agree to participate by completing the *Healthy Neighbourhoods Survey for Parents* (***optional****; if yes, please seal the survey in the envelope provided and return with signed consent form*)

☐ I am interested in being contacted about participating in a parent focus group (***optional***). Please provide either phone or email contact information _____

B. Child Involvement:

☐ I agree to let my child _____ ***(child participant's name – please print)*** participate in the full 14 days (two 7-day periods within the next 2-3 months) of monitoring as outlined above.

OR

☐ I agree to let my child _____ ***(child participant's name – please print)*** participate **ONLY** by way of completing the *Healthy Neighbourhoods Survey for Youth* (to be administered at child's school) rather than the full study.

C. If you are providing consent for your child to participate in this study, please answer the following questions:

☐ I agree to allow my child to participate in an optional focus group at the end of the study.

☐ I am aware that unidentified direct quotes from the focus groups could be used in future publications.

☐ Please check if your child has *health issues* which restrict their ability to walk/exercise or otherwise participate in this study.

_____ _____ _____
Parent/Guardian Print Name Parent / Guardian's signature Date

Child Letter of Information

How healthy is the Environment in Your Neighbourhood?

Letter of Assent- Student

Principal Investigator:
Dr. Jason Gilliland, Department of Geography, University of Western Ontario

Hello! We are researchers from the University of Western Ontario and we are doing a study in your neighbourhood! We need students in Grades 4-8, like you, to help us with this project!

What are we going to study?

We all know that getting lots of exercise and eating the right foods can help keep us healthy. We'd like to know if the places or facilities that you have and use in your neighbourhood also help to keep you healthy. You will not be tested! We want to collect this information so we can share our results with you and others who can help make your environments healthier.

What would you have to do?

If you agree to be in the study there are 4 things we would like you to do:

1. Wear 2 small pieces of equipment every day for a week this Fall, and again in the Winter. A small GPS unit will help us to make a map of all the places you visit every day. You would also wear a 'loonie'-sized piece of equipment called an accelerometer on an elastic band around your waist that will tell us when you are doing physical activity, like running or playing sports. Both pieces of equipment are very light and easy to use. We will also come to your school every day in case you need help.
2. Fill out a short 1-page diary everyday about the activities you did that day during both sessions.
3. Fill out a short survey on what you think about your neighbourhood. You will fill this out one day at school with your classmates both during the Fall and Winter sessions. It takes about 30-45 minutes.
4. Then you would wear the equipment and fill out the diary again for a week later this Winter.

To work some of the equipment we'll need to measure your height and weight. We'll do this in a private area at your school. Your teacher can be in the room. We won't share the information with anyone else.

After both weeks are done, you could also join in a group discussion with some of your classmates to talk to us about where you like to go in your neighbourhood and the activities you like to do. You do not have to join in this group activity. This will take place at your school. We would like to audio record our talk. All focus groups are audio-recorded and transcribed word for word, as it is not possible to audio-record some participants and not others.

Therefore, if you do not wish to be audio-recorded you will not be able to participate in the focus groups. We as researchers cannot guarantee what is said in the focus group won't be shared by your classmates, but we always remind all students not to share what they have heard.

Do you have to join this project?

No – you will only join if you would like to. You can also decide at any time that you would like to stop. We will never share your information with anyone else, even your parents, but you can ask to see it at any time. You can ALWAYS talk to your teacher or the researchers if you have any questions or worries. We only ask that if you did not participate in the survey AND the GPS/accelerometer/activity diary portions of the study that you do not participate in the focus groups.

This letter is yours to keep for future reference.

I want to participate in this study!

If you would like to join this study in some way, choose one of the following two options:

☐ I want to participate in the full 2 week study **OR** ☐ I only want to complete the in-class survey

AND please choose whether or not you would like to participate in a focus group:

☐ Yes, I would like to participate in the audio-recorded focus groups OR
☐ No I do not want to participate in the audio-recorded focus groups

If you answered YES to participating in the focus groups:

☐ Please check this box if you are aware that anonymous direct quotes from the focus groups could be used in future books or published papers.

_____
Print First and Last Name

_____	_____	_____
Signature	Age	Date

_____	_____
Signature of Person Obtaining Assent	Date

STEAM Child Survey – Relevant Sections

HEAL
HUMAN ENVIRONMENTS ANALYSIS LABORATORY

STEAM study – Registration Form

Section A: General Information

1. I am ☐ girl ☐ boy ☐ other
2. When is your birthday (Day/Month/Year)? _____

3. What grade are you currently in? _____
4. I live at my main home with…

☐ one parent
☐ two parents
☐ other : _____

5. I live in…

☐ one home (sleep all nights in the same home)
☐ more than one home (please describe): _____

6. How many days a week do you live at your main home?

1 2 3 4 5 6 7

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

☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 or more

8. How many children (including yourself) live in your main home?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

9. Do you have a dog? ☐ Yes ☐ No
   a. If yes, on how many days last week did **YOU** walk your dog?

0 1 2 3 4 5 or more days

10. I live in a…

☐ single house (not attached to any others)

☐ semi-detached house (a house attached to just ONE other house)

11. Have you and your family moved homes within the last 2 years? ☐
Yes ☐ No

What is your primary race / ethnic background (check ONE or TWO)?

☐ Middle Eastern (e.g., Egypt, Iran, Lebanon)

☐ Latin American

☐ North American Indian, Metis or Inuit

☐ Black/African/Caribbean

12. Do you have asthma or regularly have breathing problems?

☐ Yes ☐ No

a. If yes, do you use an inhaler (puffer)? ☐ Yes ☐ No

J : Barriers to <u>activity</u> in your neighbourhood parks/playgrounds

Please tell us whether this stops you from going to a park/playground in your neighbourhood.	No	Sometimes No	Sometimes Yes	Yes
1. It is too far from my house or takes too much time to get there	☐	☐	☐	☐
2. There is no or not enough equipment or activities I like	☐	☐	☐	☐
3. There is not enough room from the activities I like to do	☐	☐	☐	☐

Please tell us whether this stops you from going to a park/playground in your neighbourhood.	No	Sometimes No	Sometimes Yes	Yes
4. There are no other kids to play with there	☐	☐	☐	☐
5. There are no adults there to supervise	☐	☐	☐	☐
6. It feels unsafe there because of crime (ex: strangers, gangs, drugs)	☐	☐	☐	☐
7. I get bullied or teased when I go there	☐	☐	☐	☐
8. I have nobody to go there with	☐	☐	☐	☐
9. There are too many people there / feels too crowded	☐	☐	☐	☐
10. There is too much garbage or graffiti	☐	☐	☐	☐
11. Other reason? _____ _____	☐	☐	☐	☐

K : Streets in my neighbourhood

	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
1. There are enough sidewalks on the street in my neighbourhood.	☐	☐	☐	☐
2. There are walking trails in or near my neighbourhood that are easy to get to.	☐	☐	☐	☐
3. There are bicycle lanes or trails in or near my neighbourhood that are easy to get to.	☐	☐	☐	☐

4. There are lots of trees along the streets in my neighbourhood.	☐	☐	☐	☐
5. I know a lot of people in my neighbourhood.	☐	☐	☐	☐

L : Safety in my neighbourhood

	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
1. There is so much traffic along the streets near my home that it is difficult or unpleasant to walk.	☐	☐	☐	☐
2. There is so much traffic along the streets near my home that it is difficult to ride my bike or play on the street.	☐	☐	☐	☐
3. Most drivers go too fast while driving in our neighbourhood.	☐	☐	☐	☐
4. There is a lot of crime in my neighbourhood.	☐	☐	☐	☐
5. It feels unsafe to walk by myself around my neighbourhood during the day.	☐	☐	☐	☐
6. It feels unsafe to walk with friends or siblings around my neighbourhood during the day.	☐	☐	☐	☐
7. I am worried about being or walking by myself in my neighbourhood and local streets because I am afraid of being taken or hurt by a stranger.	☐	☐	☐	☐
8. My parents or guardians are afraid that I will be taken or hurt by a stranger if I am out walking alone in my neighbourhood.	☐	☐	☐	☐

M : My Quality of Life

About my health and activities…

In the past month…	Never	Rarely	Sometimes	Frequently	Always
9. It has been hard for me to walk more than one block	☐	☐	☐	☐	☐
10. It has been hard for me to run	☐	☐	☐	☐	☐
11. It has been hard for me to do sports activity or exercise	☐	☐	☐	☐	☐
12. It has been hard for me to lift something heavy	☐	☐	☐	☐	☐
13. It is hard for me to take a bath or shower by myself	☐	☐	☐	☐	☐
14. It is hard for me to do chores around the house	☐	☐	☐	☐	☐
15. I have hurt or ached	☐	☐	☐	☐	☐
16. I have had low energy	☐	☐	☐	☐	☐

About my feelings….

In the past month…	Never	Rarely	Sometimes	Frequently	Always
1. I have felt afraid or scared	☐	☐	☐	☐	☐

2. I have felt sad or blue	☐	☐	☐	☐	☐
3. I have felt angry	☐	☐	☐	☐	☐
4. I have had trouble sleeping	☐	☐	☐	☐	☐
5. I have worried about what will happen to me	☐	☐	☐	☐	☐

How I get along with others….

In the past month…	Never	Rarely	Sometimes	Frequently	Always
1. I have had trouble getting along with other kids	☐	☐	☐	☐	☐
2. Other kids have not wanted to be my friend	☐	☐	☐	☐	☐
3. Other kids have teased me	☐	☐	☐	☐	☐
4. I cannot do things that other kids my age can do	☐	☐	☐	☐	☐
5. It has been hard to keep up when I play with other kids	☐	☐	☐	☐	☐

About school…

In the past month…	Never	Rarely	Sometimes	Frequently	Always
1. It has been hard to pay attention in class	☐	☐	☐	☐	☐
2. I forget things	☐	☐	☐	☐	☐
3. I have had trouble keeping up with my schoolwork	☐	☐	☐	☐	☐
4. I have missed school because of not feeling well	☐	☐	☐	☐	☐
5. I have missed school to go to the doctor or hospital	☐	☐	☐	☐	☐

STEAM Parent Survey – Relevant Questions

Healthy Neighbourhoods Survey for Parents

We need your help to make our study a success. Your honest answers to the items in this survey are very important to us. This will not take too long to complete. If you have more than one child bringing home a survey – we would appreciate you filling out a survey for each child since many answers will be specific to each child.

A. General Information

What is today's date? _____ month _____ day _____ year

1. My child is ☐ Female ☐ Male ☐ Other
2. My child's current age is _____ years old.
3. What is your relationship to the child (taking part in the study)?

   ☐ Mother ☐ Father ☐ Primary caregiver/Guardian ☐ Other _____

4. My child lives primarily in a:

   ☐ Single-parent household ☐ Two-parent household ☐ Other _____

5. My child:

   ☐ lives in a single household
   ☐ splits their time equally between 2 households
   ☐ lives in one household by regularly visits/lives in a second household
   ☐ has another household arrangement

6. Have you and your family moved homes within the last 2 years? ☐ Yes ☐ No
7. How many motor vehicles in working order (cars, vans, trucks, and motorcycles) are there at your household?

   ☐ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

8. Please **check and circle** the highest level of education the **child's mother** has completed.

   ☐ Grade: 1 2 3 4 5 6 7 8 9 10 11 12 13
   ☐ College/University
   ☐ Graduate School
   ☐ N/A

9. Please **check and circle** the highest level of education the **child's father** has completed.

- ☐ Grade: 1 2 3 4 5 6 7 8 9 10 11 12 13
- ☐ College/University
- ☐ Graduate School
- ☐ N/A'

10. Which of the following best describes the current work status of the **child's mother**?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ At home with children
- ☐ Unemployed
- ☐ Student
- ☐ other _____
- ☐ I prefer not to answer
- ☐ not applicable

11. Which of the following best describes the current work status of the **child's father**?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ At home with children
- ☐ Unemployed
- ☐ Student
- ☐ other _____
- ☐ I prefer not to answer
- ☐ not applicable

12. Which of the following best describes the current work status of the **child's primary caregiver/guardian if different than above**?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ At home with children
- ☐ Unemployed
- ☐ Student
- ☐ other _____
- ☐ I prefer not to answer
- ☐ not applicable

13. Please indicate the total income from all sources that you and other members of your household received in the last year (Jan-Dec) before taxes. The total income from all sources was:

- ☐ Less than $20,000
- ☐ $20,000 - $29,999
- ☐ $30,000 - $39,999
- ☐ $40,000 - $49,999
- ☐ $50,000 - $59,999
- ☐ $60,000 - $69,999
- ☐ $70,000 - $79,999
- ☐ $80,000 - $89,999
- ☐ $90,000 - $99,999
- ☐ $100,000 - $109,999
- ☐ $110,000 - $119,999
- ☐ $120,000 - $129,999
- ☐ $130,000 - $139,999
- ☐ $140,000 - $149,999
- ☐ $150,000 or more
- ☐ I don't know
- ☐ I prefer not to answer

14. What is your child's primary race / ethnic background (choose 1 or 2)?

- ☐ White/Caucasian
- ☐ South Asian (e.g. East Indian, Pakistani, Sri Lankan)
- ☐ East Asian (e.g., China, Japan, Korea)
- ☐ Middle Eastern (e.g., Egypt, Iran, Lebanon)
- ☐ Latin American
- ☐ North American Indian, Metis or Inuit
- ☐ Black/African/Caribbean

15. Does your child have any medical or physical limitation which prevents them from engaging in physical activity?

☐ Yes ☐ No

16. Does your child have asthma or regularly have breathing problems?

☐ Yes ☐ No

a. If so, do they use an inhaler? ☐ Yes ☐ No

J. Barriers to activity in parks/playgrounds

Please tell us whether you agree or disagree with the following by checking the answer that best applies.

It is difficult/unpleasant for my child to play or do activities at the parks and playgrounds in our neighbourhood because…	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
1. It is too far from our house or takes too much time to get there	☐	☐	☐	☐
2. There is no or not enough equipment or activities they like	☐	☐	☐	☐
3. There is not enough room for the activities they like to do	☐	☐	☐	☐
4. There are no other kids to play with there	☐	☐	☐	☐
5. There are no adults there to supervise	☐	☐	☐	☐
6. It feels unsafe there due to crime (e.g. strangers, gangs, drugs)	☐	☐	☐	☐
7. They get bullied or teased when they go	☐	☐	☐	☐
8. They have no one to go there with	☐	☐	☐	☐
9. There are too many people there or it is too crowded	☐	☐	☐	☐
10. There is too much garbage or graffiti	☐	☐	☐	☐
11. It does not have good lighting at night	☐	☐	☐	☐
12. Other reason: _____	☐	☐	☐	☐

K. Streets in our neighbourhood

Please check the answer that best applies to your child and neighbourhood	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
1. There are enough sidewalks on the streets in our neighbourhood	☐	☐	☐	☐
2. There are walking trails in or near our neighbourhood that are easy to get to	☐	☐	☐	☐
3. There are bicycle lanes or trails in or near our neighbourhood that are easy to get to	☐	☐	☐	☐

Please circle the answer that best applies to your child and neighbourhood	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
4. There are lots of trees along the streets in our neighbourhood	☐	☐	☐	☐
5. We know a lot of people in our neighbourhood	☐	☐	☐	☐

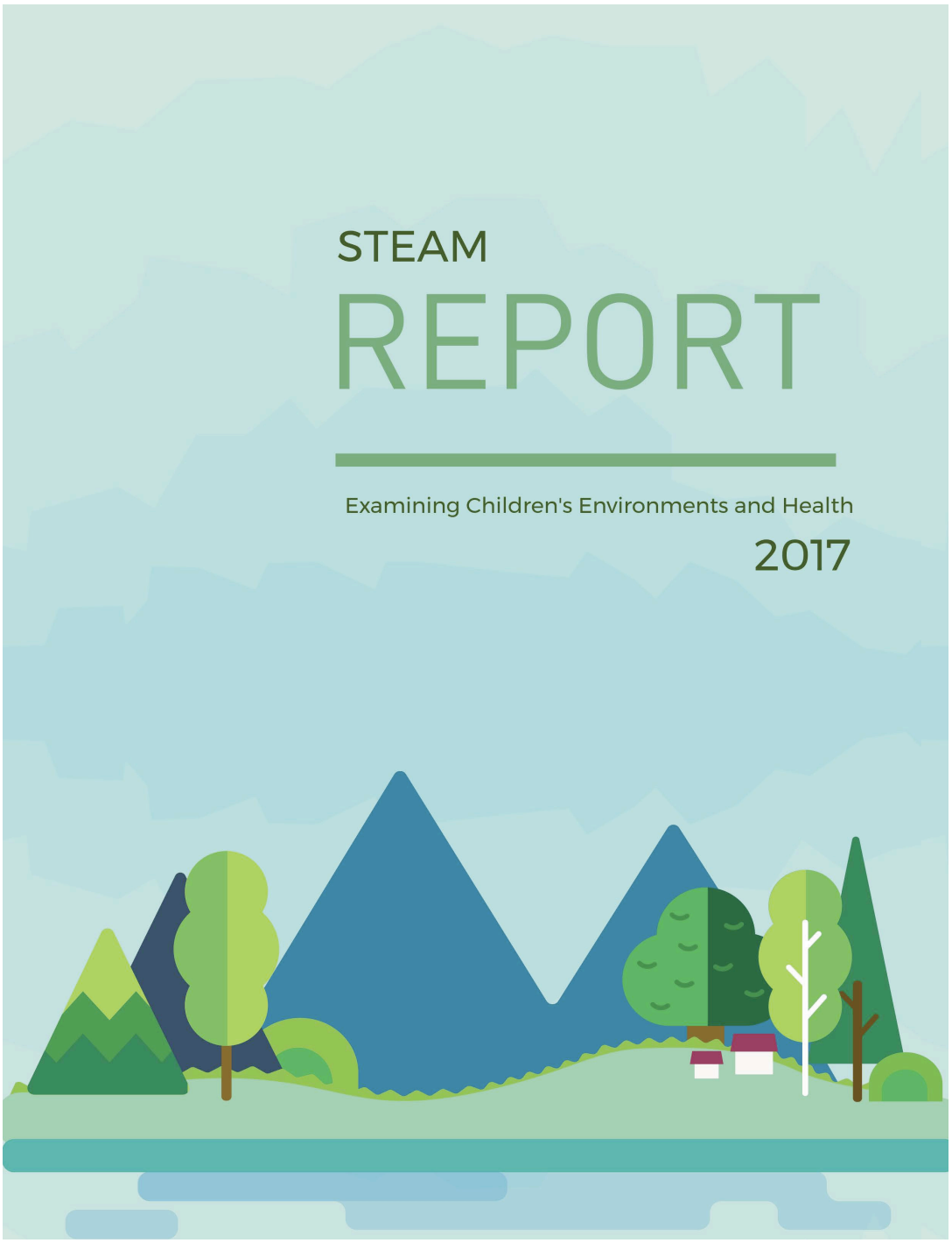
L. Neighbourhood Safety

Please check the answer that best applies to you, your child, and your neighbourhood:

	I strongly disagree	I disagree a little bit	I agree a little bit	I strongly agree
1. There is so much traffic along the street we live on that it makes it difficult or unpleasant for my child to walk.	☐	☐	☐	☐
2. There is so much traffic along other streets near our home that it makes it difficult or unpleasant for my child to ride their bike or play on the streets in our neighbourhood.	☐	☐	☐	☐
3. Most drivers go too fast while driving in our neighbourhood.	☐	☐	☐	☐
4. There is a lot of crime in our neighbourhood.	☐	☐	☐	☐
5. If feels unsafe to let my child walk alone around our neighbourhood during the day.	☐	☐	☐	☐
6. It feels unsafe to let my child walk around with friends or siblings in our neighbourhood during the day.	☐	☐	☐	☐
7. I am worried about my child being or walking alone in my neighbourhood and local streets because I am afraid of him/her being taken or hurt by a stranger.	☐	☐	☐	☐

You're finished! Thank you for all your help!!

Appendix C: Knowledge Translation



Available at: http://theheal.ca/projects/previous-projects/

Curriculum Vitae

Name: Brenton Button

Post-secondary Education and Degrees:

Lakehead University
Thunder Bay, Ontario, CA
2006-2010 H.B.K.

Lakehead University
Thunder Bay, Ontario, CA
2010-2011 B.Ed.

Queen's University
Kingston Ontario, CA
2011-2013 M.Sc.

The University of Western Ontario
London Ontario, CA
2015-2020 Ph.D.

Related Work Experience:

Teaching Assistant
Queen's University & The University of Western Ontario
2011-2013 & 2015-2020

Publications:

Taylor, L., Clark, A., Wilk, P., Button, B., & Gilliland, J. 2018. Exploring the effect of perceptions on children's physical activity in varying geographic contexts: using a structural equation modelling approach to examine a cross-sectional dataset. *Children* 5(12):159.

Tillmann, S., Button, B., Coen, S., and Gilliland, J. 2018. 'Nature makes people happy, that's what it sort of means:' children's definitions and perceptions of nature in rural Northwestern Ontario. *Children's Geographies* 0(0):1–14.

Button B. & Janssen, I. 2014. Interaction between school built environments and physical activity policies and programs on student physical activity. *Journal of Child & Adolescent Behavior* 2(4):2–7.

Button, B., Trites, S. & Janssen I. . 2013. Relations between the school physical environment and school social capital with student physical activity levels." *BMC Public Health* 13:1191.