HEALTH PROMOTION AND CHILDHOOD OBESITY AMONG INDIGENOUS CHILDREN

HEALTH PROMOTION AND CHILDHOOD OBESITY AMONG INDIGENOUS CHILDREN: UNDERSTANDING COMMUNITY PRIORITIES, PREVENTION PROGRAMS AND PROTECTIVE FACTORS

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Lay Abstract

Childhood overweight and obesity has become more common in the last 40 years. Evidence suggests that the risk of developing non-communicable chronic diseases, including obesity, starts with early-life exposures. There are populations that have a higher burden of childhood obesity, in Canada this includes Indigenous peoples.

The higher burden of obesity is rooted in the social determinants of health. For Indigenous peoples in Canada the social determinants of health include historical and present-day factors including colonialism and racism that have ongoing impacts on health outcomes.

The work in this thesis includes three studies. The first study is a qualitative descriptive study in partnership with two First Nations communities in Canada. The objective of the study was to support two Indigenous communities in identifying priorities and strategies for promoting healthy nutrition and physical activity for young children. The second study is a systematic review which describes the effectiveness of programs aimed at obesity prevention and/or the promotion of healthy lifestyle behaviours for Indigenous children. The last study examines how factors including social disadvantage, maternal education, maternal diet, and traditional birth practices are associated with infant diet at age 1-year. The final chapter describes the implications of the findings.

Abstract

The global prevalence of childhood overweight and obesity has more than quadrupled in the last 40 years. Emerging evidence suggests that the propensity to develop non-communicable chronic diseases, including obesity, is rooted in early-life exposures. There are populations that have a more significant burden of childhood obesity and related complications, in Canada this includes Indigenous peoples.

The higher burden of obesity and non-communicable chronic diseases is explicitly rooted in the social determinants of health, and any discussion of the determinants of health for Indigenous peoples in Canada should be inclusive of historical and present-day contextual factors that have ongoing impacts on health outcomes including colonialism, racism, and self-determination.

With a guiding framework of community-based participatory research this thesis consists of two published manuscripts and one manuscript prepared for submission. The work is woven together by the theme of understanding community priorities, effectiveness of programs, and determinants for obesity prevention strategies among Indigenous children. The first study is a qualitative descriptive study in partnership with two First Nations communities in Canada. The objective of the study was to support two Indigenous communities in identifying priorities and strategies for promoting healthy nutrition and physical activity for young children. The second study is a systematic review which sought to describe the effectiveness of programs aimed at obesity prevention and/or the promotion of healthy lifestyle behaviours for Indigenous children. The last study examines how factors including social disadvantage, maternal education, maternal diet, and traditional birth practices are associated with infant diet at age 1-year. The final chapter describes the implications of the findings.

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I had an extraordinary supervisory committee, led by my supervisor, Dr. Sonia Anand. Dr. Anand's dedication to my personal growth as a researcher and writer has forever changed the trajectory of my career. She has provided invaluable mentorship, sponsorship, and friendship – which I can only hope to pay forward in the future. Drs. Susan Jack and Russell de Souza were incredible committee members, and I am thankful for their guidance and expertise, and for most of all believing that I had more to give, even when I doubted it myself.

I am grateful to friends and colleagues in the Department of Pediatrics, who provided me time and space to finish this work. I am thankful for my family and their ongoing support as I finished yet another degree. And finally, this thesis is dedicated to my children, Uma, Arya, and Shaan, and my husband, Hamit, who have been my guiding light with their unwavering love and support.

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List of all Abbreviations

ABC	An Indigenous Birth Cohort
ACEs	Adverse childhood experiences
BMI	Body mass index
CBPR	Community-based participatory research
CI	Confidence interval
EPHPP	Effective Public Health Practice Project Quality Assessment tool
FFQ	Food frequency questionnaire
GDM	Gestational diabetes mellitus
HF	Healthy foods
iDS	Infant diet score
LHF	Less healthy foods
NCDs	Non-communicable disease
OCAP®	Ownership, Control, Access, and Possession
OR	Odds ratio
RCT	Randomized controlled trials
SDoH	Social determinants of health
SSB	Sugar-sweetened beverage
SDI	Social disadvantage index
SEM	Socio-ecological model
TRC	Truth and Reconciliation Commission of Canada
WHO	World Health Organization

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Declaration of Academic Achievement

This thesis is a "sandwich thesis" which consists of three individual projects, two manuscripts have been published in peer-reviewed journals and one is prepared for publication.

The student (Gita Wahi) is the first author on all three manuscripts and is responsible for the development of the research questions, research design, data collection, data analysis and interpretation of the findings and writing of the manuscripts and this dissertation.

The following details the contributions in all of the chapters:

Chapter One: Unpublished work. Gita Wahi is the sole author.

Chapter Two: Published in *Current Developments in Nutrition*. Gita Wahi is the first author. Gita Wahi, Julie Wilson, Joel Gittelsohn, Sonia Anand designed the research project; Gita Wahi and all of the listed authors conducted research; Gita Wahi, Julie Wilson, Sujane Kandasamy, Susan Jack, Cindy Martin, Sonia Anand analyzed data; and Gita Wahi, Julie Wilson, Susan Jack, Sonia Anand contributed to writing the paper. Gita Wahi had primary responsibility for final content. All authors read and approved the final manuscript.

Chapter Three: Published in *Preventative Medicine Reports.* Gita Wahi is the first author. Gita Wahi, Russell de Souza and Sonia Anand designed the research project; Gita Wahi, Russell de Souuza Katrina Hartmann, and Lucia Giglia conducted research; Gita Wahi with all of the listed authors analyzed data. Gita Wahi wrote the paper and had primary responsibility for final content. All authors read and approved the final manuscript.

Chapter Four: Unpublished work. Gita Wahi is the first author; Gita Wahi and all listed authors from Six Nations Birthing Centre contributed to developing the study question and interpreting the data; Gita Wahi conducted the data analysis, wrote the paper, and had primary responsibility for the final content.

Chapter Five: Unpublished work. Gita Wahi is the sole author.

Chapter 1

Introduction

The developmental origins of diseases hypothesis suggests that early life factors can modify the emergence of disease into adulthood.[1] The propensity to develop highly prevalent non-communicable chronic diseases, including obesity, may be rooted in preconception, prenatal and early-life exposures.[2] Particular ethno-cultural populations including Indigenous peoples in Canada have experienced a more significant burden of non-communicable chronic diseases when compared to white Canadians .[3] There are over 1.6 million Indigenous peoples living in Canada, with a birth rate 1.5 times higher than the general population.[4]

Researchers including myself, Dr. Sonia Anand and Dr. Russell de Souza have worked with the Six Nations of the Grand River Health Services leadership teams focused on collaborative research efforts that have centered around obesity, nutrition, and cardiovascular disease prevention.[5-8] During a community meeting in 2011, the community members brought to attention and identified a rising health challenge - *childhood obesity*.[9] Collaborative research efforts have since focused on understanding cardiometabolic risk factors among mothers and children of the community with a longitudinal birth cohort study, originally the Aboriginal Birth Cohort (ABC) study,[8,10] now called "An Indigenous Birth Cohort."

Childhood obesity, as identified by community health leadership as a priority area, is the key health topic that drives all components of this thesis, which includes: a qualitative descriptive study to understand priorities and strategies for childhood obesity prevention

including healthy nutrition and physical activity of two Indigenous communities in Canada; a systematic review of programs aimed at obesity prevention among Indigenous children in Canada, USA, Australia, and/or New Zealand; and lastly, an analysis of contextual factors associated with Indigenous infant diets using data from the ABC study.

Note on terminology

We use the term Indigenous peoples to represent First Nation, Métis, and Inuit peoples in Canada.[11] Until recently, 'Aboriginal' was a term more widely used in Canada that collectively refers to First Nations, Métis and Inuit people, it is a term found in the Canadian constitution Indian act.[12] We use peoples instead of people to recognize the richness, heterogeneity, and vast diversity in culture, language and ways of living among these distinct groups of peoples.[11] We recognize that the term Indigenous is used internationally and may in some contexts represent other groups, for example in Australia and New Zealand.[11] However, there is no single definition of Indigenous. Criteria for consideration as described by the United Nations[13], as outlined by Gracey and King[14] include:

- *"Self-identification as Indigenous peoples by individuals and acceptance as such by their community*
- *Historical continuity and land occupation before invasion and colonisation*
- *Strong links to territories (land and water) and related natural resources*
- *Distinct social, economic, or political systems*
- *Distinct language, culture, religion, ceremonies, and beliefs*
- *Tendency to form non-dominant groups of society*
- *Resolution to maintain and reproduce ancestral environments and systems as distinct peoples and communities*
- *Tendency to manage their own affairs separate from centralised state authorities"*

Further, definitions and considerations to note as summarized in the University of British Columbia's resource - Indigenous Peoples: Language guidelines:[11]

First Nations: "*can be applied to individuals, but technically refers only to those who have Indian status under Canadian law as part of a recognized community."*

Métis: *"Métis are a specific Indigenous (and Aboriginal) group in Canada with a very specific social history. Until very recently, they have not been regarded as 'Indians' under Canadian law and are never considered 'First Nations.'"*

Inuit people are *"historically located in the Arctic and legally and culturally distinct from First Nations or legally-defined Indians and Métis."*

Important context

Parallel to the importance of terminology, is acknowledgement of the historical context of Indigenous peoples in Canada. The country now known as Canada was colonized by European settlers. The Indian Act of 1867 is a piece of federal legislation that defined and controlled the identification of an 'Indian', set up policies to appropriate lands, set governance structures, and assimilate Indigenous Peoples' to Eurocentric culture.[12] Although revised since 1867, significant components of the legislation continue to exist in present day policies.[12] The negative impacts of colonization on the health and wellbeing of Indigenous peoples in Canada continues in the present day.

Background

Key concepts contained within this thesis include: the epidemiology and consequences of childhood obesity in both the Canadian population and specifically among Indigenous children in Canada; an approach to obesity prevention that centres on the social determinants of health; and a description of community-based participatory research as a guiding framework.

Childhood obesity

Obesity is defined as "*abnormal or excessive fat accumulation that presents a risk to health."*[15] Since the 1980's there has been a steady rise in the prevalence of childhood obesity around the world.[16,17] The global prevalence of overweight and obese children aged 5 to 19 years increased from 4% to 18% between 1975 and 2016.[15] In Canada, the prevalence of childhood overweight and obesity rose from 15% in 1978 to 26% in 2004[18] and to over 30% in 2011.[19] The World Health Organization deems childhood obesity as one of the most serious public health issues of this century.[20] At the present rate of rise there will be 70 million overweight or obese infants and children by 2025.[21]

The 1.6 million Indigenous peoples of Canada carry a disproportionate burden of obesity-related disease including type 2 diabetes and cardiovascular disease compared to non-Indigenous Canadians.[3,22] Among Indigenous children in Canada, rates of overweight or obesity are alarming and continue to rise. Data from the Canadian Community Health Survey (CCHS) in 2004 showed that Indigenous children (aged 2 to 17 years) living off-reserve were 2.5 times more likely to be obese than non-Indigenous children.[23] Further, children (aged 6 to 18 years) of the Tsimshian Nation living on the remote Pacific coast of

British Columbia were found to have a prevalence of overweight/obesity of 19%/26% in 2005.[24] In Ontario, First Nation children of Sandy Lake have a prevalence of overweight of 27.7% in boys and 33.7% in girls.[25] Among Mohawk children of the Kahnawake communities aged 5 to 12 years, 30% of boys and 33% of girls are overweight or obese.[26] Finally, the St. Theresa Point First Nation community of Manitoba document that 64% of girls and 60% of boys aged 4 to 19 years are either overweight or obese.[27] Inequalities in the health of Indigenous peoples are a consequence of colonization which resulted in the loss of traditional lifestyles and significant challenges in adapting to the encroachment of the dominant society.[14] The transition from traditional lifestyle to a lifestyle characterized by an increase in processed, low-nutrient, energy-dense foods and low physical activity tracks with the increased prevalence of obesity and related complications in these populations.[28] It is important to understand this context when considering disparities in the burden of illness between populations.

The complications of childhood obesity are significant and include physical, metabolic, and mental health consequences including dysglycemia, dyslipidemia, hypertension, obstructive sleep apnea, and bullying, poor body image, and low self-esteem.[29-31] The health consequences of childhood obesity also significantly impacts health outcomes into adulthood.[32,33] Systematic reviews of observational studies confirm that childhood obesity can contribute to ongoing health concerns through adulthood including: obesity [odds ratio (OR) 5.21, 95% confidence interval (CI) 4.50 to 6.02][34], cardiovascular disease (OR 1.20; 95% CI 1.10–1.31)[35] and type 2 diabetes (OR 1.70; 95% CI 1.30–2.22).[35]

Current predictive models suggest that obesity will be a major contributing factor to a reduction in life expectancy of present day youth compared with previous generations.[36]

Prevention of childhood obesity & context

The etiology of obesity is complex and multifactorial, as are prevention strategies.[15] Approaches to prevent childhood obesity that exclusively take an individual-level approach and emphasize the sum of the individual balance of energy consumption (i.e., diet) and energy expenditure (i.e., physical activity), fail to acknowledge the intricate interplay of biology, psychology, socioeconomics and the built environment.[37] One approach that allows for a broader approach to understanding the factors that contribute to childhood obesity is the application of the socio-ecological model (SEM), which accounts for the interaction and interplay between various components in the environment.[38] Levels of influence within a SEM that have traditionally described specific health behaviours include: intrapersonal factors, interpersonal processes and primary groups, institutional factors, community factors, and public policy.[39] Willows *et al* describe an adaption of a socio-ecological framework to consider the context of Indigenous peoples and communities in Canada as it pertains to childhood obesity (Figure 1).[40] In this SEM framework an individual is embedded within a dynamic system that includes family and peers, community and socio-cultural environments, built environments, society and historical factors.[40]

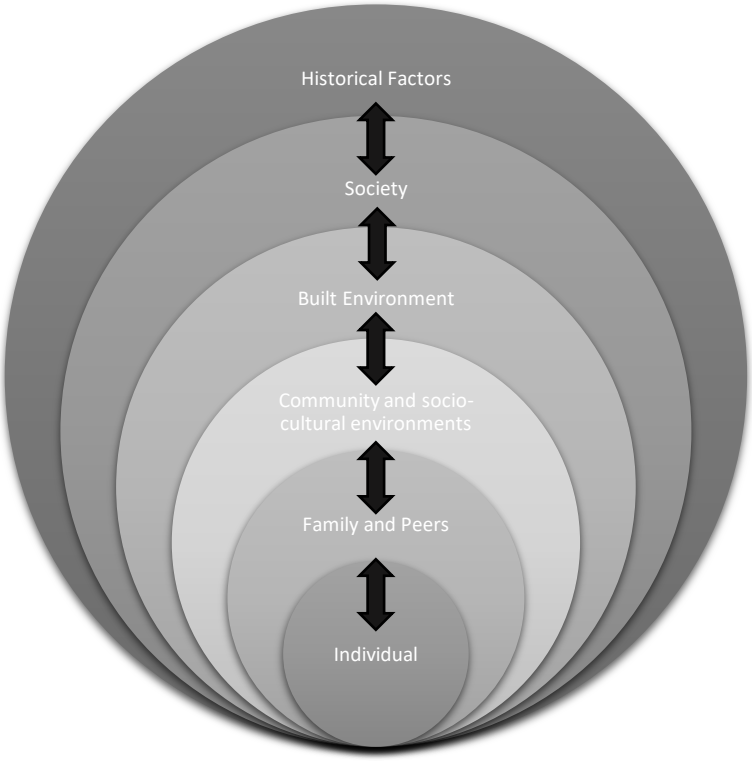

Figure 1: Socio-ecological approach to understanding childhood obesity prevention among Indigenous children as adapted from Willows *et al* [40]

Using the socio-ecological framework in health promotion helps ensure that important social determinants of health that impact underlying etiology and prevention strategies for obesity are addressed. The social determinants of health (SDoH) are "*conditions in which people are born, grow, live, work, and age*".[41] Social and economic factors work upstream to influence the health of a population.[42] When one considers that in 2017, 1 in 10 Canadian children lived below the poverty line,[43] it becomes apparent that the risks of childhood obesity are not shared evenly across the population. For example in a population-based study in Canada, children living in low-income neighbourhoods were more likely to be overweight/obese compared to children living in high-income

neighbourhoods (OR 1.29, 95% CI 1.14, 1.46).[44] In addition to broad considerations of the SDoH, any discussions of the determinants of health for Indigenous peoples in Canada should be inclusive of historical and present-day contextual factors that have ongoing impacts on health outcomes.[45] In the National Collaborating Centre for Aboriginal Health report "*Health inequalities and the social determinants of Aboriginal Peoples' health*", Wiens and Reading describe unique distal determinants of health: colonialism, racism, and self-determination; each with considerable consequences.[46] It must be noted that colonialism is not a historical event, but an ongoing process.[45] Colonialism has impacted Indigenous communities' relationships and connections with the land which has led to cultural and spiritual disconnection, but also to the loss of traditional ways of life including disruptions of traditional practices such as in hunting, fishing, and trapping.[46] Policies to propagate assimilation to the dominant European colonial culture led to degradation of culture and Indigenous ways of life. The most horrific of these policies resulted in genocide[47] at the hands of residential schools. As described in the Truth and Reconciliation Report:[47(pV)]

> "Residential schools were created for the purpose of separating Aboriginal children from their families, in order to minimize and weaken family ties and cultural linkages, and to indoctrinate children into a new culture—the culture of the legally dominant Euro-Christian Canadian society, led by Canada's first prime minister, Sir John A. Macdonald. The schools were in existence for well over 100 years, and many successive generations of children from the same communities and families endured the experience of them."

Children who were forcibly removed from their family and sent to a residential school endured a childhood devoid of family and traditional values, culture, and language. They lived in poor conditions and were subjected to neglect and abuse, and had minimal if any

education.[47] Through intergenerational trauma the impact of residential schools continues to be profound and propagates negative health consequences.[48]

Community based participatory research

Community-based participatory research (CBPR) is a "*partnership approach to research*"[49] and is the guiding framework for the work included in this thesis. Specifically, we worked with Six Nations' community members and health services leadership teams to collaboratively identify areas of focus for study and develop strategies for addressing areas of concern. "Action research" was initially described by Lewin in the 1940's[50]; and a robust body of literature exists describing components of participatory action research including principles of CBPR as described by Israel *et al.*[51] For academic-Indigenous partnerships, Laveaux and Christopher made additional suggestions derived from the literature as well as experiences working with Native American reservation communities in Montana, USA.[52] Key components include: "1. Acknowledge historical experience with research and with health issues and work to overcome the negative image of research. 2. Recognize tribal sovereignty. 3. Differentiate between tribal and community membership. 4. Understand tribal diversity and its implications. 5. Plan for extended timelines. 6. Recognize key gatekeepers. 7. Prepare for leadership turnover. 8. Interpret data within the cultural context. 9. Utilize Indigenous ways of knowing."[52(p7)] The World Health Organization (WHO) outlines similar considerations in the document: *Indigenous Peoples and Participatory Health Research*.[53] Castleden *et al*'s definition of CBPR lays the groundwork for the work we describe: "*community-driven research that is rooted in the*

coproduction of knowledge between academic and community partners for the purpose of social and institutional change."[54(p4)]

The following describes the contextual details and key partnerships for the work described in subsequent chapters:

Setting: The primary community setting of this work is Six Nations of the Grand River Reserve, located in Brant County, Ontario, Canada. It is approximately 30km from Hamilton, Ontario, Canada. Over 12,000 people live on reserve, with other Six Nations community members living in surrounding communities.

Key partnerships: Members of our research team have worked with Health Services leadership of Six Nations of the Grand River since 1998.[3,6] Tsi Non:we Ionnakeratstha (a Mohawk Language Word translating to: "The Place They Will Be Born") Ona:grahsta' (a Cayuga Language Word translating to: "A Birthing Place") was established in 1996 as a Birthing Centre located on the Six Nations of the Grand River Territory with Indigenous midwives providing traditional midwifery services. I met and began working with the supervisor of the Six Nations Birthing Centre, Ms. Julie Wilson, in 2011. The Indigenous Midwives of the Six Nations of the Grand River are community-directed and under the auspices of the Six Nations Council. It is through the Six Nations Council, Six Nations Health Services, the Tsi Non:we Ionnakeratstha Ona:grahsta' Maternal and Child Centre Advisory Committee and Grandparents Group, *Ionkhisothokon/Etihsot so,* that the authority to practice and provide services to the people is given. With approximately 100 births per year, the Six Nations Birthing Centre is the one of the first community-led training programs for Indigenous midwifery in Ontario, Canada.[55] The Six Nations

community provides families an accessible option for services and programs that are consistent with their beliefs and customs.

Priority setting: In April 2011, we participated in a community consultation with the Six Nations Health Services team. Health services leaders and community members emphasized that the community priorities include **childhood obesity** as an urgent health concern, which needed to be addressed.[9] There are five elementary schools on the Reserve with an enrolment of 1,110 students. Although data exists on the prevalence of overweight and obesity among Indigenous children in regions across Canada, there are no systematically collected data from children from Six Nations of the Grand River. Furthermore, observations of the Six Nations Health Services leadership indicated that the prevalence of overweight/obesity among school-aged children was likely to be substantial. The identification of this key health concern by community members was a central guiding focus of the work we have done together.

Further to CBPR, this thesis was further guided by principles of Ownership, Control, Access, and Possession (OCAP®)[56]. OCAP® First Nations principles guide data governance in health research;[56] and are addressed in the following ways throughout this body of research. *Capacity building:* From previous joint research efforts, study staff included members of the community to recruit, complete study visits, and follow participants. Through our knowledge translation activities and community gatherings we fostered knowledge exchange between community leaders, health care practitioners and community members. *Seek advice from leadership and elders:* The guiding principles of this foundation of this work include connecting with leaders from the community at all

phases, including setting the research agenda, interpreting the data, and placing the results into context. *Develop culture-based frameworks, methods, tools, and training:* The central tenet of this thesis was to develop a health promotion framework that is congruent and based on the beliefs and values of the community. *Ethical guidelines and community and cultural protocols:* The Hamilton Integrated Research Ethics Board and Six Nations Research Ethics Board approved all activities. *Identify respectful researchers and cultivate long-term relationships:* Members of the academic team have worked with the Six Nations community since 1998 and the primary work of this thesis began with relationship building with the Six Nations community and Birthing Centre in 2011 and is ongoing. *Require review prior to publication of research involving your community:* Collaboration ensured that findings are reflective of the formative work and all community-based publications are co-authored by academic and community members.

Researcher Positionality

Reflexivity is a researcher's process of examining their positions and assumptions as it relates to their approach to the research.[57] Given this dissertation includes qualitative methodology, self-reflexivity is included to position the researcher.

I am a non-Indigenous, second-generation South Asian Canadian. I was born in Ontario, Canada to parents who emigrated with professional vocations to Canada. I grew up in southwestern Ontario, in a household immersed in traditional north Indian (Punjabi) culture, food and language. My household traditional practices were central to my upbringing and shaped my worldviews. Positioning my culture and heritage is important

in this work as I am not an expert, nor do I have any lived experience as an Indigenous person in Canada. I complete this work in the spirit of evolving, active allyship.

Despite living, working, and studying in Ontario, the history of Indigenous peoples of Canada was not a significant part of my formal education. I only started my journey to better my understanding of Indigenous health issues when I travelled to a remote, First Nations community on the northwestern coast of British Columbia (BC). I was a pediatric resident at B.C. Children's Hospital (BCCH) and physicians at BCCH attended monthly pediatric medicine clinics in a remote First Nations' community. Through dialogue with community leadership, it had been identified that childhood type 2 diabetes and obesity were major concerns for the community. During my time as a pediatric resident at BCCH I joined the team that completed work to understand the scope of the community's concern about childhood obesity and diabetes in partnership with the community.[24,58] This engagement was transformational for my development as a person, physician and researcher and was imprinted by the invitation into the community, and the time spent during our trips with families who shared with us their homes, food and hospitality. After I left BC, this academic-community partnership has continued with ongoing work.[59,60] My work as a physician has also influenced my approach to this work. I am a pediatrician in an academic, tertiary-level hospital where I have a clinic in the Children's Exercise and Nutrition Centre at McMaster Children's Hospital. In this clinic I care for children with obesity and related complications. I meet children and their families and discuss progress with goals that including nutrition, physical activity, sleep, and mental wellbeing. I am also a mother of three children and recognize that promoting "healthy active living" behaviours

such as providing children 'healthy foods', making sure they are physically active, and limiting screen time is a very trying endeavour – I do not have the lived experience of layering the pressures of low income, housing instability, poor accessibility, and lack of education to this almost impossible task. There is no doubt that my privilege and position in life impacts my approach to the research topic and interpretation of data.

Summary of Thesis Chapters

This thesis consists of two published manuscripts and one manuscript prepared for submission. The work is woven together by the theme of understanding the underlying priorities, effectiveness, and determinants for obesity prevention strategies and/or programs among Indigenous children. The final chapter describes the implications of the findings and directions of future research.

Chapter 2: Strategies for Promoting Healthy Nutrition and Physical Activity Among Young Children: Priorities of Two Indigenous Communities in Canada is a manuscript published in *Current Developments in Nutrition* in 2019. This study is a qualitative descriptive study in partnership with two First Nations communities in Canada – Six Nations of the Grand River in Ontario and Pigeon Lake in Alberta with academic researchers from McMaster University and the University of Alberta. A partnership with researchers at the University of Alberta and their long-term relationship with community leadership in Pigeon Lake guided this collaborative effort. The objective of the study was to support two Indigenous communities in identifying priorities and strategies for promoting healthy nutrition and physical activity for young children. The full citation of the article:

Wahi G, Wilson J, Oster R, Rain P, Jack SM, Gittelsohn J, Kandasamy S, de Souza RJ, Martin CL, Toth E, Anand SS. Strategies for Promoting Healthy Nutrition and Physical Activity Among Young Children: Priorities of Two Indigenous Communities in Canada. Curr Dev Nutr. 2019 Nov 28;4(1):nzz137. doi: 10.1093/cdn/nzz137. PMID: 31938762; PMCID: PMC6949274.

Chapter 3: Effectiveness of programs aimed at obesity prevention among Indigenous children: a systematic review is a manuscript published in *Preventative Medicine Reports* in 2021. This study is a systematic review which sought to describe if programs aimed at obesity prevention and/or the promotion of healthy lifestyle behaviours for Indigenous children are effective. Thirty-four studies from Canada, USA, Australia, and New Zealand were included in the review, which found limited impact of programs on anthropometric measurements, nutrition, and physical activity. The full citation of this article:

Wahi G, de Souza RJ, Hartmann K, Giglia L, Jack SM, Anand SS. Effectiveness of programs aimed at obesity prevention among Indigenous children: A systematic review. *Prev Med Rep*. 2021;22:101347. Published 2021 Mar 9. doi:10.1016/j.pmedr.2021.101347

Chapter 4: Impact of maternal health behaviours and social conditions on infant diet at age 11year: Results from a prospective Indigenous birth cohort in Ontario, Canada is a manuscript prepared for submission. This study characterizes the diet of young children of the Six Nations of the Grand River enrolled in a prospective birth cohort study, ABC, one of the first Indigenous-focused birth cohorts in Canada.[8] The research question was developed with the Indigenous midwives of the Six Nations Birthing Centre and develops an infant diet score for 1-year old offspring enrolled in the cohort, and describes how factors including social disadvantage, maternal education, maternal diet, and traditional birth practices are associated with infant diet at age 1-year.

Chapter 5: Implications of the findings and directions of future research is the final chapter of this dissertation. In this chapter the overview and key findings from previous chapters are summarized with reflection on how the methods and findings are connected and how they contribute to the knowledge and methods of the study of childhood obesity prevention. Strengths, limitations, and future directions are discussed.

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CHAPTER 2

TITLE: Strategies for promoting healthy nutrition and physical activity among young children: Priorities of two Indigenous communities in Canada

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Abstract:

BACKGROUND: Indigenous people in Canada carry a disproportionate burden of obesity and obesity-related diseases compared to non-Indigenous Canadians, which may be related to intergenerational trauma exposures. Implementing effective health promotion strategies to improve nutrition and physical activity behaviors during early childhood may be one strategy to mitigate the burden of intergenerational trauma exposures that have the potential to impact the trajectory to obesity and related complications throughout the lifecycle.

OBJECTIVE: The aim of this study was to support two Indigenous communities in identifying priorities and strategies for promoting healthy nutrition and physical activity for young children.

METHODS: Using a formative approach, we conducted a two-phase study that started with two community engagement workshops (n=37 participants), followed by a qualitative descriptive study. In this latter study, in-depth interviews were conducted with a purposeful sample of 23 community parents, health care providers, and traditional knowledge holders. Data from both study phases were analyzed and synthesized using conventional content analysis.

RESULTS: To promote healthy nutrition and physical activity among young children living in Indigenous communities, it was identified that the primary pathway to health and well-being must prioritize the integration of knowledge about Indigenous ways of life including traditional Indigenous foods and physical activities. Participants also identified individual/family and community/contextual factors that ultimately influence the nutrition and physical activity of children in their communities.

CONCLUSIONS: Informed by this formative study conducted to better understand community members' strategies for healthy eating and physical activity for young children, we argue for the continued recognition of the unique Indigenous context, incorporating the history of inequity and injustice and looking toward Indigenous-led interventions which incorporate this history and ways of life as solutions in the future.

Key words: Indigenous, child health, health promotion, nutrition, physical activity

Introduction: Since the late 1990's, there has been an exponential rise in global rates of non-communicable diseases (NCDs).[1] There is emerging evidence suggesting that the propensity to develop NCDs and poor health outcomes is strongly influenced by adverse childhood experiences (ACEs).[2-4] Common ACEs include exposure to family violence, child maltreatment, mental illness, and in the context of Indigenous people of Canada, multiple historical traumas.[5,6]

Indigenous people in Canada include three distinct groups: First Nations, Métis and Inuit. Among these communities, individuals have endured historical traumas perpetrated by social, political and religious institutions, including colonization and being removed from their homes and isolated in residential schools. These traumas have resulted in the loss of traditional lifestyles, language, and significant challenges in adapting to the encroachment of the dominant society, which in turn has led to substantial health inequities.[7] A large proportion of Indigenous people in Canada live with limited resources, and methods of coping with this adversity may include, among other pathways, adoption of risky lifestyle behaviors including consumption of poor diets and low physical activity.[4] Indigenous people in Canada, including children and youth, carry a disproportionate burden of obesity and related diseases including type 2 diabetes and cardiovascular diseases compared to non-Indigenous Canadians.[8-10] Evidence suggests the development of obesity and related conditions are rooted in early life experiences.[11] Therefore implementing effective health promotion strategies to improve nutrition and physical activity behaviors during early childhood may be one strategy to mitigate the burden of intergenerational trauma exposures,

the health impact across generations, and have an impact on the trajectory of obesity and related complications throughout the lifecycle.

Successful health promotion strategies must be pragmatic, culturally-tailored, and consider contextual facilitators and barriers to implementation.[12] In obesity prevention programs, healthy behaviors include limiting the consumption of energy-dense, nutrient-poor foods, minimizing sedentary behaviors, and staying physically active. Traditional Indigenous knowledge and beliefs have endured in Canada despite historical traumas, and this tremendous resiliency emphasizes the central place of traditional teachings and culture in the design of health interventions.[13] There is limited evidence for obesity prevention interventions with young Indigenous children in Canada.[14,15] Our partnership in formative work provides opportunity for Indigenous communities to shape future interventions and tailor them for cultural and geographical context.[16]

This study was built on a longstanding a partnership between academic researchers from McMaster University and the University of Alberta and two Indigenous communities in Canada, Six Nations of the Grand River, Ontario and Pigeon Lake, Alberta.[8,12,17-19] The partnership between the Six Nations community and academic researchers includes ongoing work on a birth cohort study to understand the cardio-metabolic risk factor profile of Indigenous women and infants and ways to promote health outcomes.[17] The overarching goal of this project, which included community engagement workshops as well as a descriptive qualitative study, was to identify and understand community-identified strategies for the primary prevention of childhood obesity among young Indigenous children (< 5 years) in Canada which could be used to inform the development of future

health promotion interventions. Using previously established formative research approach to intervention development, we identified community priorities for nutrition and physical activity for young children and families and community strategies to prevent obesity and promote health.[16]

Methods: *Setting* The Six Nations Reserve is situated in Brant County, Ontario and took its present form of 20,000 hectares in 1847, and is home to over 12,000 Six Nations people.[8] Pigeon Lake Reserve is 1,921 hectares in size and is situated in central Alberta, bordering Wetaskiwin County, with a population of 429 according to Statistics Canada 2016 Census.[20,21] The Pigeon Lake Reserve is shared between the four communities that comprise the community of Maskwacis: Ermineskin Cree Nation, Louis Bull Cree Nation, Samson Cree Nation, and Montana Cree Nation. Despite differences in the size of the population of the communities, both are similar distances to large Canadian cities and each has a community health center on reserve.

Study Design We used a formative research approach for the initial stages of intervention development.[16] Benefits of formative research include its inclusivity in producing an intervention that is both culturally and geographically appropriate to a community.[16] Formative research methods are typically conducted with both qualitative and quantitative methodologies and can use multiple approaches to data collection and community input.[17,22] We conducted a two-phase study between September 2015 and June 2017. In Phase 1, we held community engagement workshops in each community focused on nutrition and physical activity for children under age 5 years. The goals of these workshops were to: 1) identify priority nutrition and physical activity issues for community members

who live and work with young children and families; 2) discuss key principles that would inform how to address the priorities; and 3) identify key stakeholders for the next research phase. The purpose of Phase 2, a qualitative descriptive study, was to deepen our understanding of the themes that arose during Phase 1, and to continue to identify and document community priorities and strategies to address this important health issue.[23] Findings from Phase 1 that informed the protocol for Phase 2 included strategies for purposeful sampling and key concepts to explore within the context of semi-structured, in-depth interviews. An audit trail was kept detailing all decisions made throughout the study to ensure that the study's conclusions represent the data.

Ethics: Approval was received from the Hamilton Integrated Research Ethics Board, University of Alberta Research Ethics Board, the Six Nations Council Research Ethics Committee, and partners within Pigeon Lake Reserve. The study followed guidelines to ensure informed consent, study governance, and publications in keeping with the Tri-Council Policy Statement 2 (TCPS-2) Chapter 9 on Research Involving the First Nations, Inuit and Métis Peoples of Canada[24] and OCAP® (ownership, control, access and possession) principles.[25] Participants provided written informed consent prior to individual and group interviews, which included follow-up contact if needed.

Phase 1 Community Engagement Workshops Members of the research team collaborated with a Six Nations of the Grand River community leader who was a partner on the study to plan the community engagement workshops. The community leader identified three community stakeholders with extensive experience working with community families with young children, who guided the researchers on how to successfully organize and facilitate

a community engagement workshop. We planned two workshops: one in Six Nations of the Grand River and another in Pigeon Lake. We invited community members who were knowledgeable in any of the following areas: child health, community programs, had lived experience (parents), health promotion experience, Indigenous knowledge keepers and elders, to participate in the workshops.

In September 2015, we held the initial community workshop at Six Nations of the Grand River. In total, 21 people participated including representatives from Six Nations Health services, local schools, and daycares as well as community members including Elders and academic researchers. The initial workshop was co-facilitated by an academic researcher (JG) and a community health leader (JW). In January 2016, the second community workshop was held in Pigeon Lake following a similar protocol. A total of 16 participants, including parents, Elders, academic researchers and representatives from Health Services joined the meeting held at the Pigeon Lake Health Centre. An academic researcher present at the Six Nations workshop (GW) co-facilitated the workshop in Pigeon Lake with an academic researcher who works with the community (RTO). For both workshops, after a brief introduction of the objectives for the day, participants introduced themselves and discussed their experiences with young children and health as well as their goals for the day. The agenda for the community workshop included: introduction of all participants; identification of nutrition and physical activity priorities for young children; identification of community resources for young children; facilitators and barriers to accessing resources; and identification of potential solutions. The prioritization activities with the initial topics

chosen were based on previous community workshops,[22] although the agenda was flexible and changed based on input from participants.

Analysis Plan: For the workshop, facilitators addressed each agenda item, techniques similar to those described by Gittelsohn *et al* in the development of chronic disease prevention program from Inuit communities were employed.[22] After each topic was introduced, participants brainstormed and listed items specific to each topic. A member of the team wrote all the ideas on a flip chart in a list format. The results were posted on the walls of the workshop room. Participating community members then identified their priority issues within each category through a process of voting, by placing a sticker next to their preferred option. The number of stickers each participant was given ranged from 8-12 per topic. The items identified as high priority had the highest number of votes received. The results of the lists with prioritization from participants as well as written notes summarizing the discussion during the workshops were returned to all participants within two weeks of the workshop.

Phase 2: Qualitative Descriptive Study Building on the findings from the Phase 1 community engagement workshops, the principles of fundamental qualitative description informed all sampling, data collection and analytic decisions in Phase 2.[26] Qualitative description is used to describe a phenomena with a low amount of inference by the researcher and staying close to the language and words of the participants.[26] The academic researchers on the team were non-Indigenous, therefore this methodology allowed for prioritization of the voice and ideas of the community members to be highlighted and direct areas of priority and need with respect to the topic of research.

The purposeful sample we invited to participate in this phase of the study, included: 1) community members providing health care services and/or health promotion programming; 2) current parents/caregivers of young children (under age 5 years); and 3) community members with Indigenous knowledge, e.g. Elders. At the onset of this phase of the study, we invited key informants identified from the Phase 1 workshop with a high degree of knowledge about the topic. Using snowball sampling, we identified community members from this initial sample who could speak knowledgeably about emerging themes.[27] Sampling continued until saturation, the point information from data sources does not contribute new information to the emerging themes, was reached.[27] The research group decided when saturation had been reached through group discussion of emerging themes. To achieve credibility, member-checking interviews with five participants were completed and included review of data and emerging themes. A combination of individual and group interviews provided triangulation of data sources.[28]

We interviewed 23 participants (Six Nations n = 13, Pigeon Lake n = 10). The participants included community members involved with health promotion programs (n = 14); mothers with young children who lived in the community at the time of recruitment (n = 5) and Elders (n = 4). Each interview was a single, face-to-face 1:1 in-depth semi-structured interview of approximately 60 minutes. In Six Nations of the Grand River the interviews were facilitated by an academic researcher and pediatrician (GW) who has worked with the community since 2011. Interviews in Pigeon Lake were facilitated by either an academic researcher who has worked with the community since 2013 (RTO) or a community research associate. The interview guide was directly informed by the findings

summarized from the community workshops and revised after the first few interviews. It included questions on nutrition and physical activity priorities for families with young children similar to the workshops; it also included questions on culture and traditional knowledge in health promotion, as well as discussion of facilitators and barriers to health promotion in follow-up to discussion from the workshops. To maintain neutrality and limit bias, a reflexive journal was kept by the primary academic researcher GW with specific attention to her role of a non-Indigenous researcher. We audio-recorded and transcribed all interviews verbatim with personal identifying information omitted. Interview manuscripts were imported into NVivo-11 software.

Analysis: The principles of conventional content analysis guided the coding and synthesis of these data, and included processes of open, focused, and thematic coding for the purposes of creating linkages.[29] Two team members (GW and SK) coded all the data separately and then met to discuss and resolve differences. A member of the community participated in and reviewed the development of the coding schema (JW) and in Pigeon Lake a team member (RTO) reviewed coding schema with a community member with knowledge of child health issues.

Results:

The overarching theme generated through both research phases, informed by the experiences of knowledge holders, was the following: *Traditional Indigenous ways of life are the primary pathway to health and wellbeing for young children and families.*

Participants described that traditional, Indigenous ways of life were promoted through traditional knowledge and teachings and that there was an important connection between

traditional ways of life and health. This is how one community member described the intersection between tradition, culture and health: *"Traditional health is based on our teachings and our customs, and knowledge that has been passed down. Everything that has been in the past, that has guided our people for generations, it's still valid today." [P1]* This process of passing on traditional knowledge, practices, and worldviews from one generation to the next was described by participants as being important and the responsibility of all community members. Further, successful understanding and engagement was perceived to be achieved when this form of cultural continuity occurs in multiple settings including home, schools, and the community at-large. Multi-generation engagement in traditional activities, was seen as fundamentally instrumental to promoting the physical, mental, and spiritual well-being of young children. Having an appreciation of past practices, and then recognizing similar activities and strengths in a current generation of children by parents, was seen as a valuable process, as one parent shared:

> *When you look back many, many years ago and you really try to visualize what life was like for people. Hunting, the little boys would be 5 or younger and they would go out with their dads roaming in the fields. And I find my little one has a lot of that inside of him, where he likes to explore, and he's got sticks. [P10]*

Participants identified strategies to increase knowledge and understanding of traditional practices including: 1) learning through personal family teachings; 2) integration of traditional knowledge within community programming; 3) embedding traditional knowledge and skills into school curricula and 4) teachings from Elders. Many participants described the high value families placed on traditional Indigenous teachings that also was

an important element for healthy child development, this is illustrated with one mother's description of her family experience learning traditional activities: *I think when the parents have that in their mind, body and spirit, the First Nations teachings then that really gets passed on because then you're encouraging them. [P10]* Along with the family-unit, community-led programs were described as an area of strength and a source of traditional knowledge and teachings, and included community gardens, baby food making classes, cooking classes, and other health promotion community initiatives. Further, schools and daycares were considered an important venue for passing on traditional knowledge to children and participants in one community discussed an example of a local elementary school committed to teaching Indigenous language, serving traditional foods, and providing opportunities for culturally-relevant physical activities. This example was a community-led model of integrated culture into daily school teachings, including experiences with traditional foods, language, hunting and gathering for the next generation. Finally, all community members spoke in high regard of Elders in the communities and the important role they have as holders of traditional knowledge, with their integral role in the physical and mental wellbeing of communities.

Indigenous ways of life include traditional foods and physical activities

Across both phases of the project, multiple conversations were held about the types of food most commonly consumed and the physical activities encouraged for children in the two communities. Indigenous ways of life including traditional knowledge and teachings are considered synonymous with healthy food choices and participation in regular physical activity in both communities. This link was further exemplified in the workshop activities,

where participants were asked to prioritize the foods consumed as well as the types of physical activities young children participated in. The following foods were identified by participants as "healthy" foods consumed by children in the community: "water, fish, white corn, wild meats, seeds, berries, homemade soups and vegetables" (See Table 1). The discussion that arose following this prioritization activity included observations that foods on this list were more often whole ingredients versus ready to eat foods. Further, foods on the lists were identified as part of a traditional Indigenous diet for each community. In comparison, community members were acutely aware of the frequency and extent that many local children also regularly consumed processed, sugar-laden foods in their daily diets. The most common food sources that were labelled by participants as "unhealthy" included "pop, fast food, pasta, sugary foods, grains (e.g. cereal, pastries, and bread) and other sweet drinks" (See Table 2). Physical activities considered important and desired included traditional activities such as hunting or traditional games that were connected to the land and the outdoors. During the workshop, participants brainstormed different types of activities that should be promoted to young children. The most common types of physical activities that were prioritized by participants included: "walking, running, school sports, winter play/sports, gardening, swimming, traditional dancing, hunting, and picking food" (See Table 3 for priority physical activities for each community). In discussion at the workshop many of the participants described the characteristics of ideal opportunities for physical activity for young children would include activities that have a minimal to no cost and are accessible in the community setting.

Factors Influencing Young Children's Dietary and Physical Activity Patterns of Behavior

Through data triangulation and synthesis of emergent categories, we identified individual/family and community/contextual factors that influence the uptake of healthy nutrition and physical activity for young children living in these communities.

Individual and family factors

The individual and family level factors contributing to dietary and physical activity patterns of behaviors were significant, and included: economic factors, physical factors, and individuals' knowledge and skills. Participants described that unless these factors were addressed, families would have difficulty in make healthy food and regular physical activity a priority. Economic factors such as income were particularly a concern for participants, and low income and its connection with food insecurity was described by participants. A community health care provider described her experience with clients and food insecurity, not having reliable access to sufficient quantity of food. Specifically that food insecurity would come up in indirect ways such as not having other basic items for young children or through how food provisions, such as food baskets, were received:

> *If there is food insecurity it can be missed, especially if people don't say anything. I have had some recently, that don't have money for a car seat when baby is born. So, helping them through that, but there is a lot that don't say it. But sometimes we do home visits, or through talking to them, and how they receive the food basket is a really good indicator [P6].*

A family's level of income was also perceived to limit traditional food consumption as these sources of nutrition were perceived to be more expensive compared to processed, energy-dense convenient foods that were more conveniently located in their neighborhoods. Further in one community, participants described that local food banks commonly stock foods that were energy-dense and of poorer quality which made it difficult to avoid these nutrition sources for families in need. One health care professional further illustrated the additive impact of these barriers and shared that, "[community programming] *to think of things for a family that might say, "I don't have the transportation, I don't have the money, I don't have the resources" [P3]*. For the impact of finances on physical activity many participants described a minimal cost associated with many activities in their communities such as walking, running and school sports (Table 3).

The physical factors that were identified and perceived to limit healthy diets and regular physical activity for children and family were time and transportation. Participants described that families with young children have busy schedules which prevented home preparation of meals and meal planning. Physical activity was also limited by time, and one community member described her approach to physical activity community programming which takes into consideration the factors that influence active play:

> *A lot of the families that I work with the moms has two jobs or its just really hard to find that time when the child is available and mom is not making dinner or bathing another child, or anything of that sort, and so that is why we thought*

> *unstructured was the best way, given those five minutes in the middle that you have that you can play with the child. Because taking them for programming again, is expensive and you need transportation. So just low tech, anything at home that you can play with, we try to encourage (PL4)*

Transportation was described as impacting families in the communities and their participation in health promotion programing, one community member describes transportation as a barrier to access and how they try to address it: *"Always transportation. Our program is getting a van, which will help a lot because transportation is a big thing, it's not a very walkable community, other than this area"* [PL 7]. In the discussion of the barriers of time and transportation participants described community-led solutions to support families.

Participants also described individual and family-level strategies for engaging in healthy food consumption and encouraging physical activity. One solution described by participants was community programs aimed at increasing individual's knowledge and skills in nutrition knowledge and food skills. Participants noted that there were many community programs run with the intention of addressing gaps in individuals or family's knowledge and skill as it pertains to food preparation for example events in community kitchens were noted to be useful in one community. Further it was also described that community gardens were a source for alternative foods once the perceived barriers of time

and lack of knowledge were addressed. One community member described current successful community programs that promoted healthy food consumption:

> *We have done some successful cooking classes, several a year in fact, with great attendance. There are initiatives within the community and the health centers to teach people how to eat more healthy meals on the go. So, there's, and that's been a huge success. I am not 100% aware of what all the communities do, but I know that there's initiatives that are going on as we speak for community gardens.*
>
> *[P13]*

Another positive strategy which engaged families was community-run health promotion programs. Many participants described the important contribution of a strong family-unit to a healthy community and prioritizing families was considered an essential pathway to promoting health for the community as a whole. In planning community events and initiatives many participants discussed attending to the needs of the family-unit, such as child-care, meals, and activities for all members. Participants described the variety of community-led programs that were family-focused in promoting healthy lifestyles. They highlighted the key elements of successful programs, including: 1) promoting a family-friendly atmosphere; 2) providing childcare or age-appropriate activities for all participants; 3) providing healthy food for participants; 4) respecting that families are busy and developing programs with this in mind; 5) incorporating community initiatives such as community gardens; and 6) addressing the unique needs of families that may prevent them

for attending community programs, such as family meals, transportation, and admission costs.

Community and Contextual factors

Woven through all participants' narratives, there was an awareness and deep consideration of how community and contextual factors, specifically geographic, historical and cultural factors, influence nutrition and physical activity within the community. Geographic factors included commonly identified barriers such as: community safety and environmental contamination. Participants described personal safety as barriers to participation in physical activity programs, for example a participant described how the physical environment may deter a family from participating in physical activity: "*we are hoping for a safer community as a whole, so that a lot of the moms that do have these fears are able to go out and do things with their kids. You don't see a lot of people walking on the road. It's not safe." [P3]* The contamination of the physical environment was a barrier to traditional food consumption described by participants. Community members described high levels of environmental contamination and the negative impact on food sources, especially fishing in local lakes. One community member described how they perceive this environmental contamination and its effect on food sources: "*When I was little, we lived on fish and wild meat. And vegetables, wild berries. But when they came here, it's different. Some still do all those things, yeah. But we can't eat the fish from here." [P22]* The land and its attributes were considered very important and their roles must be recognized and acknowledged.

A clear and overarching theme throughout the study was the importance of understanding context, specifically the impact of colonization in shaping the life course of community

members. One community health care provider described how historical contextual factors may impact connection to culture.

> *"It's the shaming around the identity of the culture. Like people didn't want to be associated as being Indigenous or First Nations, they didn't want anyone to know because of the influence of colonization." [P2]*

Connection to culture, family and socio-economic barriers are all impacted by historical traumas and this context is essential for understanding the data. One community member described how loss of connection to Indigenous traditions and teachings have impacted traditional activities: *"The knowledge to go hunting, fishing, we need more of that, cause these life skills are part of our culture and we weren't allowed to do that, so it's not being passed down." [P1]* Further, in striving to achieve health, community members discussed the need to understand the impact of colonization and its role with their present day lives. Participants described eating traditional foods and participating in traditional physical activities as strategies to promote health. One community member described the importance of bringing traditional knowledge into current day practice:

> *A lot of our spiritual practices and a lot of our traditional knowledge of medicine, a lot of those things is what fell through the cracks when we came here and, so I think that's what's really impacting our community now and where children are feeling disconnected. People are making a move back to growing their own food, but we've come so far from there. [P5]*

Consuming foods based on a traditional diet from community-led health initiatives was considered a model for a healthy diet. This is demonstrated by a community health care provider's description of the importance of traditional foods to health: *"So looking at food, I think how food connects to our spirit. And a lot of us have disconnected that food to our spirit and that linkage." [P2]* The important context of tradition and culture is a vital factor that must be considered in any programs and interventions for healthy nutrition and physical activity promotion.

Discussion:

This is the first study to describe the priorities and strategies of community members for promoting both healthy nutrition and physical activity among young Indigenous children in Canada. Our findings highlight that community members prioritize traditional Indigenous ways of life including traditional foods and physical activities, considering these the most important factors for promoting health for young children and families. Our study furthers emphasizes critical pieces for understanding and context, specifically the importance of cultural continuity and an overarching theme woven through the study – the importance of the distal factors that pervade health inequities specifically the social determinants of health and historical traumas including colonization.

The intent of the workshops was to generate concrete examples and consensus ideas generated by community members in the areas of healthy dietary intake and physical activity to provide strategies for young children and families in the community to optimize these aspects of their lives. The discussion of the workshop attendees were consistent with current global recommendations.[30] In a socio-ecological model of health behaviors, these

would represent proximal factors, which often reside with the individual and/or family. Interventions that only target individual-level factors and do not address the unique Indigenous context in Canada, including intergenerational traumas, are likely to fail.[31] In comparison, interventions led and developed by Indigenous communities would, by definition, include an understanding of the Indigenous context and traditions and therefore have a greater likelihood of succeeding.

By addressing factors that promote traditional ways of life we were able to identify areas of strength within the community that facilitate healthy nutrition and physical activity, specifically various community programs and community-led initiatives that focus on culture, family, and the passion for educating children in the community. Participants prioritizing and describing the connection between physical activity for children to traditional, culturally-based activities is similar to what Tang *et al* described with the Yellowknives Dene First Nation community.[32] Led by the participant discussions, the workshops also addressed barriers to healthy lifestyles which were also addressed in the qualitative study, specifically, economic, physical and geographic factors. Similar barriers to traditional food systems were described by participants in six First Nations communities as described by McGregor *et al.*[33] As well, findings are in line with results of a previous study from one of the communities examining the contextual determinants of health behaviors in adults, which found an unfavorable built environment, specifically poor accessibility to active transportation, limited availability of healthy food, and poor safety.[12] These barriers highlight the ongoing need to address community-level factors to promote healthy lifestyles in many Indigenous communities.[31]

Cultural continuity is described as "*the integration of people within their culture and the methods through which traditional knowledge is maintained and transmitted*".[34] For this study the concept of cultural continuity facilitates the description of cultural connection as the pathway to health described by participants. Cultural continuity is protective and confers health benefits to Indigenous peoples' in Canada.[35,36] In 1998 Chandler and Lalonde examined cultural continuity as it related to youth suicide among First Nations' communities in British Columbia, Canada.[36] The authors identified six measures of cultural continuity (land titles, self-government, educational services, police and fire services, health delivery, cultural facilities) at the community level and described how each was independently related to and protective against youth suicide.[36] A mixed methods study by our co-author Oster *et al* explored the concept of cultural continuity and its relationship to rates of diabetes among First Nations Bands in Alberta, Canada.[35] Cultural continuity was conceptualized as "being who we are" and very much connected to traditional Indigenous language. Oster *et al* went on to show that communities with more members speaking their traditional languages had significantly lower rates of diabetes.[35] Our study adds to the literature as it shows another example of community driven data that furthers the argument for culture as the central component of health and wellness as described by Indigenous community members including caregivers of young children. This is similar to work done by other Indigenous communities in Canada that highlight the importance of culture and it's relation to nutrition and physical activity.[32,33] A logical extension of our work is a quantitative analysis to better understand of the impact of culture continuity on healthy

lifestyle factors, for example nutrition and physical activity among families with young children in the community.

The strengths of this study included a rigorous methodological approach to sampling, data collection and analysis. The triangulation of both data types and sources contributed to the overall credibility, or truth value, of the findings. Credibility of the findings were further enhanced by the participatory activities embedded in the data collection process, the partnerships between Indigenous and non-Indigenous researchers, each bringing unique worldviews and understanding of the issues under study to the analysis. The dependability of the findings was enhanced through a rigorous process of analysis, that again included a team approach to coding and interpretation. Limitations of the study included the small number participants who were parents or caregivers and the paucity of fathers/male participants which may have enriched the data. Further, although there was remarkable concordance in themes between the two communities, this study may not be applicable to all Indigenous communities in Canada, although similar themes have been established in other health areas and communities in Canada.[32,33,35,36]

Our study contributes to the mounting voices that call for cultural connection and continuity as a pathway to health and well-being for Indigenous peoples in Canada. What started as a formative study to better understand community members' strategies for healthy eating and physical activity for young children transcended the individual-level factors and argues for the continued recognition of the unique Indigenous context incorporating the history of inequity and injustice, and look toward Indigenous led

intervention which incorporates this history and traditions as possible solutions in the future.

Acknowledgments

We would like to acknowledge the communities of Six Nations of the Grand River, Ontario, Canada and Pigeon Lake, Alberta, Canada. We are also grateful to participants in the study for generating this knowledge with us. We would also like to acknowledge the assistance of Stephanie Courtney, Loshana Sockalingam, and Grant Bruno.

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Tables:

Table 1: List of 10 most common foods that each community prioritized as healthy for young children (less than age 5 years).

	Community A		Community B	
Rank	**Food item**	**# Votes**	**Food item**	**Votes**
1	Water	20	Neckbones	9
2	Fish	13	Berries	8
3	Whole grains	12	Moose	8
4	White corn	11	Subway	7
5	Wild meat	11	Blender Foods	5
6	Wild rice	11	Tea	5
7	Seeds	10	Vegetables	4
8	Strawberries	9	Roasts	4
9	Deer meat	8	Steak	4
10	Homemade soups	8	Potatoes	4

Table 2: List of 10 most common foods that each community prioritized as unhealthy for young children (less than age 5 years).

	Community A		Community B	
Rank	**Food item**	**# Votes**	**Food item**	**Votes**
1	Pop (Soft drinks)	17	Take Out	13
2	Fast food	17	Pop	12
3	Pasta	17	Chips	12
4	Sugar cereal	12	Flour	9
5	French fries	11	Alcohol	8
6	Pizza	11	Raw Noodles	6
7	GMO foods	9	Drugs	6
8	Poutine	7	Salt	6
9	Pastries	6	Candies	5
10	Bread	6	Chicken burgers	5

Table 3: List of 10 most common physical activities that each community prioritized as important for young children (less than age 5 years).

	Community A		**Community B**	
Rank	**Activity**	**# Votes**	**Activity**	**Votes**
1	Walking	19	Powwow Dancing	16
2	Running	16	Going for Walks	11
3	School sports	14	Playing Outside	9
4	Winter play/sports	11	Trampoline	7
5	Gardening	10	Hunting	7
6	Interactive/imaginary play	10	Swimming	6
7	Swimming	9	Dancing	5
8	Playing	9	Games	5
9	Circle games	9	Skating	5
10	Picking food	8	Beading	5

Appendix 1: Letter of invitation to community workshop

McMaster University

Department of Pediatrics
3A - Health Sciences Centre
Department of Pediatrics
1280 Main Street West, Hamilton, ON L8S 4K1
Tel: 905.521.2100

McMaster Children's Hospital
HAMILTON HEALTH SCIENCES

August 24, 2015

Dear

We are writing to invite you to a **Community Research Workshop** so that you can be part of setting the agenda for future research in the areas of **nutrition, physical activity and healthy living among Six Nations infants and young children (birth to age 3 years)**.

Who are we? We are part of a team of researchers from McMaster University. Since 1996, we have worked in partnership with the Six Nations community to help understand health conditions including heart disease and type 2 diabetes. In 2013 we initiated a project, the Aboriginal Birth Cohort (ABC) study, which focuses on understanding the early life environment that may impact heart disease and type 2 diabetes later in life. We are hoping to expand the ABC study to contribute to future solutions. The next step is this workshop that seeks to understand what the community priorities for research are and to generate ideas to promote the health of young children and families.

Details of the event?

Date:	Thursday, September 17th, 2015
Time:	9:00AM to 3:00PM
Location:	Sports Den at the Six Nations Community Hall
Co-Moderators:	Julie Wilson, Supervisor of Maternal and Child Centre
	Gita Wahi, McMaster University

RSVP by September 11, 2015 to Tammy Hill, (519) 445-4922 or hbhcr@sixnations.ca

We would like to extend our gratitude for your support. The information generated from this workshop will be shared with all those that participate, as well as the Six Nations community.

Yours in Partnership,

Dr. Sonia Anand MD, PhD, FRCPC
Professor of Medicine
McMaster University

Dr. Gita Wahi, MD, MSc, FRCPC
Assistant Professor, Pediatrics
McMaster University

Appendix 2: Agenda of Community Research Workshop

September 17, 2015

Nutrition, physical activity and healthy living among Six Nations young children

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8:30AM – 9:00AM	Registration and breakfast/coffee
9:00AM	Opening
9:05AM	Introduction & goals for the workshop – G. Wahi/J. Wilson/J. Gittelsohn
9:10AM	Participant self-introductions, participants share their experiences
10:15AM	Brainstorming and priority setting activities for food
12:30-1:00PM	Lunch
1:00PM	Brainstorming and priority-setting activities for physical activity
3:30PM	Wrap-up
3:45PM	Closing

Appendix 3: Sample interview guide

Time of interview: _____

Date of interview: _____

Place of interview: _____

Interviewer: _____

Interviewee: _____

[Add a short script introducing yourself, summarizing the focus of the interview, indicating that there are no right or wrong answers, that all of their information will remain confidential and will not be shared with employer or families they work with etc]

Questions:

1. Can you briefly describe your role as a [daycare/ECE staff or nurse or health director) and the work that you do with families in your community?
    a. Within your work with families, what is your role in addressing healthy nutrition and physical activity?
    b. Clarify if they focus predominantly on health of infant/toddler or also on mother and/or family.
    c. Probe for assessment, identification of issues, health education activities, role modeling, referrals, etc.

2. In the work that you do, what would you identify as the greatest strengths amongst the families you work with?
3. In the work you do, what do you see as the greatest challenges experienced by families in this community?
4. I would now like to turn our focus to discussing your role and work you do to promote healthy nutrition and physical activity in infants and toddlers.

   a. In your work with families, what are the most common nutrition issues among infants and toddlers that you observe? What are the most common nutrition issues raised by mothers or other family members?
   b. What current strategies are used to address these issues? What is the response from the family to these strategies?
   c. What do you think would be the best way to connect with families around promoting healthy infant and toddler nutrition practices and promoting physical activity?
   d. What types of programs or strategies would you recommend developing for the community?
   e. Are there programs in your community that have been successful in achieving these goals?
   f. What is the role of culture and traditional knowledge in promoting healthy nutrition and physical activity during early childhood?
5. In Jan 2016 – we met at a workshop to discuss early childhood nutrition and physical activity. After the workshop, what were your thoughts about the discussions we had related to:
   a. Nutrition
   b. Physical activity
6. Again, the overall goal of my study is to understand how to best promote nutrition and physical activity for children in the first 5 years of life – is there any other information you could share with me to help me achieve this goal?
7. Who else should I speak to about this topic?

CHAPTER 3

TITLE: Effectiveness of programs aimed at obesity prevention among Indigenous children: a systematic review

AUTHORS: Wahi, G., de Souza, R.J., Hartmann, K., Giglia, L., Jack, S.M., Anand, S.S.

JOURNAL: Preventative Medicine Reports

CITATION: Wahi G, de Souza RJ, Hartmann K, Giglia L, Jack SM, Anand SS. Effectiveness of programs aimed at obesity prevention among Indigenous children: A systematic review. Preventive medicine reports. 2021 Jun;22.

Abstract

Given the significant health burden of childhood obesity, it is imperative that effect interventions be better understood. When evaluating obesity prevention efforts, one must recognize the contextual factors which drive the disproportionate risk of obesity between populations. This systematic review sought to understand if programs aimed at obesity prevention and/or the promotion of healthy lifestyle behaviours for Indigenous children are effective.

We conducted a search using Medline, EMBASE, PsychINFO, ERIC, CINAHL and iPORTAL databases from inception to August 13, 2019. We included experimental and quasi-experimental studies. The main outcomes of interest were change in anthropometrics, nutrition or physical activity. Our narrative synthesis included an assessment of study quality using the Effective Public Health Practice Project Quality assessment tool.

A total of 34 studies met selection criteria. Most studies used a quasi-experimental design (n= 25) and were assessed as low to moderate quality (n = 32). Three studies showed a significant change in anthropometric measures, 13 studies demonstrated at least one significant nutrition-related behaviour or dietary-pattern change, and five studies demonstrated a significant impact on physical activity.

This systematic review of programs to prevent obesity among Indigenous children finds a limited impact on anthropometric measurements. Future studies must prioritize Indigenous knowledge and ways of knowing to lead all phases of development, implementation, and evaluation of programs.

Introduction: The World Health Organization identifies obesity as the leading modifiable risk factor for cardiovascular and non-communicable diseases worldwide.[1] Over the past two decades the prevalence of childhood obesity has steadily risen around the world[2-4] such that it is considered one of the most serious public health issues of this century.[3] Childhood obesity has substantial physical health consequences including hyperglycemia, dyslipidemia, non-alcoholic fatty liver disease, high blood pressure and disordered sleep, as well as psychosocial sequelae leading to stigmatization, bullying, and adverse mental health effects.[5] Obesity early in life is associated with an increased risk for premature death in adulthood.[6] Given the increasing prevalence of obesity and its significant associated health effects, identifying effective prevention programs must remain a top public health priority.

When evaluating obesity prevention efforts, one must recognize the contextual factors which drive the disproportionate risk of obesity between populations. A socio-ecological approach frames the importance of distal factors such as socio-economic policies, systemic racism, and physical environment in understanding the causes and consequences of obesity.[7] Among Indigenous communities, the social determinants of health are also inclusive of systemic injustices including colonialism, cultural genocide, and intergenerational trauma all which have led to poor health outcomes across the life course.[7,8] The cumulative impact of intergenerational traumas and ongoing oppression has led to health disparities including the increased prevalence and complications of obesity among Indigenous children.[7,9] The United Nations estimates that over 370 million Indigenous people live across 70 countries worldwide.[10] Though the term *Indigenous* does

not have a universal definition, it has been described to include a diverse peoples and settings, with self-identification as a central tenet.[11] Further, the United Nations has described Indigenous peoples as: *"inheritors and practitioners of unique cultures and ways of relating to people and the environment. They have retained social, cultural, economic and political characteristics that are distinct from those of the dominant societies in which they live. Despite their cultural differences, Indigenous peoples from around the world share common problems related to the protection of their rights as distinct peoples".*[11] Approximately 1 in 3 Indigenous children in Canada, the United States, Australia, and New Zealand are obese; a rate far greater than non-Indigenous children in those countries.[12,13] The primary driver for the disparities between Indigenous and non-Indigenous children in these countries include the loss of traditional culture and practices another consequence of historical traumas and colonialism.[7] The burden of obesity among Indigenous communities is significant, therefore obesity prevention strategies are urgently needed.

The existing literature shows modest benefit of obesity prevention interventions among children.[14-16] In addition, there is limited inclusion of programs specific to Indigenous communities in previous systematic reviews. For example, a 2019 Cochrane review of interventions to prevent obesity among children aged 0 to 17 years, included 153 randomized controlled trials (RCT).[16] The authors found a modest reduction overall in body mass index (BMI) with interventions that focused on both nutrition and physical activity among children up to 12 years old.[16] However, this review included only studies of RCT design and did not consider subgroups of populations that have increased burden of disease due to systemic barriers, such as with Indigenous communities.[16] There have

been limited systematic reviews addressing obesity prevention specific to Indigenous populations.[17,18] Godin *et al* reviewed obesity prevention programs for Indigenous children in the school setting in Canada.[17] They identified seven studies and concluded that most programs did not prevent obesity, and there was a lack of studies addressing the unique needs of Métis and Inuit children in Canada.[17] A systematic review by Laws *et al* published in 2014 included childhood obesity prevention studies focused on Indigenous families and/or children living in low socio-economic status settings among children from birth to 5 years.[18] Only 2 studies specific to Indigenous families were identified and both were feasibility studies considered to be low quality with no significant effect on outcome. Given the scope of previous reviews specific to Indigenous children, which limited inclusion of studies by age, country and settings, and the considerable burden of obesity on health outcomes for Indigenous communities, we sought to complete a review to understand if, among Indigenous children, programs aimed at obesity prevention and/or the promotion of healthy lifestyle behaviours, including nutrition and physical activity, are effective in preventing obesity.

METHODS

Study selection: The study is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement recommendations (checklist in Appendix).[19] The study designs included both RCT and quasi-experimental studies. Included studies evaluated strategies to either prevent obesity or promote the adoption of healthy lifestyle behaviours among Indigenous children aged birth to 18 years of age. The

lifestyle behaviours included in this review were nutrition and/or physical activity related, other behaviours including sleep, screen time and sedentary time were not included. The primary population of interest for this review were Indigenous children residing in Canada, United States, Australia or New Zealand. The primary outcomes were child anthropometric measurements (e.g., weight for age, BMI for age, waist circumference, prevalence of overweight/obesity, measure of adiposity), diet or physical activity. We excluded studies that: 1) focused solely on breastfeeding; 2) targeted the treatment of obesity; or 3) included participants with pre-existing medical conditions. When full text articles were reviewed, if a study included a significant proportion of non-Indigenous participants, which we defined as more than 15% of the reported sample size and outcomes were not reported specifically for the proportion of participants that identified as Indigenous, the study was excluded. This was done to increase the confidence that the results were applicable to the population of review.

Data sources and search strategy: We searched Medline, EMBASE, PsychINFO, ERIC and CINAHL databases and the iPORTAL (Indigenous studies portal) research tool from their respective inception through August 13, 2019. The search strategy was customized for each database and included derivations of the terms: anthropometric measure (e.g. BMI)* OR obes* OR overweight* AND nutrition* or physical activity* or sedentary activity* AND health promotion* or intervention* AND Indigenous or First Nation or Native American or Pacific Islander or Aboriginal or Maori or Inuit or Métis AND clinical trial/ or randomized controlled trial/ or quasi experiment* or intervention*. The search was

not restricted by language. A librarian with expertise in health sciences and systematic reviews was consulted to refine the search strategy. See appendix 1.

The titles and abstracts of each study retrieved from the above search were independently screened by two investigators (GW, LG) for study eligibility. Full text articles were then retrieved for all studies that met the inclusion criteria and the same two investigators (GW, LG) independently reviewed all full text articles to identify articles for final article inclusion. Additional potential eligible studies were located through a hand search of the reference list from eligible articles, and related systematic reviews. At each stage, any disagreements were resolved through discussion with a third investigator (RJD).

Data extraction: Two investigators (GW, KH) independently extracted information in duplicate from included studies using a standardized form. Data was extracted on each study's: 1) objectives; 2) characteristics (e.g., design, sample size, participants' age,) 3) program components (e.g. provider, duration, location, setting, strategies); 4) targeted outcomes; 5) control group; and 6) key findings.

Data synthesis and analysis: A narrative synthesis was completed for included studies. Studies were summarized by study characteristics and then then results were further explored by reported outcomes. Methodological quality was assessed with the Effective Public Health Practice Project Quality Assessment tool (EPHPP)[20] on six domains, including selection bias, design, confounders, blinding, data collection methods and withdrawal rates. Each domain is rated as 'strong' (i.e. minimal risk of bias), 'moderate' or 'weak' (higher risk of bias) and then an overall assessment based on the cumulative

assessment from each domain. This tool is reliable and valid for the assessment of quality of intervention studies,[20] and appropriate for reviews that include experimental studies designs.[21]

RESULTS

We identified 2654 articles from the initial search of the databases (Medline 853; EMBASE 953; PsycInfo 109; ERIC 334; CINAHL 403; iPortal 2). Figure 1 details the flow of selection of studies. Following the removal of 491 duplicate titles, 2163 article titles and abstracts were screened for eligibility. Overall, 1996 articles were excluded because they did not meet the selection criteria. Of the remaining 167 articles we included 34 studies in this review. A full-text review excluded 133 of the 167 studies for the following reasons: methods only reported (n=32); participants were non-Indigenous (n=28); participants' age > 18 years (n=17); non-experimental design (n=16); duplicate publication (n=13); report of baseline data only (n=10); program did not focus on obesity prevention (n=9); or secondary paper (n = 8). The 8 secondary papers stemmed from 4 studies that had multiple publications with reports of various outcomes.[22-25] In these instances we included the primary publication of the study with the most comprehensive report of the primary outcome for this review.[26-33]

Characteristics of included studies

Tables 1 and 2 summarize the characteristics of the 34 selected studies (9 RCTs[23,25,34-40] and 25 quasi-experimental designs[22,24,41-63]). Quasi-experimental designs included pre-post intervention tests (n=20)[24,41-59] and parallel non-equivalent control arm designs (n=5).[22,60-

[63] Thirteen studies were described as pilot or feasibility studies.[24,35,36,41,43-45,49,50,56,58,60,61] Fourteen studies were conducted in Canada[22,34,41-45,50-52,57,60,61,63];14 in the United States (US)[23-25,35,37,38,40,46-48,53,54,58,62]; 4 in Australia[39,49,55,59]; 1 in New Zealand[56]; and 1 in both the US and Canada.[36] Nineteen included studies had programs focused on more than one lifestyle behaviour such as a combination of nutrition and physical activity.[22-25,34-38,40,46,47,50,52,54,57,59-61]; 12 studies focused solely on nutrition[39,41-45,48,51,55,58,62,63]; and 3 studies focused on physical activity.[49,53,56] Programs varied in duration with 12 studies taking place for 6 months or less.[24,34-36,41,44,47,49,52,56,60,62] All studies commented on the community engagement or the use of a community participatory research design, at one or more of the design stage, implementation stage, or through involvement of community members in interpretation of results.

Characteristics of study participants and programs

The 34 studies included 8463 participants, with a range in study sample sizes of 16 to 1704.[25,56] The most common study setting were studies conducted in schools (n = 23)[22,23,25,35,37,41-46,49-54,57,59-63] followed by home-settings (n=6)[34,36,38-40,58]; after-school programs (n=4)[24,47,48,56] and one study was conducted in a health clinic setting (n=1)[55]. Since most studies involved schools, the primary age range of study participants was 6-18 years. Only six studies focused on children less than age 5 years.[23,36,38-40,58] All studies had almost equal representation of male and female participants.

Studies conducted in school settings (n=23)[22,23,25,35,37,41-46,49-54,57,59-63] were most often educational sessions focused on nutrition and/or physical activity knowledge and/or practical skills. These curricula and/or activities were led by combinations of

teachers,[25,31,37,45,46,49-52,54,57,61] community members,[35,45,49,51,53,54] mentor/peers,[60,61] community health workers[59], and/or researchers.[41,43,62] A number of studies also included materials or education directed to families and/or community events.[22,23,25,31,37,41,43,50-52,57] A number of studies (n = 11) also addressed the school or community environment, including changing menus, availability of foods, snack programs or physical activity opporunities.[22,23,25,41-43,50,51,54,57,63] There was considerable heterogeneity in the size and length of studies. The size of studies ranged from pilot programs limited to single classrooms to multi-school cluster randomized control trials. The length of programs in the school setting ranged from single educational sessions to studies that followed participants for 8 years.[22,62]

Studies that were primarily conducted in a home-based setting (n=6)[34,36,38-40,58] included education delivered either in person[34,36,38,39,58] or by mail-outs.[37] In person-led lessons were most often delivered by one or more members of the community including trained community health counsellors.[34,36,38,40,58] Most (n=5) home-based programs addressed the needs of young children and mothers during pregnancy.[36,38-40,58]

After-school program programs (n=4) varied in age groups and program components. The range of ages of children in after-school programs were aged 5-17 years, as some included all children at a school[48], others aimed at middle school,[24,47] and others targeted high school students.[47,56] Two studies focused on after-school exercise programs, with elements of healthy nutrition snacks and education[47,56] and education for parents.[47] Another program focused on obesity prevention and traditional knowledge through talking circles.[24] Finally, one program provided educational sessions on nutrition with policy changes to meal

planning.[48] One study included a health clinic setting where families with young children received annual health visits combined with weekly fruit and vegetable baskets with a minimal copayment, and recipes and practical cooking and nutrition education sessions with dietitians were offered.[55]

Study design

The nine RCTs[23,25,34-40] in this systematic review accounted for 26% (9 of 34) of included studies and 58% of participants (n = 4921). We highlight the characteristics and outcomes of these studies as they account for a large proportion of study participants. The majority of RCT studies (n = 7) were ≥ 6 months in length[23,25,34,37-40]; conducted in the USA (n = 7)[23,25,35-38,40]; and in the home-setting (n = 5).[34,36,38-40] Six of the nine RCTs included outcomes measures from each of anthropometrics, nutrition, and physical activity.[23,25,34-36,40] Table 3 outlines the outcomes for the RCT studies. None of the eight RCT studies[23,25,34-36,38-40] which included an anthropometric (e.g. BMI or percent body fat) demonstrated a significant change. Eight RCT studies showed a significant impact on change of a dietary habits[23,25,34,36-40] and three showed a significant increase in diet-related knowledge or attitude.[25,35,36] For physical activity measures, no RCT study demonstrated a change in measured physical activity and only two showed a significant increase in self-reported physical activity.[25,37]

Assessment of study quality

The Effective Public Health Practice Project Quality Assessment tool (EPHPP)[20] was used to evaluate the quality of both RCT and quasi-experimental studies included in our review.

Most studies (32 of 34) had at least one weak rating. The most common reason for a 'weak' rating was the reporting of blinding of outcome assessors or participants to the study objectives. For the assessment of selection bias, 7 of the 9 RCT[34-40] were flagged as weak or moderate quality. In an RCT, selection bias refers to "*systematic error in creating intervention groups, such that they differ with respect to prognosis*"[64], applying this definition all of the RCT studies would have a 'strong' rating. Given this discordance, we did not assign an assessment for selection bias within the RCT studies. Overall two studies had all strong assessments, with no weak ratings.[39,40] Most studies had a moderate or weak overall quality assessment rating. (Table 4)

We summarize the results of studies as they address key outcomes of interest including changes in anthropometrics, nutrition, and physical activity. We did not synthesize data using a meta-analysis because of the heterogeneity in study designs, the variability of study quality, and the heterogeneity of reported outcomes. This summary includes all study designs, both RCT and quasi-experimental.

Anthropometric measurements

Twenty-one of the studies reported at least one anthropometric measure as an outcome. This included body mass index (BMI), BMI z-score (zBMI), weight, waist circumference, percent body fat, and weight-for-height z-score. Of the 21 articles, nine[23,38-40,46,57,58,60,61] measured zBMI , and only two reported a statistically significant change in zBMI score with their program.[60,61] Both of the programs that showed a significant decrease in zBMI were quasi-experimental, pilot studies focused on school-based programs that included peer-mentoring components. BMI was measured in nine studies[22,23,25,35,47,48,50,53,56] and

none of the studies reported a significant change in individual participant BMI, though one study did report a decrease in proportion of participants who were overweight. [23] Seven studies[22,23,25,34,47,50,55] reported measures of adiposity (percent body fat), with one study showing a significant reduction[47] and another showing a smaller increase in body fat in the intervention group compared to the control group.[22] Overall of 32 studies (9.3%) reported a significant change in at least one child anthropometric measurement with an obesity prevention program.[47,60,61]

Change in lifestyle behaviours

Nutrition

Twenty-seven (79%) studies reported nutrition-related outcomes, including: energy consumption, sugar and/or fat intake, fruit and/or vegetable intake, beverage intake (e.g. sugar sweetened beverages, milk, water), dietary patterns, and measures of knowledge, attitudes and barriers towards nutrition. Six studies reported some measure of energy consumption by participants.[25,35,36,39,52,57] In two of the studies, participants had significantly decreased energy intake[25,36] In four studies participants reported minimal change in dietary energy intake.[35,39,52,57] Seven studies[22,25,34,37,39,48,50] reported changes in sugar and/or fat consumption. Caballero and Saksvig reported a significant decrease in consumption of energy from fats.[25,50] Studies led by Anand and Davis reported a significant decrease in fat intake.[34,37] The study by Paradis *et al* reported reduction in high sugar and high fat food items intake.[22] Finally Rinderknecht reported an increase in fat and sugars with their program.[48] Smithers *et al* reported a significant decrease in energy intake from sugar.[39]

Six studies reported a change in beverage intake.[23,34,38,41,57,63] One study reported a significant increase in water consumption,[34] two studies reported an increase in milk consumption[41,63], and two demonstrated a decrease in sugar-sweetened beverage (SSB) consumption.[23,34] Two studies showed no change in SSB consumption.[38,57]

Fruit and vegetable consumption was described by ten studies.[22,34,38,40-42,44,45,57,63] Of these ten studies, two reported a significant increase in fruit and vegetable intake[38,63] and four reported no impact on fruit and vegetable intake.[22,34,40,57] One study demonstrated an increase in the variety of vegetables consumed,[57] and five studies demonstrated a significant increase in the fruits and vegetables tried and liked by participants.[41-43,45] One study reported on change in dietary pattern and observed a significant improvement in healthy diet patterns after the program.[40] Of the 12 studies reporting changes in either knowledge, attitudes, and/or behaviours towards components of nutrition. Two studies showed no significant change.[34,52] Ten studies demonstrated a significant increase in either knowledge, attitudes, and/or behavior towards diet or nutrition.[25,35,37,41-43,45,50,59,60] Mihrshahi *et al* also demonstrated change in knowledge and attitudes towards SSBs.[59]

Overall, of the 27 studies with nutritional outcomes, 13 studies reported at least one significant change in a positive direction for either dietary intake or pattern,[22,23,25,34,36-41,50,57,63] and 10 studies reported a positive change in diet-related knowledge or attitude towards nutrition.[25,35,37,41-43,45,50,59,60]

Physical activity

Thirteen studies reported outcomes related to change in physical activity.[22,24,25,34-37,40,52,53,56,57,59] Of these, 8 studies reported objectively measured outcomes related to

physical fitness and activity including accelerometry[25,35,36,52,57] and a 1-mile run/walk and shuttle run tests.[22,53,56] Teufel-Shone *et al* also reported changes in curl-ups, push-ups, and sit/reach tests.[53] Self-reported measures of physical activity were collected through questionnaires in 10 studies[22,25,34,35,37,40,52,56,57,59], and a further 6 studies reported measures of knowledge, attitudes and behaviours around physical activity or exercise.[24,25,34,37,52,59] One study also reported on maternal intention to change physical activity and self-efficacy for physical activity.[36] No studies that objectively measured physical activity with accelerometers showed a significant change, and only 2 studies[25,37] reported a significant change in self-reported physical activity. Three studies showed a significant increase in aerobic fitness.[53,56,57]

Discussion

We have summarized the primary literature addressing obesity prevention programs among Indigenous children across multiple settings and countries. Our study highlights programs to prevent obesity among Indigenous children have a negligible impact on anthropometric measurements such as BMI. We observed evidence of changes in nutrition and physical activity in a limited number of studies. A limitation of the synthesis of this body of literature is that most studies were quasi-experimental design and were assessed as low to moderate quality, which puts into question the validity of the results.

RCTs are considered the highest level evidence for the evaluation of the efficacy of an intervention.[65] In North America, Australia, and New Zealand, interventional research accounts for only 18% of published Indigenous health research.[66] To move towards reconciliation and better health for Indigenous Peoples, Anderson describes the need for

Indigenous health research to be "*well-designed, high-quality interventional research affecting population health outcomes*".[66] Despite this, only 26% of studies included in our review were RCTs, however this accounted for the majority of study participants (58%). There were many potential reasons for the diversity of the study designs in this review. Some authors noted that elements of an RCT design were not considered well-suited for their community-engaged evaluation and was not appropriate after consultation with community members. The studies that were RCT design were cluster RCT design, that is they were randomized at the level of a community, school, or family, and this may have been considered more acceptable to communities. It is imperative that Indigenous research paradigms and worldviews inform research to improve health outcomes, this includes interventional research.

Along with study design, the components of the obesity prevention programs must be considered in evaluating effectiveness. A review by Willows *et al* outlines the importance of understanding the contributions of socio-ecological factors for weight-related considerations among Indigenous communities.[7] This framework includes the individual and family context but also highlights the undeniable impact of social determinants of health, and for Indigenous communities this includes the enduring legacy of colonialism that continues to have downstream effects.[7] However despite facing adversity, Indigenous communities have shown strength and resilience through connection to language, culture and land.[67,68] In a qualitative study to understand the priorities and strategies for healthy active lifestyles for young children, participants from two Indigenous communities in Canada highlighted similar themes including the importance of integrating traditional ways

of life into nutrition and physical activity programs, as well as placing into context the knowledge and understanding of systems that perpetuate health inequities.[69] There were studies included in this review that addressed themes of traditional culture and knowledge through different methods including talking circles,[24] content such as traditional foods and activities,[35] and multi-level programs aimed at influencing the environment with policy changes.[22,25] However, future programs must consider the negative health impacts of the social determinants of health which have eroded many positive health behaviours rooted in traditional Indigenous knowledge and culture.[69] The connections to tradition, culture, and land are a pathway to health that must be prioritized.[68,70]

The outcomes reported by studies varied, which led to challenges with synthesizing results across studies. For example, of the 27 studies that reported nutrition-related outcomes, 13 showed at least one significant difference in a nutrition behaviour. However there were considerable variations in the study designs, and the measurement of the outcomes which precluded a meta-analysis. Another important consideration for reported outcomes is prioritizing outcomes identified by Indigenous communities. For example, in spite of our finding that all 34 of studies had noted partnerships with communities, it was unclear in some studies how communities participated in prioritizing participant- and/or community-important outcomes. In this review we did not assess, within each of the included studies, the contributions or priorities of Indigenous participants and communities. This is an important limitation which we highlight to draw attention for the need of methodologies specific to Indigenous-focused systematic reviews. There are tools for systematic reviews that could be used for this purpose. For example, Hartfield *et al* have developed a quality

appraisal tool specific to Aboriginal and Torres Strait Islanders to "*assess the quality of research from an Indigenous perspective*".[71] Further, a 'two-eyed seeing' approach, which honours Indigenous methodologies, could be the foundation for culturally-relevant and appropriate systematic review methodologies that are guided by Indigenous knowledge, and is an approach to guide researchers that honour Indigenous ways of knowing.[72,73]

We also identify other potential limitations of our review. First, we limited the geographic restrictions placed on the selection of studies. However, because countries in all regions have similar histories of colonization, negative health consequences and systemic injustices we felt it was a reasonable inclusion criterion. Second, we did not perform data synthesis through meta-analysis given the variability of study design and quality assessments. Third, the quality of the evidence was relatively poor. All but two studies had at least one assessment to be either poor or moderate quality. However, a consideration for the interpretation of study quality must be the definition of the terms used in the tool. The one element that was notably weak on a number of studies was 'blinding'. For a study to receive a positive rating ('strong') for blinding the study participants must be unaware of the research question. In the context of a participatory research design, this definition may be against principles of community partnerships. However, having outcome assessors blinded to the allocation of participants to groups could be a consideration. Another example, one must consider is how selection bias is defined for RCT studies. In our study 7 of 9 RCT studies had moderate or weak ratings. In the EPHPP, to receive a 'strong' rating for selection bias, recruited participants were to be 'representative' of the target population, i.e. reflecting the selection from the broader population, as well as and have a high (>80%)

rate of participation. Selection bias in RCT studies is traditionally considered differently, specifically Cochrane defines selection bias as the "systemic difference between baseline characteristics of the groups that are being compared",[74] which may impact the estimate of the effect.[75] If this alternate definition is applied, a higher proportion of the included RCT studies would have a "strong" rating, we chose in this case to not provide an appraisal for selection bias for RCT studies. Lastly, we acknowledge that the composition of our study team was primarily non-Indigenous, academic researchers, although some have long-standing experiences working with Indigenous communities, only one author identifies as Indigenous.

In conclusion, there is a paucity of high-quality evidence to guide the implementation of obesity-prevention programs for children among Indigenous communities in Canada, United States, Australia and New Zealand. Given the significant health burden of childhood obesity and its complications, it is imperative that programs be better understood. As importantly, Indigenous knowledge and ways of knowing must be valued and supported to lead all phases of development, implementation, and evaluations of programs. Finally, prioritizing the impact of upstream factors are important and is imperative for child health outcomes and future generations.

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Table 1: Description of study characteristics (study design, community, age, intervention)

Author	Study design			Location	Community or population^	Age	Intervention description
	RCT	Quasi	Pilot				
Anand	√			Ontario, Canada	Six Nations of the Grand River	Community members including children aged 5 to 18 years	Home-based intervention Intervention: Trained community health counsellors set goals with families around diet and physical activity Control: Families received Canada's Food Guide to Health Eating and Canada's Physical Activity Guide to Health Active Living
Black		√		New South Wales, Australia	Aboriginal in Clarence Valley	Youth aged <17 years	Clinic-based intervention A weekly box of subsidised fruit and vegetables provided to families linked to preventive health services and nutrition promotion at an Aboriginal Medical Service.
Brown	√		√	Montana USA	Northern Plain Indian	Youth 10-14 years	School-based intervention Intervention: Community lifestyle educators led curriculum on health lifestyles modified from the Journal Diabetes Prevention Program curriculum and included components of traditional activity, language, and Elder participation Control: Alcohol and drug prevention curriculum
Caballero	√			Arizona, New Mexico, South Dakota, USA	Tohono O'odham Nation; Gila River Indian community; Navajo; Sicangu Lakota; Ogala Lakota; White Mountain Apache; San Carlos Apache	Grade 3 students	School-based intervention Intervention: Classroom: Two 45-min lessons were delivered by teachers each week for 12 weeks during the 3rd and 4th grades (decreased to 8 weeks during 5th grade to allow for the follow-up measurements during the final 2 month of the school year). Food Service: Pathways guidelines for food-service personnel and regular visit by Pathways nutritionist to support and monitor school-lunch preparation. Physical Education: Minimum of three 30-minute sessions per week of moderate-to-vigorous physical activity. The program included exercise breaks of 2–10 min duration. Family Involvement: family fun nights, workshops, and events at school; family packs linked to classroom curricula. Control: regular care
Chansavang		√	√	Auckland, New Zealand	Pacific and Māori	High school students	After-school program University student instructors led a group-based exercise and lifestyle intervention programme which included moderate to high-intensity activities, a healthy snack after each session, and support through text messaging
Colip		√		New Mexico, USA	Zuni Pueblo	Middle and high school students	After-school program Community Health representatives led exercise programs that incorporated aerobic exercise, resistance training and group exercise and monthly diet and nutritional education session led by a registered dietician from the Indian Health Services. Parents attended an instructional session on healthy eating and preparing nutritional sack lunches for their children.
Davis	√			New Mexico, USA	Navajo and Pueblo	Grade 5 students	School-based program

							Teachers and community members led five units on the cardiovascular system, exercise, nutrition, tobacco, social influences with a focus on activities that included traditional knowledge, as well as attitudes, and behaviors. Materials sent home to share with families. Control: No intervention for first 3 years
Eskicioglu		√	√	Manitoba, Canada	Garden Hill (Kistiganwacheeng) First Nation	Grade 4 students	School-based program High school mentors delivered a weekly curriculum of healthy snacks, 45 min moderate to vigorous physical activity, educational game or activity.
Gates, A 2011		√	√	Fort Albany Ontario, Canada	Fort Albany First Nation	Grade 6 to 8 students	School-based program University student delivered a curriculum focused on fruit and vegetables; 30 minutes weekly in class presentations, handouts. Change in school snack program guided by policy guidelines. A healthy eating community event with a traditional feast and led by the students.
Gates, A 2016		√		Ontario, Canada	Cree First Nation	Grade 6 to 8 students	School-based program Snack program delivered by school that focused on milk, milk-products, vegetables and fruits.
Gates, M 2013 (1)		√	√	Ontario, Canada	Cree First Nation	Grade 6 to 8 students	School-based program Research staff and community volunteers led a food provisions program delivered through schools. With one school implementing a snack program and the other school supplementing the existing snack program with milk.
Gates, M 2013 (2)		√	√	Ontario, Canada	Fort Albany First Nation	Grade 6 to 8 students	School-based program University student delivered a healthy eating curriculum with a focus on milk and milk products adapted from Dairy Farms of Canada program; 30 minutes, once per week for 5 weeks and a healthy food provision. Family/community events including a traditional feast that was combined with event by Gates, A 2011.
Gates, M 2016		√	√	Ontario, Canada	western James Bay Cree First Nation community	Grades 6 to 7 students	School-based program Teachers and community members led an afterschool physical activity program. The intervention included fundamental skills training for teachers, increased availability of equipment, increased availability of after school sports
Harvey-Berino	√		√	New York State, US and Ontario, Quebec, Canada	Akwesasne Mohawk	Mothers w/ infants 9 months to 3 years	Home-based program Peer educator delivered a parenting program based on the Active Parenting curriculum with culture-based adaptations as necessary with a focus on improving parenting skills of appropriate eating and exercise behaviors in children. Control: Parenting program without eating and exercise components
Karanja		√	√	Idaho, Oregon, Washington, US	American Indian tribes who are members of Northwest Portland Area Indian Health Board	Pregnant mothers	Home-based and community interventions Two interventions arms 1) Community-wide intervention (including media, to raise awareness, provide health education, change behavior, change public policy, modify environment) and family intervention (8 home-visit delivered by community health workers) or 2) Community-wide intervention only.
Kelley		√	√	Oklahoma, US	United Keetoowah Band	Youth aged 10-13 years	After-school program

					of Cherokee Indian Tribe		A trained Keetooway-Cherokee interventionist with cultural knowledge and identity led talking circles focused on Native American history, obesity education, stressors, self-esteem, and traditional ways of life including diet and physical activity. Control group: A tribal health educator provided health education curriculum designed for the general public.
Mihrshahi		✓		Queensland, Australia	Māori and Pacific Islander communities	Youth aged 6 to 19 years	School-based program Trained multicultural health workers delivered nutrition and physical activity lessons with cultural performing arts including games, songs, and books
Oosman		✓		Saskatchewan, Canada	Métis	Grades 3 and 4 students	School-based program Teachers led 17 classroom lessons that included take home materials, classroom exercise breaks, storytelling, goal setting and whole school activities. Control group: No intervention
Paradis		✓		Quebec, Canada	Kanien'keha:ka (Mohawk)	Grade 1 to 6 students	School and community-based program Teachers led health education curriculum including ten lessons per year for each grade - topics included T2DM, nutrition, PA, healthy lifestyles. School nutrition policy; Community activities and collaborations with community groups; use of local newspaper and radio to promote community events and reporting results to community; School nutrition policy, construction of pathways and cycling paths; Comparison group: No intervention for first 2 years
Peralta		✓	✓	New South Wales, Australia	Aboriginal and Torres Strait Islander People	Grades 7 to 10 students	School and community-based Indigenous teachers and community members led 17 lessons focused on promoting MVPA, mastery of sport skills, Indigenous cultural knowledge, understanding, practicing skills, improving awareness of career/vocational pathways, leadership and money management
Rinderknecht		✓		Minnesota, US	Anishinaabe	Youth aged 5 to 18 years	After-school program Researchers and after-school staff led lessons focused on self-efficacy, nutrition and physical activity Environmental modifications to meal planning, including changes to after-school dinner menu
Ritenbaugh		✓		New Mexico USA	Zuni Pueblo	High school students	School-based program Teachers implemented curricula in various classes targeting diabetes prevention strategies Community trainers led activities at a youth-oriented fitness center. Increased availability of drinking water and decrease of sugar-sweetened beverages in schools. Student researchers created posters, displays, radio announcement Comparison group: non-Zuni Pueblo, Anglo students.
Ronsley		✓	✓	British Columbia, Canada	Tsimshian Nation; (Gitga'at, Gitkxaahla, Lax Kw'alaams bands)	Kindergarten to grade 12 students	School-based program Teachers taught older students, who in turn led sessions for students in younger grades. Curriculum included 21 lessons and 6 fitness loops, each 30 minutes. Topics of lessons included nutrition, physical activity, and healthy body image. Comparison school: no intervention

Saksvig		✓	✓	Ontario, Canada	Sandy Lake (Ne gaaw saga'igan) First Nation	Grades 3 to 5 students	School-based program Teacher led in class curriculum focused on knowledge and skills development related to healthy eating, physical activity, and diabetes education. Family component informed parents and family members about the healthy eating and physical activity messages children were learning in school. Peer component that provided opportunities for peers to act as role models. School policies that removed high-sugar and high-fat foods, and included a healthy school lunch program
Skinner		✓		Ontario, Canada	Cree, Fort Albany First Nation	Grades 6 to 10 students	School-based program Snack program provided morning snack to all students and an afternoon snack to students in grades kindergarten to grade 8. Comparison group: student who did not participate in the snack program
Smithers	✓			Southern Australia	Australian Aboriginal	Pregnant mothers or mothers with baby <6weeks old	Home-based program Research staff delivered anticipatory guidance and motivational interviewing about oral health and sugar sweetened drinks during pregnancy and early life. Dental supplies and written materials were provided, as well as dental treatments for families and fluoride varnish for children. Control group: Usual care, offered similar program at age 2 years
Story	✓			South Dakota, US	Lakota, Oglala Sioux tribe	Kindergarten students	School and family-based program Multiple components including: PA: minimum of 60 min daily accomplished through school PE, class walks outdoors, in-class action breaks, and active recess. Diet: food service at school oriented to offer 1% white milk instead of alternatives, serve recommended portion sizes, purchase and use low-calorie/fat foods, provide more fruits and vegetables, and offer second helpings only on fruits and vegetables. Teachers were trained to limit daily snacks in the classroom, and if used, to be only low-fat and low-sugar foods. Family: three family night events related to nutrition and physical activity during the intervention period and one summer event. Control schools: usual care
Teufel-Shone		✓		Arizona, US	Hualapai tribe	Grades 3-8 students	School-based program Trained community members led activity sessions consisting of strength training and cardiovascular activities/games.
Tomayko 2016	✓			Wisconsin, US	Bad River band, Lac du Flambeau bad, Menominee Nation, Oneida tribe of Indians of Wisconsin	Youth 2-5 years old	Home-based program Mentors, tribal community members, delivered in-person monthly lessons, focused on fruit and vegetable intake, sugar sweetened beverages, physical activity, and screen time, second year included group visits and written materials via mail. Control group: Mail delivered toolkit
Tomayko 2018	✓			USA (northeast, midwest, north mountain, southwest regions)	4 American Indian tribal reservations and 1 urban setting	Youth 2-5 years and parents	Home based program Wellness Journal toolkit included 12 monthly mail outs to families including healthy lifestyle lessons, items, and books. Messages included increasing fruits and vegetables, decreasing sugar consumption, increasing PA, decreasing screen time, improving sleep habits and for adults decreasing stress Control: Child-safety focused toolkit
Tomlin		✓		British Columbia, Canada	Tsimshian Nation	Grades 4-12 students	School-based program

							Teacher-led classroom healthy eating education; PA opportunities at recess and after-school; environmental changes, e.g. changing playground equipment; community and family events
Triador		✓		Alberta, Canada	Alexander First Nation reserve	Grades 1-6 students	School-based program Elders, teachers, and librarians led gardening activity combined with a weekly snack program offering a vegetable or fruit to each child; written materials were sent home.
Vogeltanz-Holm		✓		North Dakota, USA	Spirit Lake Tribe, Standing Rock Sioux Traibe, Three Affiliated Tribe, Turtle Mountain Band of Chippewa	Grade 3 students	School-based program Teachers, staff and administrators led delivery of classroom, PA, food services delivery, and family components based on the Coordinated Approach to Child Health (CATCH).
Weber		✓		Arizona and New Mexico, USA	American Indian	Grade 2 and 3 students	School-based program A portion-size training activity including: introducing standard units; practice estimating and measuring foods and beverages; practicing reporting food quantities from labels; practice choosing the correct measuring device and performing measurements Control: no intervention

^as described in the study authors

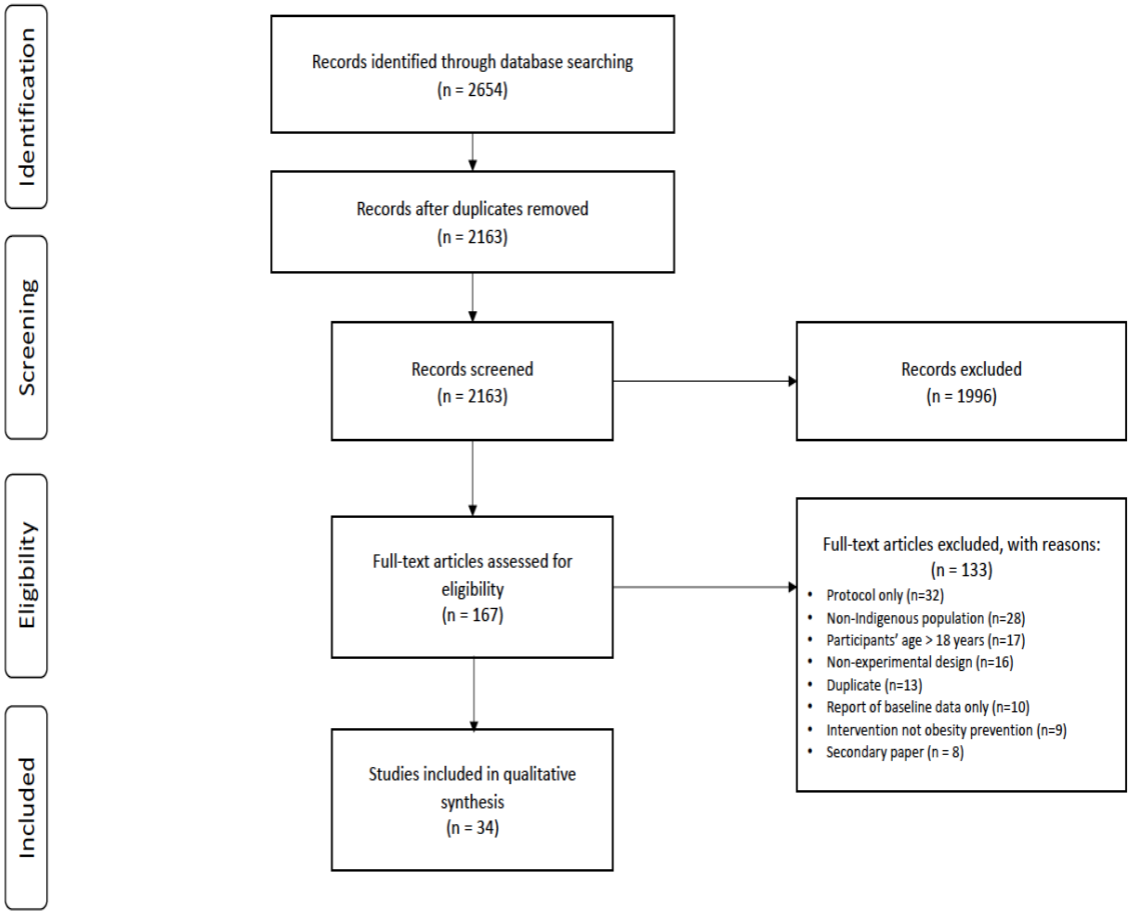


Figure 1: Flow of study selection

Table 2: Description of study outcomes (objectives, participants, results)

Author	Study objectives	Number of participants	Duration of intervention	Reported outcomes			Results
				Diet	PA	Anthro	
Anand	Determine if a household-based lifestyle intervention is effective in reducing energy intake and increasing energy expenditure.	47+	6 months	√	√	√	Energy intake was reduced in both groups; in intervention group compared to control group: increase in water consumption*; decrease in SSB*; decrease in consumption of fats, oils, sweets; no change in FV intake; decrease in trans fatty foods; increase in highly active leisure PA; reduction in ST; no changes in body weight, waist circumference, body fat; both groups gained weight; increase in knowledge about health foods among children.
Black	Evaluate the impact of a fruit and vegetable subsidy program on short-term health outcomes of disadvantaged Aboriginal children.	167	12 months	√		√	Increase in haemoglobin level, weight and BMI*; lower levels of anemia, hospital visits*, and oral antibiotic prescriptions*. No change in body fat percentage.
Brown	Develop a lifestyle change program for Native American youth by modifying the Diabetes Prevention Program (DPP) and assess implementation indicators and short term behavioral and physiological outcomes of the intervention.	76	3 months	√	√	√	There was no change in dietary recall, there was a decrease in energy consumed, increase in knowledge about nutrition*, change in average minutes of activity and sedentary behaviour, increased BMI.
Caballero	Evaluate the effectiveness of a school-based, multicomponent intervention to prevent or reduce excess weight gain in elementary school children.	1704	3 years	√	√	√	No significant difference between intervention and control groups in anthropometrics (%BF, BMI); total energy intake (24h recall) lower* and energy from fat lower* in intervention group; No difference in energy content in lunches; No difference in measured PA; higher self-report PA in intervention group*; No difference in injuries from PA; knowledge, attitudes, and behaviours increased significantly in intervention group*; higher self-efficacy in intervention group.

Chansavang	Assess the feasibility of an after-school group-based exercise program to improve cardiorespiratory fitness, health and usual activity in less-active Pacific and Māori adolescents over six weeks.	16	6 weeks		√	√	Improvement in cardiorespiratory fitness*, lowered systolic blood pressure, lowered HbA1c*, increased vigorous and moderate physical activity*. Non-statistically significant improvement in insulin resistance. Increase BMI and waist circumference*.
Colip	Demonstrate that an afterschool program has a beneficial effect on the anthropometric and cardio-metabolic parameters of adolescents.	65	6 months			√	Improvements in BMI percentile*, fasting lipid profile*, A1C*, total body fat*, fat free mass*.
Davis	Increase knowledge and lead to cardiovascular health changes.	1543	5 years	√	√		In intervention group: improved knowledge* and increase in self-reported exercise*. Decrease in overall fat (butter) intake*.
Eskicioglu	Assess the efficacy of an after-school, peer-led, healthy living program on adiposity, self-efficacy, and knowledge of health living behaviors.	151	5 months	√		√	In intervention group compared to control group: Change in WC* and lower zBMI*, improved knowledge of health foods*, and body image and satisfaction*.
Gates, A 2011	Investigate the impact of a pilot multi-component school fruit and vegetable program.	30	5 weeks	√			After the program an increase in nutrition knowledge*, and numbers of FV tried* and liked*; no change in self-efficacy; children, parents, and teachers had positive impressions of the program.
Gates, A 2016	Evaluation of the healthy school snack program.	92	4 years	√			Youth consumed more milk*, milk products*, vegetables* and fruit*. Increase in macro and micronutrients intake* and a change in food attitudes and behaviours.
Gates, M 2013 (1)	Investigate the change in milk and alternatives, calcium, and vitamin D intakes of First Nation youth following the implementation of pilot food provision programs.	85	12 months	√			Kashechewan: increased calcium intake* after 1 week, but no change from baseline and not sustained over a year Attawapiskat: increased milk and alternatives* and vitamin D* intake after 1 week. In both schools the majority of students and teachers had a positive response to the programs.

Gates, M 2013 (2)	Investigate the impact of a pilot multi-component school on milk and milk alternatives	30	5 weeks	√			Increase in knowledge and intentions of trying milk and milk alternatives, no change in reported intake.
Gates, M 2016	Evaluate the implementation of an afterschool sports program	57	9 months		√	√	There were no changes see in anthropometric measures (zBMI, waist circumference, body fat); Increased participation of MVPA*, increase in muscle strength*, increase in shuttle run stages among boys*
Harvey-Berino	Determine if maternal participation in an obesity prevention plus parenting support (OPPS) intervention would reduce the prevalence of obesity	43	4 months	√	√	√	Decreased restrictive-parental feeding style*, decreased WHZ scores, decreased energy intake*.
Karanja	Prevent excess weight gain in American Indian/Alaskan Native toddlers, by promoting breastfeeding and curtailing SSB consumption and decrease zBMI.	205	24 months	√			Successful feasibility indicators; Intervention groups higher rates of breastfeeding compared to national breastfeeding rates; parents had higher confidence in SSB and water intake for toddlers.
Kelley	Investigate the effectiveness of a cultural-tailored program, addressing Cherokee self-reliance.	100	7 weeks	√	√		Increase in Cherokee self-reliance*; decrease in perceived stress*; increase in obesity knowledge and behaviors.
Mihrshahi	Effectiveness of the Good Start program to improve knowledge, attitudes, and practices related to health eating and physical activity.	375	12 months	√	√		Increase in knowledge of F/V*, attitudes towards vegetables*, practice of F/V intake*; Increase in knowledge and attitudes towards SSBs*; Changes in knowledge*, attitudes and practice* towards snacks and sugar; change in knowledge*, attitudes, and practices towards physical activity.
Oosman	Evaluate the impact of a culture-based school health program.	37	4 months	√	√		No difference in dietary intake; reported PA; or KAB questions for diet and PA. Comparison group showed a decrease in MVPA and increase in sedentary time*; similar change not observed with intervention group
Paradis	To evaluate an obesity prevention intervention to reduce	657	8 years	√	√	√	Compared to the non-intervention community over 2 years, participants from the intervention community had a smaller increase in adiposity*; no difference in rate of increase in BMI; decrease in frequency of gym class*;

	the prevalence of obesity, high-calorie and high-fat diets, and physical inactivity among elementary school children.						lower performance of run/walk test*; no change in television watching; no changes in sugar, fat or fruit/vegetable consumption When compared over 8 years, participants from the intervention community had (compared to baseline) a higher risk in BMI and adiposity, no significant increase in physical activities or fitness; a reduction of high-sugar*, high-fat foods*, a decrease in fruits and vegetables*
Peralta	Investigate the effect of a community and school sport program on Indigenous adolescents' life skills and physical activity levels within program sessions.	34	10 weeks		√		No change in overall life skills measures or MVPA
Rinderknecht	Improve dietary self-efficacy through nutrition intervention	154	7 months	√		√	Improvement of dietary self-efficacy in participants aged 5-10-years*; no changes in dietary self-efficacy among participants aged 11-18 years. Increase in fat and sugar intake in participants aged 11 to 18 years*
Ritenbaugh	Evaluate the effects of interventions to change behaviors thought to affect diabetes risk in the school's physical environment and the ability of a curriculum to increase knowledge and enhance attitudes towards diabetes and diabetes prevention.	236	3 years			√	No difference in BMI zscore; Increase use of fitness facility; decrease consumption of sugar-sweetened drinks; Decreased plasma insulin levels*; no change in plasma glucose levels.
Ronsley	Determine if a whole-school curriculum, peer-led program to promote healthy eating, activity and self-esteem impacts anthropometrics and change behaviors.	179	10 months	√	√	√	In intervention schools had a decrease in zBMI*, WC*. In control group, increase in zBMI and no change in WC. In the intervention group: self-esteem, nutritious food consumption, healthy body image all increased.
Saksvig	Demonstrate that a culturally appropriate school-based intervention would increase the students' knowledge, skills, and self-efficacy and positively change	122	8 months	√		√	There was a significant increase in BMI* and % body fat*, an increase in nutrition knowledge, intention, and self-efficacy* Decrease in dietary energy from fat for males* not females.

	behaviors related to diet and physical activity.						
Skinner	Examine the impact of a school snack program on dietary intake.	113	3 years	✓			For children who participate in the snack group: higher fruit and vegetable intake*(2004); and higher milk and alternatives* (2007) as well as higher intake of various nutrients; children reported the program helped them eat healthier, was motivating, allowed them to eat more fruit, and make better dietary choices.
Smithers	Investigate whether a culturally appropriate multi-faceted oral health promotion intervention reduced Aboriginal children's intake of sugars from discretionary foods at 2 years of age.	454	2 years	✓		✓	Increase in anthropometric z scores*(weight, height, BMI, mid-upper arm circumference). Decrease in % energy intake from sugars and discretionary foods*; no significant change in consumption of total energy or macronutrients
Story	To reduce excessive weight gain by increasing physical activity and healthy eating practices through changes in school and household environments	454	15 months	✓	✓	✓	Compared to control schools, the interventions schools demonstrated no change in BMI, zBMI, skinfold thickness or % body fat; a decrease in prevalence of children with overweight* and lower parent-reported child intake of sugar-sweetened beverages*; reduction of fat and saturated fat in served meals*. Increase in PA time in interventions schools
Teufel-Shone	Examine whether physical activity classes could change diabetes risk factors	109	24 months		✓	✓	Increase in BMI, decrease in number of youth with high fasting glucose levels, increase in fitness measures*
Tomayko 2016	Evaluate the impact of a healthy lifestyle toolkit, delivered either by home mentors or mailings.	150	24 months	✓		✓	There was no difference in change in BMI. Children with obesity had a decrease in BMI percentile*; The toolkit led to an increase in fruit/vegetable intake*; no change in SSB; decrease in reported screen time*;
Tomayko 2018	Evaluate a healthy lifestyle promotion/ obesity prevention intervention	450	12 months	✓	✓	✓	Children in the intervention group had no change in zBMI; an increase in healthy food dietary pattern*; no change in PA, screen time; or sleep
Tomlin	Determine the impact of a whole-school physical activity and health eating intervention.	148	7 months	✓	✓	✓	No change in zBMI, MVPA, FV intake, caloric intake, or SSB consumption. Increase in zWC, aerobic fitness*, variety of vegetables consumed*.

Triador	Evaluate the impact of a gardening and vegetable/fruit snack program	76	7 months	√			Increased preference for fruits and vegetables*; no change in home consumption of fruits and vegetables.
Vogeltanz-Holm	Evaluate the effectiveness of an enhanced, culturally informed school-based program to reduce obesity and promote health	105	3 years			√	Overall decrease in zBMI over 3 years*; among American Indian children, zBMI increased from baseline to end of grade 3 and then remain stable to the end of grade 5*
Weber	Examine if portion-size training would decrease portion size estimation errors.	110	1 session	√			Within group estimation error decreased for 7 of 12 foods*; between group estimation error decreased for 3 of 12 foods*

+ Participants age < 18 years

* denotes statistically significant outcome

Table 3: Outcomes of included RCT studies

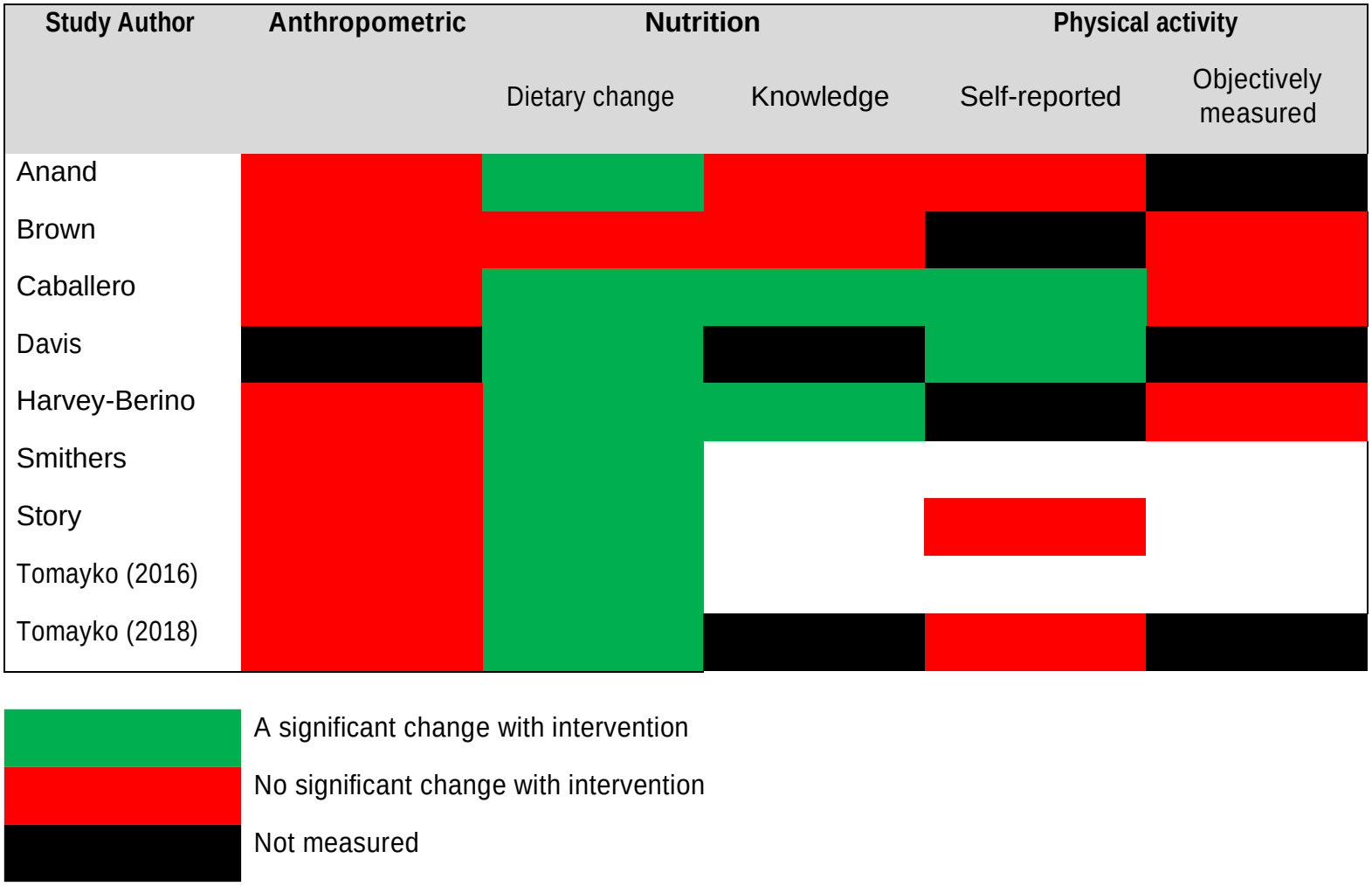
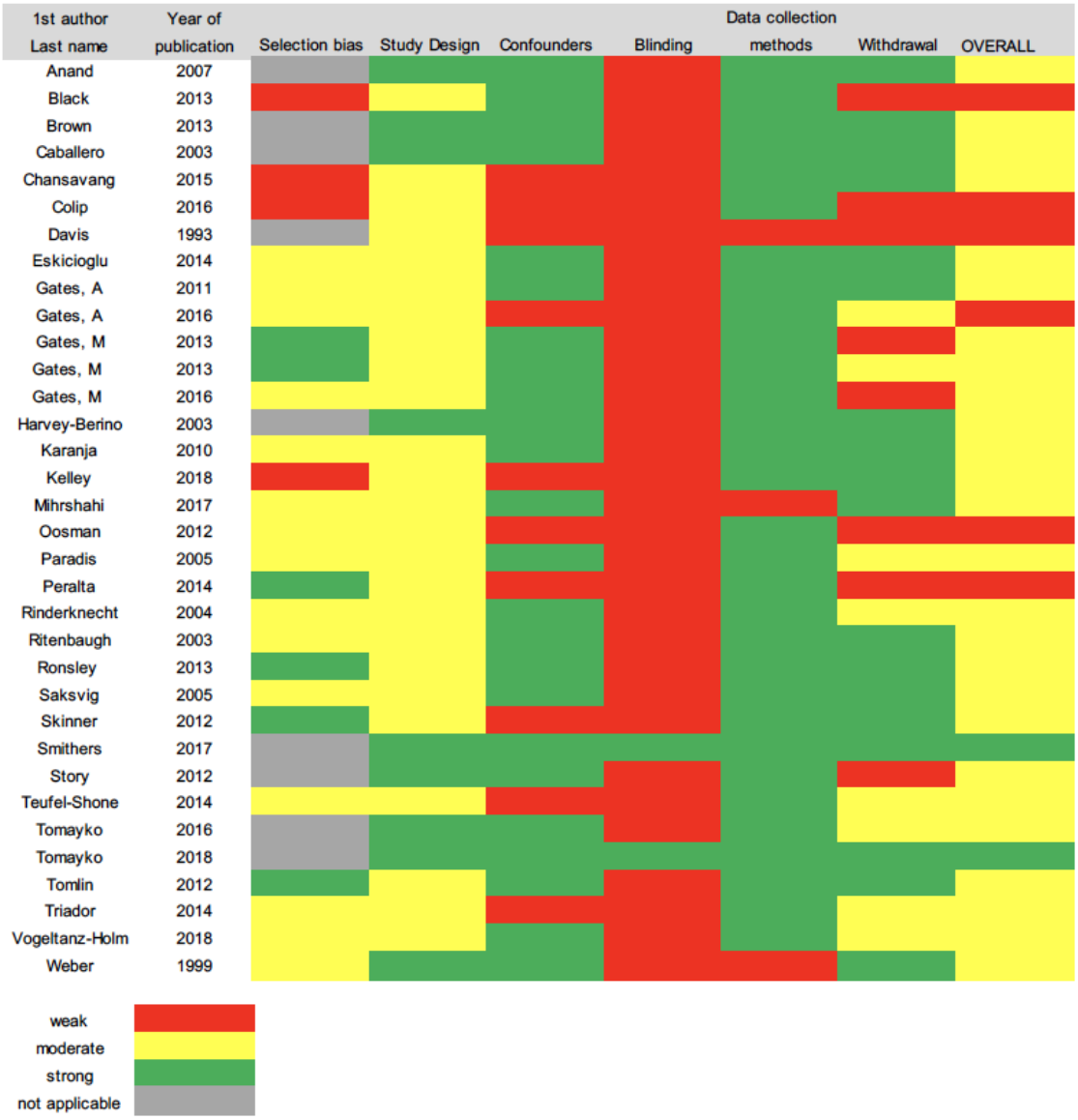


Table 4: Assessment of quality of included studies



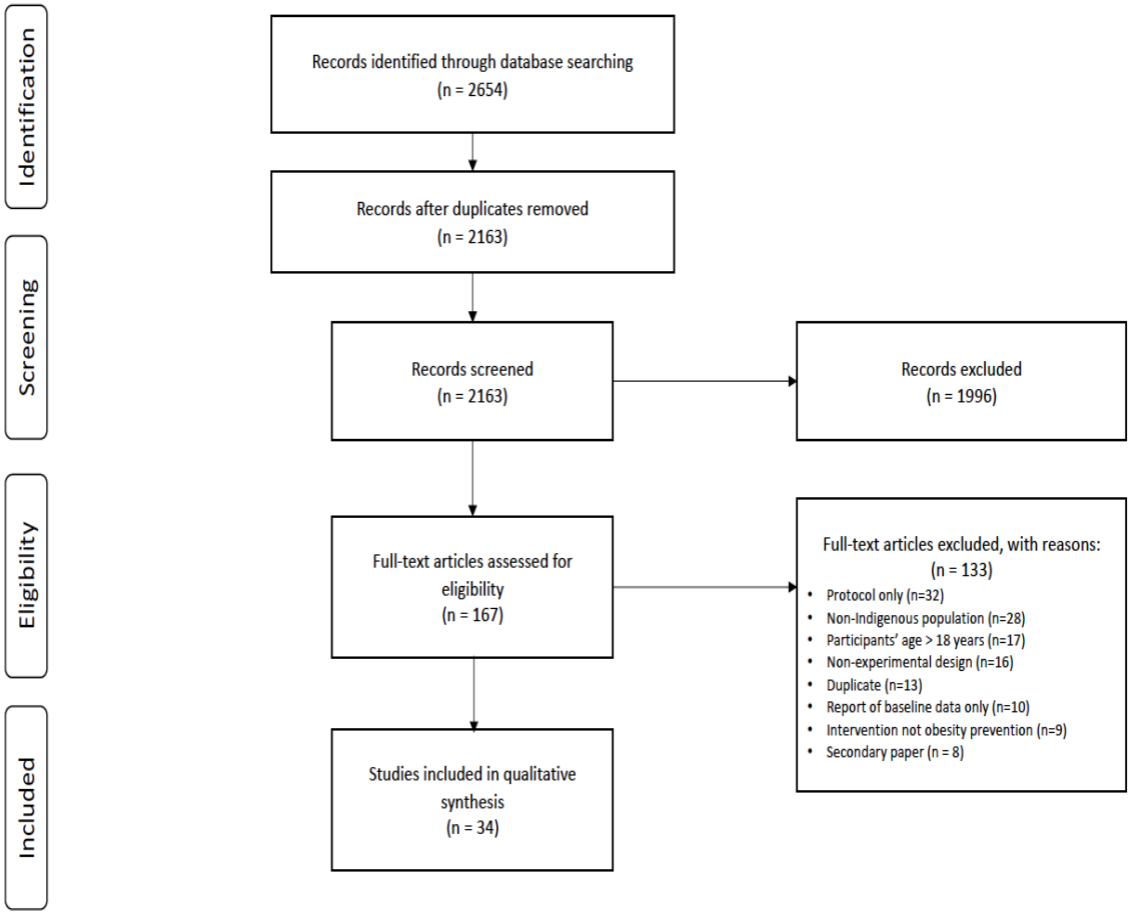


Figure 1: Flow of study selection

Appendix 1: OVID Medline search strategy August 13, 2019

# ▲	Searches	Results
1	body fat distribution/ or body mass index/ or body size/ or skinfold thickness/ or waist-hip ratio/	140677
2	(waist adj2 hip).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	12871
3	obesity/ or obes*.mp.	332205
4	adiposity/ or adipos*.mp.	146867
5	Body Composition/	40288
6	anthropometry/ or anthropometric*.mp.	70065
7	BMI.mp.	132652
8	body weight/ or body weight changes/ or body-weight trajectory/ or weight gain/ or weight loss/	240941
9	weight*.mp.	1216044
10	Waist Circumference/	9501
11	Pediatric Obesity/	7015
12	Overweight/	22745
13	Health Promotion/	70302
14	Public Health/	77222
15	community health services/ or child health services/ or community networks/ or community participation/ or health services, indigenous/	74288
16	Primary Prevention/	17651
17	prevent*.mp.	2254228
18	Schools/	35498
19	school health services/	16618
20	health education/ or health education*.mp.	84845
21	Family Health/ or Family/	94665
22	parenting/ or parent*.mp. or parent-child relations/	459284
23	health policy/ or nutrition policy/	72125
24	(health* adj2 (life* or living)).mp.	29766
25	indigenous/ or indigen*.mp.	37533
26	american native continental ancestry group/ or alaska natives/ or indians, north american/ or inuits/ or oceanic ancestry group/ or US Indian Health services/	26505
27	(native adj2 (america* or alaska* or hawa*)).mp.	8695
28	torres strait*.mp.	1601
29	(aborig* or metis or native or first nation* or inuk* or tribal* or tribe*).mp.	226462
30	(Maori* or pacific island*).mp.	11100
31	((Canad* or America* or australia*) adj2 (Native* or Indian*)).mp.	24395
32	child*.mp. or child, preschool/ or child/	2342473
33	toddler/	0
34	(teen* or adolescen*).mp. or adolescent/	2024870
35	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12	1636529
36	13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24	2993624
37	25 or 26 or 27 or 28 or 29 or 30 or 31	283074
38	32 or 33 or 34	3382510
39	clinical study/ or comparative study/ or (clinical trial* or comparative study).mp.	2668215
40	clinical trial/ or adaptive clinical trial/ or randomized controlled trial/	789663

☐	41	quasi experiment*.mp.	12120
☐	42	intervention.mp. or *Early Intervention (Education)*/	568229
☐	43	random*.mp.	1293545
☐	44	39 or 29 or 41 or 42 or 42	3339924
☐	45	35 and 36 and 37 and 38 and 44	853

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	appendix
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7

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Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	n/a
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	n/a

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7-13
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	10-11
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	n/a
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	n/a
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	n/a
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	14

PRISMA 2009 Checklist

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14-16
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	17

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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CHAPTER 4

TITLE: Impact of maternal health behaviours and social conditions on infant diet at age 1-year: Results from a prospective Indigenous birth cohort in Ontario, Canada

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ABSTRACT:

Background: Understanding the impact of maternal health behaviours and social conditions on childhood nutrition are important to inform strategies to promote health during childhood.

Objective: To describe how maternal health sociodemographic factors (e.g. socioeconomic status, education), health behaviours (e.g. diet), and traditional health care use during pregnancy impact infant diet at age 1-year.

Methods: Data were collected from the Indigenous Birth Cohort (ABC) study, a prospective birth cohort formed in partnership with an Indigenous community-based Birthing Centre in southwestern Ontario, Canada. 110 mother-infant dyads are included in the study and were enrolled between 2012 and 2017. Multiple linear regression analyses were performed to understand factors associated with infant diet score at age 1-year, with a higher score indicating a diet with more healthy foods.

Results: The mean age of women enrolled during pregnancy was 27.3 (5.9) years. Eighty percent of mothers had low or moderate social disadvantage and 47.3% had completed more than high school education, and 70% were cared for by a midwife during their pregnancy. The pre-pregnancy body mass index (BMI) was <25 in 34.5% of women, 15.5% of mothers smoked during pregnancy, and 14.5% of mothers had gestational diabetes. Being cared for by an Indigenous midwife was associated with a 0.9-point higher infant diet score (P = 0.001) at age 1-year, and lower maternal social disadvantage was associated with a 0.17-point higher infant diet quality score (p = 0.04).

Conclusion: This study highlights the positive impact of health care provision by Indigenous midwives and confirms that higher maternal social advantage has a positive impact on child nutrition.

BACKGROUND: The social determinants of health (SDoH) are defined by the World Health Organization as: "*conditions in which people are born, grow, live, work, and age*".[1] There is ample evidence to suggest that social risk including low income, lack of housing, poor literacy, inaccessibility to transportation and food insecurity have a negative impact on health outcomes.[2] These social and economic factors work upstream to influence the health of a population and are important contributors to the increasing global prevalence of non-communicable diseases, including obesity.[3,4]

Determinants of health range from proximal factors such as biological factors, individual lifestyle behaviours to social and community factors and distal determinants such as systems of policy and education.[5] Key proximal determinants of obesity and other non-communicable diseases are health-related behaviours including diet. Among children, dietary practices may impact the trajectory of health outcomes across the life course and contribute to the rising prevalence of childhood obesity.[6,7] However, childhood nutrition is influenced by a complex interplay of factors including but not limited to household income, parental education, and access to health services.[8-10] Despite widespread acceptance that obesity is a product of proximal, intermediate, and distal factors, the focus of obesity prevention programs over the last 25 years continues to focus on individual-level or proximal factors.[5] Characterizing the impact of the distal SDoH on childhood nutrition and obesity, and identifying protective factors are important to inform strategies to promote healthy nutrition during childhood and prevent childhood obesity.[11]

In Canada and other countries where historical context is rooted in the legacy of European colonization, it would be incomplete to discuss the impact of the SDoH on

obesity and related factors without considering the context of Indigenous peoples. As outlined by Reading and Wien in the National Collaborating Centre for Aboriginal Health, the overarching determinants of health that significantly impact the health of Indigenous peoples in Canada include: colonialism, racism and social exclusion.[12] In Canada, Indigenous peoples include First Nations, Métis, and Inuit peoples; they are the original inhabitants of Turtle Island, the land that is now called Canada.[13] Colonization and government-led genocide has eroded traditional practices, language and ways of life among Indigenous communities in Canada and have led to poor health outcomes.[14,15] Examples of these health disparities include rates of infant mortality, which in Canada are higher among Indigenous peoples compared to non-Indigenous Canadians.[16] Indigenous children and adults also have higher rates of chronic diseases including obesity, cardiovascular disease and diabetes.[17-20] Resiliency and strength among Indigenous communities is grounded in their connections with community, culture and traditions[21], and these cultural practices are important influences on dietary patterns of individuals and communities. The root of these health inequities must be put in the context of the government sponsored socio-political atrocities experienced by Indigenous communities.[12]

A recent systematic review of obesity prevention programs highlights the scarcity of effective programs for Indigenous children and noted a modest number of studies that showed beneficial dietary outcomes.[22] However, a dimension that is often not addressed is cultural continuity, or being connected to one's culture, which has shown to be protective against chronic diseases, such as type 2 diabetes, among First Nations communities.[21] Further understanding of contextual factors that serve as barriers to or facilitators of

optimal early life nutrition may help inform the design of future programs promoting healthy nutrition and preventing obesity. We sought to understand the factors that influence the diet of young children enrolled in an Indigenous birth cohort study (ABC),[23] with the understanding that nutrition is an important contributor to child health and the SDoH can impact dietary practices.[24,25] Specifically, in this analysis we aim to describe the health behaviours of mothers during pregnancy and infants at age 1-year, and understand how contextual factors including social disadvantage, maternal education, diet, and access to traditional health care practices are associated with infant diet, at age 1-year.

METHODS

Study design: This is an analysis of a prospective birth cohort study. Pregnant women and their newborns living in or nearby a First Nations community in southern Ontario, Canada were enrolled in the ABC study and followed prospectively to the age of 3 years between 2012 to 2017.[23] This is one of the first birth cohorts specifically for mothers and infants of Indigenous ancestry in Canada and gives a comprehensive understanding of factors in early life that may impact the health and wellbeing of Indigenous children of the community.[26] The cohort included women who self-identified as Indigenous ancestry in their 2nd trimester of pregnancy. Women who conceived using artificial methods including in-vitro fertilization or ovarian hyperstimulation, women carrying more than one fetus, surrogate mothers, or women with severe chronic medical conditions including active cancer, severe infectious diseases, were excluded.

Setting: The setting includes the Six Nations of the Grand River in Brant County, Ontario, Brantford General Hospital, Brantford Ontario, Hamilton Health Sciences Corporation,

Hamilton, Ontario,[27] and Tsi Non:we Ionnakeratstha (a Mohawk language word translating to: "The Place They Will Be Born") Ona:grahsta' (a Cayuga Language Word translating to: "A Birthing Place") - the Six Nations Birthing Centre. The Six Nations Birthing Centre was established in 1996 on the Six Nations of the Grand River Territory and is a place where Indigenous midwives provide traditional midwifery care and services.

Research-community collaboration: A community-based participatory research framework guided this research to redistribute power held within non-Indigenous research methods.[28,29] Academic researchers and community members identified areas of focus for the ABC study and strategies for addressing areas of concern, specifically childhood obesity. This specific study question was co-created with community Indigenous midwives and academic researchers in the fall of 2020. To accommodate social distancing due to COVID-19, information was exchanged over email, web-based surveys, and teleconferences. Initially, midwives completed online surveys that identified their areas of interest including time periods, e.g., pregnancy, birth, early childhood, as well as topics that were important to them. Subsequently, two group meetings were held over teleconference to discuss survey results and refine the questions. Through discussion of Birthing Centre priorities, available cohort data, and previous projects completed together, a list of topics and questions of interested were compiled. Generated within the list of ideas was a priority of understanding the impact of SDoH on child outcomes, including nutrition, and the impact of the care of the traditional Indigenous midwifery practice. Follow-up discussion of the data framed analysis and the interpretation of results.

Data collection: The women enrolled in the ABC study underwent a baseline assessment in their second trimester of pregnancy with subsequent data collection for mothers and infants at birth, 6 weeks, 6 months, then annually until age 3 years. Data collection methods and measures are previously published.[23] Data collected for mothers and offspring included demographics, medical and social history, as well as lifestyle behaviours including nutrition, physical activity, and sleep. For the purposes of this study, data is included from the maternal baseline visit during the second trimester of pregnancy and follow-up visit at 1-year. *Healthy lifestyle characteristics* including physical activity and screen time behaviours were self (or parent)-reported, from the mother's baseline visit during pregnancy and from the child's 1-year follow-up visit. Infant sleep duration for a 24-hour period was collected from parent-reported survey at age 1-year. *Dietary data* were collected with previously validated semi-quantitative food frequency questionnaires (FFQ) or when not available a 19-item short qualitative food frequency questionnaire.[30,31] The maternal FFQs were administered to the mother at the baseline visit during pregnancy and at 1 year follow-up. The infant FFQ was collected at age 12 months.[31] The FFQ asks the respondent to recall, on average, how many times a specified food (or group of similar food items) was consumed over a specified time (e.g., once or more per day; once per week; once or less per year). Individual foods were classified into food groupings to account for similar types of foods, for example the grouping 'fish and seafood' included items on the FFQ such as 'fish in batter', 'other white fish', 'oily fish', and 'canned fish'. We then calculated the average number of times the food was consumed per day. If the consumption was reported as a "per week" time-unit, by the participant the amount was divided by 7

(e.g., once per week = 0.14 times per day), if reported as "per month", divided by 30.44 (e.g., once per month = 0.03 times per day) and if reported "per year", divided by 365.25 (e.g., once per year = 0.003 times per day).

Through discussions with community members from the study team and informed by prior focus groups and interviews[25], we created two lists of foods. The first was "healthy foods" (HF), these were foods that were encouraged in the diet of a 1-year-old, and the second group were "less healthy foods" (LHF) that were advised to consume infrequently at age 1 year. The HF category included the following food groups: vegetables, fruit, meats, fish, breastmilk, traditional foods, whole grains, and nuts. The LHF category included the following food groups: processed foods (e.g., pizza, hot dogs, deli meat), sugar sweetened beverages (SSBs), sweets, and refined grains.

The distribution of consumption frequencies for each of the healthy and less-healthy foods were placed into quartiles to generate healthy and less healthy diet scores. Consuming more than 75% of a specific healthy food (i.e., >75th percentile) was equal to a score of 4 for a food; between 50-75%, a score of 3; and 25 to <50%, a score of 2, and <25th percentile, a score of 1. Breastfeeding was assigned by duration in months. The highest possible HF score was 32 (8 foods x 4), and the lowest was 8 (8 foods x 1). The same procedure was used for the LHF score, for which the highest possible score was 16 (4 foods x 4), and the lowest was 4 (4 foods x 1). Next, the HF and LHF scores were divided into quartiles, named the qHF and qLHF scores, which accounted for the different number of foods in each score. We used a similar system of scoring as we did for the individual scores, where the lowest quartile was assigned 1 and then highest quartile assigned 4. Infant

diet score (iDS) was defined as the difference between qHF and qLHF. It had a maximum value of 3 and minimum value of -3, with a higher score signifying a larger amount of healthy foods in the diet. The iDS were dichotomized with a value >/= 0 as a 'positive diet score' with more healthy foods and < 0 as a 'negative diet score' or more unhealthy foods for comparison of maternal and child characteristics between groups.

Contextual factors We sought to understand the impact of contextual factors on infant diet and the following constructs were chosen to be included in the model based on a review of the literature and guidance from the local midwives: maternal social disadvantage, maternal education, maternal dietary score, and health care provider. Maternal social disadvantage was defined by the social disadvantage index (SDI).[32] The SDI is a score that combines income, employment, and marital status, developed and validated with a multiethnic cohort of adults.[32] We calculated the SDI for the mother with a score out of 5 where 0 - 1 is considered low, 2-3 considered moderate, and 4-5 as high social disadvantage.[32] Maternal education was self-reported on the baseline questionnaire and dichotomized as less than or equal to high school or more than high school. Maternal diet score was calculated as previously described.[30,31] The health care provider was recorded for each participant, which included Indigenous midwife at the Six Nations Birthing Centre or other provider, for example, nurse practitioner or obstetrician practicing in a western medicine model.

Statistical Analysis: To understand differences in the distributions of contextual factors between infants with positive and negative diet scores, we performed Fisher's exact test to compare the distributions of categorical variables, and t-tests or Mann-Whitney U tests to compare means of continuous variables. We performed multiple linear regression analyses

to identify factors associated with infant diet score. Unadjusted and adjusted linear regression analyses were presented with beta coefficients, standard errors, and p values. First, each potential predictor variable was tested for its univariate association with infant diet score. Next, those variables significantly associated with diet score (simple regression $p < 0.10$) were included in the multiple regression model. The variance inflation factor was used to understand the possibility of multicollinearity among all the variables included in the models (<5 indicated insignificant collinearity). The alpha was set at <0.05 for all statistical tests, with no adjustment for multiplicity. All analyses were performed using IBM SPSS Statistics for Macintosh, Version 26.0. Armonk, NY: IBM Corp.

RESULTS:

There were 157 women recruited into the cohort between 2012 and 2017, and two participants withdrew, leaving 155 mother-infant dyads. Baseline maternal and infant characteristics are shown in Table 1. Of the dyads followed through infant age 1-year, 71% (n = 110) had complete food-frequency data for mothers at baseline and infants at age 1-year. The average age of mothers in the cohort was 27.3 (SD = 5.9) years. A total of 14.5% of mothers had gestational diabetes during second trimester screening using glucose tolerance tests and 34.5% of mothers had a pre-pregnancy body mass index (BMI) of less than 25. Overall, 15.5% of mothers smoked during pregnancy. Self-reported minutes of exercise/day was 35.8 (52.6), and they reported 196.0 (147.0) minutes/day of screen time. The average maternal diet index was 1.3 (7). With regards to contextual factors, 80% of mothers had low or moderate social disadvantage with a mean (SD) SDI score of 2.13 (1.52) and 47.3% had completed more than high school education. Most participants (70%,

n = 77) received prenatal care at the Birthing Centre, and the others with care providers including local obstetricians or primary health care providers. Of the infants, 47.3% were female, mean gestational age was 38.0 (1.7) weeks, mean birth weight was 3578 (486.9) grams and 71.8% were birthed by vaginal deliveries.

One year assessment: At the 1-year visit, 60.9% of infants had been breastfed for > 6 months, and the mean infant diet score was -0.04 (1.2), with 29% (n=32) having a diet score greater than 0 which we classified as a 'positive diet score'. The duration of mother-reported infant physical activity was 222.1 (179.7) minutes per day and exposure to screen on during day was 5.0 (5.0) minutes per day. Sleep, for children at age 1-year in a 24-hour period, was reported as 750.4 (102.4) minutes (~12.5 hours).

Table 2 compares contextual factors between infants with positive (n=32; mean = 1.4, SD = 0.6) and negative (n=78; mean = -0.6, SD = 0.9) iDS. The proportion of mothers who had completed more than a high school education was higher in the positive infant diet score group compared to the negative infant diet score group (69% vs. 39%, p = 0.014). There were more mothers experiencing low or moderate SDI (vs. high) in the positive infant diet score compared to negative infant diet score group (92% vs. 68%, p = 0.016). A significantly higher proportion of women had a household income >$60,000 annually in the positive iDS than the negative iDS group (41.9% vs. 22.7%, p = 0.047). More mothers in the positive iDS group were cared for at the Birthing Centre than in the negative iDS group (87.5% vs. 62.3%, p = 0.012). The maternal diet score was higher among infants with a positive versus negative diet score (p=0.01). There were no other significant differences in the groups with the positive and negative infant diet score for other maternal

characteristics. There were no differences in infant characteristics between high and low iDS groups, except for gestational age being slightly lower in the positive iDS group (38.4 vs. 39.1 weeks; p = 0.05).

Results of the univariate and multiple linear regression analyses are shown in Table 3. In the multiple linear regression model, care provided by Indigenous midwives at the Birthing centre was associated with higher infant diet scores (B = 0.9, SE 0.25; p = 0.001). Also, a 1-unit lower SDI score, (i.e., low social disadvantage) was associated with higher iDS (B = 0.17 (0.08) p = 0.039). Maternal diet was significant in the univariate analysis but did not remain significant in the multiple linear regression analysis. Maternal education was not significantly associated with infant diet score.

Discussion

In this paper, we describe demographic, health, and health behaviour characteristics of a cohort of Indigenous mothers and infants in Ontario, Canada.[23] We show a positive influence of low social disadvantage and with pregnancy-related health care provision by Indigenous midwives on infant diet at one year after birth, reflected in a higher infant diet quality score.

Most participants in this study received care through the Birthing Centre. The availability of holistic and community-services spanning pregnancy to early childhood may be a mechanism for higher dietary scores among those cared for at the Birthing Centre. For example, within the Birthing Centre, co-existing services and guidance from an Elders "Grandparents group" provides support for mothers and families from pregnancy into early childhood with services, including: prenatal classes, Healthy Baby, Healthy Children

services led by community health workers, breastfeeding support from an Indigenous lactation consultant, and 'Mom and Tot' groups. This highlights that Indigenous midwifery care is an important and central part of health services, not only for the health care services they provide, but also for the culturally-appropriate and support for safe practices and services that they facilitate.[33] Access to perinatal health care is essential for all mothers, and for care to be effective, it must be provided in a manner consistent with cultural values and beliefs.[34] In Canada, disparities in access to prenatal and birthing care for Indigenous communities has led to poor health outcomes for Indigenous mothers and infants.[35,36] This study provides a strong argument for ongoing funding, development, and implementation of localized, culturally-sensitive antenatal and early childhood care within Indigenous communities and with access for all Indigenous mothers.

We found that lower maternal social disadvantage during pregnancy was associated with a higher quality infant diet at age 1-year. Also of note, among infants with a positive diet score, it was more likely that mother's had higher income, more education, and higher diet score. In this study the social disadvantage index was used as a measure of socio-economic status. It has been observed that adults with a higher SDI score have higher cardiovascular risk factors.[32] The SDI was developed over 20 years ago, as a measure of socio-economic disadvantage. Anand *et al* recently showed its utility in a multi-community evaluation of cardiovascular risk factors in eight First Nations communities across Canada.[37] We believe this measure is still valid as the circumstances of participants in our cohort remain comparable to a previous cohort of adult communities from that time, as demonstrated with similar SDI scores.[32,38] A plausible explanation linking social

disadvantage to infant diet is the hypothesis that it is a proxy for household food insecurity, or inadequate access to food. Though we did not directly measure household food insecurity in our study, it may be part of pathway linking SDI to infant dietary score and has previously been shown to be related to poor general health in children.[39] Further, the prevalence of food insecurity among Indigenous communities in Canada is high[40] and has a significant impact on health outcomes.[41] This study is another observation that adds to the argument for the considering of the social determinants of health for families with young children as a key pathway to improved child health outcomes.

We considered if the participants in our sample had health profiles comparable to other populations. Compared with a retrospective chart review of 453 mothers and infants from the Six Nations Birthing Centre between 2005-2010, the ABC study included mothers of older age, lower pre-pregnancy BMI, and with a lower rate of smoking during pregnancy, but higher prevalence of gestational diabetes mellitus (14.5% vs. 4.7%).[42] Considerations for the difference in rates of GDM include that the retrospective chart review only included mothers cared for at the Birthing Centre, whereas the ABC study also included mothers cared for by obstetricians, and therefore may have had different medical profiles; further in the ABC analysis OGTTs were administered in a standardized manner whereas the method of testing was not collected from the retrospective study. In a systematic review, Voaklander *et al* describe higher rates of diabetes during pregnancy among Indigenous mothers in Canada, United States, Australia and New Zealand, although interestingly the incidence of GDM is lower when compared to a recent South Asian study reported in Canada.[43]

Infants in our cohort had a lower birth weight and gestational age compared to observations from the Birth Centre chart review.[42] Over 60% of infants were breastfed for more than 6 months, which is considerably higher than the ~33% of First Nations mothers living off-reserve as reported by Statistics Canada's 2006 Aboriginal Children's Survey.[44]

Diet is a key determinant in the trajectory of non-communicable chronic diseases including obesity.[45,46] For example, children with higher intake of processed foods and sugar sweetened beverages are at greater risk of developing obesity. The diet score created in this study was based on direct input from community members and consistent with a healthful traditional dietary pattern for young children.[25] Despite the rich traditions, heterogeneity, and diversity between Indigenous communities, similar themes emerge from distinct communities regarding traditional food consumption among children.[47] Specifically, traditional foods are an important source of nutrients and important for health, but not commonly consumed. A study with Inuit children attending daycare in Nunavut showed that only 3% of 245 children consumed traditional foods, but those that did had a higher intake of macro- and micronutrients.[48] Other studies have corroborated this including a study with Indigenous infants from rural Australia, where a cross-sectional study using 24-hour dietary recalls found that >50% of children consumed some traditional foods, and these foods were more nutrient-dense.[49] However they also observed that traditional food consumption decreased with times of food insecurity.[49] A systematic review of diets of school-age Indigenous youth in Canada summarized 24 articles and found 7 that reported on traditional food consumption.[50] In these 7 studies, traditional foods were an important dietary source of micronutrients for children, but intake was infrequent

in most settings.[50] Further, traditional food consumption has been associated with positive health outcomes as demonstrated by the Six Nations of the Grand River community-led, Haudenosaunee traditional food initiative, *Healthy Roots*.[51] Access to traditional foods should therefore be considered in future programs and evaluations of programs concerning infant diet in Indigenous communities.

Strengths of this study include leveraging the prospective cohort study design to understand relationships between family context and child-health outcomes. The other key component to this study was the co-creation of the study question by Indigenous midwives, community members and the academic study team. The development of the study question, allowed for the exploration of the impact of traditional midwifery care, an important consideration for community study team members. The primary outcome of infant diet was directly informed by qualitative interviews and a community focus group[25] and further embeds the results within the context of the community, which will improve the usefulness of the study findings in practice. Limitations to this study include the attrition of the cohort at the 1-year visit (71% follow-up at 1-year). There are also limits to the generalizability of the study results due to the non-randomly selected convenience sample, as well as the fact that only one community was included in the cohort. Therefore, the study results may not be applicable to other communities give the rich traditions and ways of life unique to each Indigenous community in Canada.

In conclusion, this study demonstrates the impact of important protective factors of higher social advantage and access to a model of healthcare that is congruent with

traditional ways of life. The academic-community partnerships among the study team led to important findings relevant to care providers.

Table 1: Maternal characteristics at baseline and infants at age 1-year

Characteristic	Total (n = 110)	N
Maternal		
Age at baseline[a]	27.3 (5.9)	100
Self-report exercise (min/day) [b]	30 (50)	106
Self-reported screen time (min/day) [b]	180 (215)	107
Diet index score[b]	1.3 (7)	94
Gestational diabetes during this pregnancy%[c]	14.5	110
Pre-pregnancy Body mass index (BMI) [a]	27.6 (6.9)	104
Pre-pregnancy BMI <25%[c%]	34.5	104
Social disadvantage index (low/moderate)[c]	80	105
SDI[a]	2.13 (1.52)	105
Maternal education more than highschool[c%]	47.3	109
Maternal smoking[c%]	15.5	110
Birthing centre[c%]	70	110
Infant	**N = 110**	
Gestational age (weeks) [a]	38.9 (1.7)	88
Sex (female) [c%]	47.3	91
Birth weight (grams) [a]	3578 (486.9)	97
Birth mode (vaginal) [c%]	71.8	89
Age 1-year visit (months) [a]	1.3 (0.4)	103
Weight at 1-year (kg) [a]	11.3 (2.6)	97
Breastfeeding (>6mo)[c%]	60.9	103
Self-reported Physical activity (min/day)[b]	150 (235)	67
Screen (TV) on at home during day (min/day) [b]	5.0 (5.0)	67
Sleep (min/24hours) [a]	750.4 (102.4)	69
Diet score[a]	-0.04 (1.2)	110

[a] mean (standard deviation); [b] median and interquartile range; [c] count (%)

Table 2: Maternal and infant characteristics at age 1-year in positive and negative diet score

Characteristic	Infant + diet score (n= 32)	Infant - diet score (n = 78)	p
Maternal			
Age at baseline [a]	28.4 (5.1)	26.8 (6.2)	0.21
Maternal smoking [b]	12.5%	16.6%	0.77
Gestational Diabetes Mellitus [b]	18.8%	12.8%	0.55
SDI (low/moderate) [b] *	92.3%	67.8%%	**0.016**
- SDI (married) [b]	75%	64.9%	0.37
- SDI (employed) [b]	65%	50%	0.09
- SDI (income >60,000) [b]	41.9%	22.7%	**0.047**
Maternal education more than highschool [b]	69%	38.5%	**0.014**
Maternal pre-pregnancy BMI <25 [b]	35.7%	36.8%	1.00
Maternal Diet score [c]	2.7 (6)	0.5 (6)	**0.01**
Birthing centre [b]	87.5%	62.3%	**0.012**
Infant			
Gestational age [a]	38.4 (2.3)	39.1 (1.2)	0.05
Sex (female) [b]	56.2%	41.7%	0.18
Birth weight (grams) [a]	3520.9 (523.9)	3604.4 (471.3)	0.44
Birth mode (vaginal) [b]	87%	89.6%	0.73
Age 1-year visit (years) [a]	1.19 (0.21)	1.28 (0.41)	0.25
Weight at 1-year (kg) [a]	11.2 (2.0)	11.3 (2.8)	0.84
Breastfeeding >6 months [b]	86.7%	56.1%	**0.003**
Infant Diet score [a]	1.38 (0.55)	-0.62 (0.87)	**<0.001**

* The Social Disadvantage Index (SDI) was developed from an ethnically diverse sample of Canadian adults and takes into account income, marital and employment status.[32] A score out of 5 is calculated. A score of 0 – 1 is considered low 2-3 considered moderate and >4 as high social disadvantage.[32]

[a] mean (standard deviation); [b] count (%) [c] median (interquartile range)

Table 3: Multiple linear regression models for infant diet score

Factor	Univariate Analysis Beta (standard error) p	Multivariate Analysis Beta (standard error) p
Maternal SDI	-0.21 (0.08) p= 0.007	-0.17 (0.08) **P = 0.039**
Maternal education	0.18 (0.14) p=0.28	-
Maternal diet score	0.04 (0.02) P= 0.004	0.03 (0.02) P = 0.11
Care provider	0.94 (0.24) p=<0.001	0.90 (0.25) **P = 0.001**

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CHAPTER 5

Summary of Findings

The overall purpose of this thesis was to explore and understand communities' priorities, effectiveness of programs, and determinants for obesity prevention strategies among Indigenous children. With a guiding framework of community-based participatory research (CBPR) methods[1], this thesis consists of two published manuscripts and one manuscript prepared for submission. As described in Chapter One and developed further in the chapters that followed (Chapters 2-4), this thesis includes the methods and findings of three distinct but related studies, each requiring the application of a different methodology. The foundational work, using formative methods including community engagement workshops and a qualitative descriptive study, centres the priorities for child health-related behaviours and health promotion of members from two First Nations communities in Canada.[2] The overarching themes highlight that for components of obesity prevention for young children, including healthy nutrition and physical activity, '*traditional Indigenous ways of life are the primary pathway to health and well-being for young children and families.*[2] Further, through community engagement workshops key components of diet and physical activity which are considered 'healthy' and 'less healthy' for children from the communities were designated. This prioritization activity was essential for informing the construction of a diet score that was subsequently utilized as a primary outcome in Chapter 4. Lastly, participants underscored the impact of the SDoH on behaviours, and most importantly they specified the context - that Indigenous health includes the crucial impact of historical traumas and colonization on traditional

knowledge and teachings, and the consequences on the health behaviours and wellbeing of children and families, now termed by many as the Indigenous determinants of health.[3]

The findings from the initial formative study were then used to inform a systematic review (Chapters 3) and analysis of data from a prospective birth cohort (Chapter 4). The key concepts of traditional ways of life, prioritization of traditional foods and physical activities, and descriptions of facilitators and barriers to community programs were further developed and integrated. In Chapter 3, we reviewed the broader context of childhood obesity prevention programs, and described the existing literature in a systematic review of the effectiveness of programs aimed at obesity prevention and health-related behaviours among Indigenous children.[4] We found that among obesity prevention programs with Indigenous communities in Canada, United States, Australia and/or New Zealand there was only a few studies with changes in anthropometric measures (3 of 34 studies).[4] Further, 14 of 34 studies reported some positive change in nutrition-related outcome[4] and four of 18 studies that reported some measure of physical activity showed benefit.[4] Overall, programs included in this review focused on Indigenous communities and demonstrated limited success in improving health-related behaviours such as nutrition or physical activity, and prevention of obesity.[4]

The final study of this thesis (Chapter 4) included analysis of data from a prospective birth cohort. The ABC study was conducted to determine the association between maternal health behaviours, social context, and infant diet.[5] The key findings included the observation of a positive impact of care provided during pregnancy and birth by Indigenous midwives on child health behaviours, specifically the diet of offspring at

age 1-year. Further, we confirmed that maternal social advantage, defined as a composite of employment, family structure and income, has a positive impact on childhood diet as measured by a derived infant diet score.

The three studies exemplify different components of obesity prevention and promotion of health-related behaviours and synergistically inform future work. The studies are framed by the overarching theme of community-based participatory research methods used to explore health promotion and obesity prevention.

Influence of Social Context on Research Program

The work in this degree was completed over 8-years, and the social and political context during that period is an important consideration to help contextualize the interpretation of the data and the final conclusions. This timeline is important as over this interval there have been many notable events, including but not limited to the release of the Truth and Reconciliation Commission of Canada (TRC) report in 2015;[6] the Coronavirus SARS-CoV-2 (COVID-19) global pandemic in 2020; and the further uncovering of unmarked graves of Indigenous children on the lands of former Residential Schools.[7] These events were influential during different times of this dissertation and prompted me to question my position in this work, the relationship of the work with the community members it is meant to serve, and the impact the work has in the field of childhood obesity prevention.

Truth and Reconciliation Community of Canada

The Truth and Reconciliation Commission of Canada (TRC) issued their report in 2015.[6] The TRC, led by Justice Murray Sinclair, was initiated from the Indian Residential

Schools Settlement Agreement and included interviews of over 6,000 witnesses, many of whom had endured and survived abuse and trauma during their childhood in residential schools. The TRC report outlines the truth and the traumas endured by Indigenous children taken to residential schools in the name of education, which in fact was genocidal policy by the Government of Canada to eradicate the culture, knowledge, and ways of knowing of Indigenous peoples. At the time the TRC was released I was interviewing participants for the qualitative descriptive study in Chapter 2 of this thesis. In our discussion of health promotion for children and families, a participant had this to say:

... even today the whole TRC information and closures coming out today, and it is very close to my heart because my husband's mom was a residential school survivor – is a residential school survivor and has very much impacted him and therefore us, and therefore our children. So looking at even food, and I think how food connects to our spirit. And a lot of us sort of disconnect food to our spirit and that linkage.

This direct participant quote speaks to the intergenerational impact of the distal determinants of racism and colonialism on individual-level health behaviours. And on further reflection, this was a key data point connecting the socio-political context to the interpretation of the data from Chapter 2 and was instrumental for the overarching direction of this dissertation. Further, the TRC outlined 94 Calls to Action. I have identified 11 of the TRC's Calls to Action which this dissertation's findings are in line with and support,[8] and briefly outline the specific findings from Chapters 2-4 that further amplify the Calls to Action, see Table 1.

COVID-19 pandemic

The global impact of the COVID-19 pandemic cannot be understated. It has led to enormous disruptions of political, social, economic, and healthcare systems. The direct consequences of the COVID-19 pandemic include significant measures of morbidity and mortality. Over 28,900 Canadians died from the start of the pandemic in early 2020 to October 2021.[9] There have also been indirect health consequences, including but not limited to, disruptions of preventative health care including cancer screening programs, increase in poor mental health outcomes due to social isolation, and disruptions of in-person school for children, of which the educational and developmental consequences have yet to be fully described.[10] Further, what the COVID-19 pandemic also highlighted were the divergent burden of illness and consequences between populations.[10] For example, in Canada the mortality from COVID-19 was 2-times higher in areas where more than 25% of the population identified as visible minorities, compared to areas with less than 1% of the population identifying as visible minorities.[10] Indigenous peoples in Canada also shared this increased burden with worse self-reported health and mental health outcomes and higher unemployment rates at the end of 2020.[10] However, despite ongoing social inequities, the resilience and leadership within Indigenous communities has contributed to lower rates of mortality and cases among First Nations, Métis, and Inuit communities in Canada.[11] In their commentary in the Canadian Medical Association Journal, Richardson and Crawford describe examples of the public health preparedness of Indigenous communities in Canada grounded in principles of self-determination and decolonized Indigenous public health measures.[11] Their call for Indigenous public health

measures as a conduit for better health outcomes for Indigenous communities could be replicated for other public health issues, including those addressed in this dissertation. *At its foundation, Indigenous public health must be self-determined: adapted for the needs of specific nations and grounded in local Indigenous language, culture and ways of knowing; developed, implemented and led by Indigenous Peoples; and informed by ongoing monitoring of data as governed by appropriate data sovereignty agreements.*[11(pE1100)] Over the past 1.5 years, there has been an increased focus on, and implementation of, public health policies and measures to mitigate and prevent the transmission of COVID-19. When considering the findings in this dissertation as an example, the description of Indigenous public health illustrated by Richardson and Crawford resonate strongly. If similar principles of self-determination were applied on a large scale to the health-related behaviours that contribute to obesity prevention and health promotion efforts, I foresee an improvement in individual and family health behaviours and an overall improvement in the health of children and future generations.

The truth of Residential Schools

From my position as a settler, the uncovering of unmarked graves of Indigenous children on the lands of former Residential schools in Canada evoked feelings of anger, guilt, and sadness. This, however, cannot compare to the experiences and feelings of Indigenous families and communities directly impacted by the historical and ongoing conditions and events. It is not yet known the exact number of unmarked graves that will be uncovered, as many ongoing investigations continue.[12] There are many points in this dissertation that 'distal determinants of health' and 'Indigenous determinants of health'

are referenced.[3] However, the constant and ongoing assault on Indigenous communities is displayed, without any doubt, through the horrific uncovering of unmarked graves of children.

As the media reported unmarked gravesites, from my vantage as a pediatrician, child health researcher, and mother, I questioned the statement of positionality I wrote in Chapter 1. Reflexivity is how a researcher examines their positioning as it relates to the research.[13] I initially describe my positioning in this work since this dissertation includes qualitative research methodology. However reflexive practice was a central process during the journey through each component of this thesis including in the writing of this final chapter. Whitaker and Atkinson describe that *"central to reflexivity is an awareness that the researcher and the object of study exist in a mutual relationship with one another"*.[14(p1)] This particularly resonates with me as I consider my position of privilege as a non-Indigenous settler and researcher. Privilege can be described as benefits or advantages that are conferred some people or groups and not others.[15] However, an important concept to acknowledge is that my privilege is possible because of a systemic injustice that in turn oppresses another group. In Nixon's model "*Coin Model of Privilege and Critical Allyship*",[16] she asks one to imagine that if there are two sides of a coin, the top side would be those that have unearned advantages, or 'privilege'; and the other side, the bottom side of the coin, are groups that are oppressed.[16] The coin itself represents the systemic injustice that has led to the separation of the groups on either side and each individual coin would represent different 'systems of inequality', for example, ableism, sexism, and racism.[16] The representation of the concept of privilege and oppression is

fundamental to my practice of reflexivity in this work. Further, how I interact with the 'coin' or the systemic injustice, is the component of allyship that has evolved over the near decade of this work. By acknowledging my position, and naming the unearned advantage given to me by the systemic injustice of colonialism and racism against Indigenous peoples, I initially considered this as form of allyship. However, over the course of this dissertation and most notable over the last few years, I have struggled with the feelings of guilt from the privilege I hold in the context of this work with Indigenous communities. The feelings of guilt likely led to a paralysis in moving the dissertation forward and an increase in time to complete the work. I have spent a considerable amount of time naming and then reflecting on these feelings. By engaging with the literature and discussions with close colleagues and community members with whom I share this work, I progressed my understanding of both my feelings of guilt and allyship, to a place where I felt that my work is not merely performative, but truly active and in solidarity. In reference to masculinity and violence, Michael Kaufman writes: "*Guilt is a profoundly conservative emotion and as such is not particularly useful for bringing about change. From a position of insecurity and guilt, people do not change or inspire others to change*."[17(p14)] Positioning my guilt alongside my privilege not only centres me, but voids me of my responsibility towards action.[16] Therefore, I acknowledge the feeling but refocus on the root of it and the need for action, which is to pull apart the systems of oppression that have led to health inequities for Indigenous peoples due to persistent and pervasive colonialism and systemic racism. Only by acknowledging its existence, ongoing influence, and taking action towards dismantling the systems of oppression will I be

practicing 'active' allyship.[16] I hope this dissertation serves as a call to action in the area of childhood obesity prevention among populations that are marginalized by systemic injustices, and highlights the importance of moving towards the strengths of communities and dismantling the roots of 'vulnerability' which are in fact systems of oppression.

Key Contributions

I will outline the key contributions of this thesis to the area of childhood obesity prevention and research methodology.

Obesity Prevention and Health Promotion programs for Indigenous Children

In 2012 the Public Health Agency of Canada (PHAC) released a report: *Curbing Childhood Obesity: A Federal, Provincial and Territorial Framework for Action to Promote Healthy Weights*.[18] Along with reinforcing the importance of recognizing childhood obesity as a complex condition requiring a multi-sectoral response, the document outlined a vision statement that read: *"Canada is a country that creates and maintains the conditions for healthy weights so that children can have the healthiest possible lives."*[18] The framework within this document outlined three strategies to achieve this goal:

1) Making childhood overweight and obesity a collective priority for action

2) Coordinating efforts on three key policy priorities: Supportive Environments; Early Action; and Nutritious Foods

3) Measuring and reporting on collective progress in reducing childhood overweight and obesity

A follow-up report to this framework was published in 2015, including a dashboard of progress at the provincial and territorial level.[19] In reviewing this framework and follow-up report, there are considerations from this dissertation that are congruent with key recommendations of the reports.[18,19] One could apply findings of this dissertation to the next iteration of a childhood obesity report that focuses on public health and multi-sectoral partnerships. Of note, the PHAC framework is by design broad, and does not specifically address health promotion in the context of Indigenous worldviews. However, in the introduction of the report, the disparity of health outcomes around childhood obesity among Indigenous communities is acknowledged.[18]

Making childhood overweight and obesity a collective priority for action is a call for multi-sectoral partnership across federal, provincial, and territorial Ministers of Health and Health Promotion as champions of collective efforts.[18] I would argue that a broader cross-section of partnerships be named in the engagement efforts. Though health and health promotion are cornerstones in this area, contribution from leadership in economics, education, housing, and environment, and from Indigenous leaders across the country must be made to impact the trajectory of obesity prevention and health promotion. This was clear from Chapter 2 where the priorities, facilitators and barriers to health promotion efforts were identified by two communities[2], and Chapter 3 where, despite a few multi-level programs, the impact was not significant amongst most interventions to date.[2]

Coordinating efforts on three key policy priorities: Supportive Environments; Early Action; and Nutritious Foods, this point suggests that health promotion efforts should be targeted to improving child health outcomes throughout the early years.[18] The PHAC framework suggests that settings for interventions should include the early years educational settings, schools, and community settings. And would also target areas of health promotion including breastfeeding, community safety, and physical activity. Many of these suggestions arose at a point in this dissertation. Although the strategy of the framework suggests a top-down approach to championing efforts from federal, provincial, and territorial governments, I would argue that community-led solutions would hasten progress significantly. Placing control of resources at the level of communities where it has been identified that the safety of the built environment has an impact on physical activity;[2] and that school-based interventions that include peer mentoring models show early promise;[20,21] are examples of self-determination within health promotion that would translate to community-led success.

Measuring and reporting on collective progress in reducing childhood overweight and obesity is the last recommendation.[18] It outlines that data must inform policy, specifically that childhood overweight and obesity be tracked, including proximal factors that impact growth trajectory (e.g., diet, physical activity, knowledge, and behaviours), and should be reported to allow for feedback of existing programs. Currently, data that have been used for national reporting on childhood obesity does not include children living on First Nations Reserves.[22]

There are two considerations for this recommendation. Firstly, although it is important that childhood overweight and obesity be tracked, it is likely just as, if not more, important to embed this within national-level data that tracks the health and development of Canadian children broadly. It is quite clear in the literature that the origins of obesity are complex and multi-factorial, and the trajectory of growth in childhood is a symptom of a larger imbalance not merely at the level of the individual or even the family, but the built environment and economy.[23] The second consideration is that as self-determination of Indigenous public health measures have shown considerable positive impacts, similar benefits of the suggested of monitoring and reporting should be driven at the level to the communities.[11] Indigenous data sovereignty must also include the capacity and support for communities to drive the changes in health promotion efforts based on their needs and interpretations of their own data.[24] Best practices from First Nations Information Governance Centre should be adhered to with consideration of the principles of Ownership, Control, Access, and Possession (OCAP).[25]

Research Methodology

There are three components I highlight in the contribution of this dissertation to advancing research methodology, specifically in the areas of: i) the use of qualitative methods in the development of health promotion interventions; ii) CBPR; and iii) systematic reviews that focus on Indigenous health.

Formative research methods allow for community participation in shaping the intervention, and helps ensure that an intervention is appropriate for a cultural and geographical context.[26] Specifically in this dissertation, formative methods included community workshops and a qualitative descriptive study to understand key priorities and needs of two communities (Chapter 2).[2] These two methods allowed for broader community input with a cross-section of membership from health, early education, and schools sectors (workshop), followed by directed inquiry of key themes from the workshop to help understand the issue with depth (qualitative description). Further, when developing an intervention, these same methods could be used to test the relevance of key materials or toolkits, refine recruitment strategies, or develop community or participant important outcomes. Further, for the field of childhood obesity and health promotion there is value added to interventions grounded in the experience of the participants.[27] Active patient engagement in research improves the process (e.g., increases recruitment and retention rates) and enhances the probability that the outcomes of the project are translated into practice.[28] Further, given the atrocious treatment of Indigenous peoples as "subjects" of research in Canada including nutritional experiments within residential schools[29], formative methods with qualitative methods allows for the voice of participants and communities to guide the direction of the research and development of programs from inception. Using methods that allow for breadth of opinions as well as depth of insight allowed for better description of the components that were important to community members.

Embedded within the foundations of CBPR is a focus on the reduction of health inequities by engaging communities and participants as active partners in research.[1,30] Through relationships built on partnership, power between the researcher and the participants finds an equilibrium that is often not redistributed within traditional research methods.[1] In Chapter 1, I described the partnerships and setting that were the bedrock of CBPR in this dissertation. There were considerable strengths to the work including the relationships I developed with members of the Six Nations Birthing Centre. This partnership has led to other collaborative projects including the development and successful funding of other research grants during the time of this dissertation including a Canadian Institutes of Health Research – Network for Environments of Indigenous Health Research development grant which I co-led with members of the Six Nations Birthing Centre. In this grant we seek to develop a research agenda unique to the needs and priorities for Indigenous midwives. We also continue to co-explore research questions from the ABC study with the priorities and needs of the Six Nations Birthing Centre team guiding the inquiry. Looking to further expand this CBPR work and method, in the future I would look to take another step to better incorporating Indigenous data collection methods into the CBPR framework. Wright *et al.* describes in a narrative review methods of photovoice, symbol-based reflection, circles and story-telling as meaningful and rigorous methods for data collection which are congruent with respectful partnership with Indigenous communities in Canada.[31] Iterations of these described methods would need to be in partnership with community members and scholars knowledgeable in their implementation and interpretation.

The final consideration for discussion is the use of systematic review methods, as undertaken in this dissertation, as a tool to advance Indigenous child health research. Systematic reviews *seek to collate evidence that fits pre-specified eligibility criteria in order to answer a specific research question. They aim to minimize bias by using explicit, systematic methods documented in advance with a protocol.*[32] There are two notable points of consideration during the process of the systematic review of Chapter 3.[4] The first is defining the characteristics of a study population that allow it to meet inclusion criteria on the basis that it focused on a specific population, in this case Indigenous children from Canada, United States, New Zealand and/or Australia. The other area of consideration, raised by a reviewer of the manuscript and subsequently added to the discussion, is how to best assess the quality of included studies and the use of an Indigenous quality assessment tool.

During the selection of full text articles to be included in the review, the study team needed to decide if studies that included more than one ethnic group met the inclusion. We included the study if a significant proportion of the participants self-identified as Indigenous, which we defined as more than 85% of the reported sample size. I was unable to find guidance in the literature on if there should be a proportion cut-off, and if so, what that proportion or criteria should be, so this cut-off was arbitrary. We also included studies if the outcomes were reported for specific ethnic groups. We made this decision to increase our confidence that the results would be applicable to the population of review. On reflection, this was a methodological decision where we could have used methods outside of typical systematic reviews. One alternative could have been including

a CBPR approach to the decisions in adjudicating if a study did or did not meet requirements for being considered inclusive of an Indigenous population. Alternatively, we could have used only studies that included only Indigenous communities however, this would have meant that our review would not have excluded some arguably informative studies that were ultimately included. Future systematic reviews in Indigenous child health topics need a plan *a priori* to consider the populations which will be included in reviews and how that will be defined. A framework embedded with community-based participatory methods could guide decisions, notably involving a community member at the stage of protocol design.

Characterizing the quality of studies including in systematic reviews are an important and required component of narrative reviews and meta-analyses.[33] This review sought to summarize the outcomes as reported by primary studies aimed at obesity prevention programs for Indigenous children. I recognize this narrow scope of focusing on outcomes including anthropometrics and health-behaviours has limitations as we have omitted a broader view including who designed the studies, how the studies were conducted, including the study teams, and where the studies sit in the landscape of Indigenous methodologies and worldviews. Given the scope of our current review I did not add an Indigenous quality assessment tool into the current manuscript. However, this limitation of our review could be a topic of an additional review and deserves fulsome attention. There are Indigenous quality assessment tools that have been developed. Harfield *et al* developed the *Aboriginal and Torres Strait Islander Quality Appraisal Tool,* which includes 14 questions developed for an Australian setting that they suggest are

included with other assessment tools in systematic reviews.[34] Future systematic reviews of Indigenous child health outcomes should also consider quality assessment tools that are inclusive of Indigenous worldviews.

Implications and Recommendations

The body of work summarized in this thesis have important implications and recommendations for policy, public health practice/programs, health care professionals' practice, and research. We review policy and public implications previously in this chapter with discussion of how the findings of the thesis amplify the TRC's Calls to Action and how they may contribute to future public health frameworks for the prevention of childhood obesity. Further, public health approaches that are inclusive of Indigenous health practitioners, including Indigenous midwives, need to be prioritized for funding and training as culturally focused care that is inclusive of traditional beliefs improves health outcomes. This dissertation further magnifies the importance of the distal determinants of health, and it is therefore important for health care practitioners to understand the scope of how this affects the care they provide to children and families. This is in line with the TRC call to action #24. However as described in the 'coin model of privilege' described previously in this chapter, education will not be enough.[16] In a commentary in the Canadian Medical Association Journal, Sharda *et al* argue that '*Universalizing and normalizing a racial-justice approach to health care will foster better patient care'*.[35(pE102)] I concur, only when we all lean in to addressing the systemic roots of oppression will there be improvement in the health and wellbeing of our patients and the population as a whole.

The final recommendation is around future research. There has been a deficit-based discourse to Indigenous health research which has perpetuated negative stereotypes and led to poor health outcomes.[29] Broadly for non-Indigenous, settler researchers, Indigenous child health research must be done in partnership with Indigenous communities with a strength-based focus on community derived priorities, with research methods that take into account Indigenous worldviews. Specifically for childhood obesity prevention programs there must be consideration of the priorities and needs of communities as well as the Indigenous determinants of health which have an overarching influence on the health-behaviours of children and families. For future culturally-informed and designed interventions to improve health-related behaviours, such as diet, CBPR methods should inform implementation strategies. Further, interventions need to be sustainable and congruent with the needs and priorities of communities. Lastly, there should also be multi-sectoral partnership that acknowledges that the health of a population is led by collaboration across all sectors of society.

Strengths and limitations

This thesis was strengthened by the multiple methodologies used to understand the central issues of childhood obesity. By using qualitative description, data from a prospective cohort, and systematic review study designs the questions were rigorously examined with multiple viewpoints and questions. In qualitative methods, triangulation is the use of one or more data sources or methods to increase confidence in the results.[36] The overlap of the three studies in this thesis could be considered a form of methodological triangulation, which occurs across methods.[37]

Health-related behaviours such as dietary intake and physical activity are often the key components of obesity prevention programs as demonstrated by the systematic review in this thesis.[4] However we demonstrate the modest effectiveness of programs that target this level of intervention. One consideration for future work includes the choice of outcome measures, for example we chose to report changes in anthropometric measures. However, a CPBR approach to the systematic review in this dissertation could have led to a better understanding of participant and/or community-important outcomes that match local values and beliefs. An example of that approach of a community-informed outcome was in the work of constructing of the diet score used in Chapter 4. This example of an outcome considers local context and priorities.

In this dissertation, I sought to not center or 'blame' a group that is considered oppressed from their state of health inequity but rather center the systemic injustices as the root cause in the failure of health promotion efforts, as well as centre solutions that acknowledge the need for policies that disrupt structures of inequities. I do this by centering the priorities of health promotion of two communities' (chapter 2) and then examining previous health promotion programs that are primarily focused on proximal and intermediate factors (chapter 3), which leads to the final study of illustrating a protective health promotion strategy that is rooted in cultural practices driven by community members (chapter 4). Further, notable components of Chapter 4 study bring forward components of CBPR methods: 1) the study question was directly informed by priorities identified by the Six Nations Birthing Centre members; 2) the exposure variables, including social disadvantage, were reinforced by the themes from the

formative work, where community members described the importance of social determinants of health which need to be considered as contributing to health-related behaviours; and 3) the diet score as an outcome was derived using the lists of 'healthy' and 'unhealthy' foods from the community engagement workshop, i.e., directly informed by stakeholders from the community.

It was purposeful to not focus on a deficit-based approach, for example a descriptive study to illustrate the negative health conditions of Indigenous communities as it related to childhood obesity, but rather bring a strength-based approach that is led by a community's visions and solutions. Allyship is an active process which involves 'learning and unlearning'[16], and I acknowledge that I have not always had similar outcomes in my work.[38] However, what my intention was is not an appropriate consideration as the harms and impact of actions need to be the focus in discussions involving groups that have been oppressed by systems of inequity.

Conclusions

The studies in this dissertation challenge the idea that individual and family factors are the most important components to consider in the prevention of childhood obesity and the promotion of health-related behaviours and magnify the importance of distal Indigenous determinants of health. Although this dissertation is specific to obesity prevention and health promotion among Indigenous communities, these ideas could be applied more broadly to other public health issues. I provide an argument that the social determinants of health and upstream factors are important drivers of obesity and health-related behaviours and acknowledge that privilege and oppression are central

considerations in work that considers a health equity lens. Finally, only when we consider collaborations inclusive of multi-sectoral partnerships will we impact the health of populations and successfully improve childhood obesity prevention and health promotion strategies.

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Table 1: TRC's "Calls to Action" and dissertation findings

Topic	**Call to Action**	**Findings from dissertation that amplify Calls to Action**
Child welfare	5. We call upon the federal, provincial, territorial, and Aboriginal governments to develop culturally appropriate parenting programs for Aboriginal families.	Chapter 2 The overarching theme was that Traditional *Indigenous ways of life are the primary pathway to health and wellbeing for young children and families.*
Education	7. We call upon the federal government to develop with Aboriginal groups a joint strategy to eliminate educational and employment gaps between Aboriginal and non-Aboriginal Canadians.	Chapter 4 Social disadvantage of caregivers, including education, had an impact on the health and health-behaviours of children.
	10. We call on the federal government to draft new Aboriginal education legislation with the full participation and informed consent of Aboriginal peoples. The new legislation would include a commitment to sufficient funding and would incorporate the following principles: … Developing culturally appropriate curricula. iv. Protecting the right to Aboriginal languages, including the teaching of Aboriginal languages as credit courses.	Chapter 2 The overarching theme was that Traditional *Indigenous ways of life are the primary pathway to health and wellbeing for young children and families.*
	12. We call upon the federal, provincial, territorial, and Aboriginal governments to develop culturally appropriate early childhood education programs for Aboriginal families.	Chapter 2 The overarching theme was that Traditional *Indigenous ways of life are the primary pathway to health and wellbeing for young children and families.*
Health	18. We call upon the federal, provincial, territorial, and Aboriginal	Chapter 2

	governments to acknowledge that the current state of Aboriginal health in Canada is a direct result of previous Canadian government policies, including residential schools, and to recognize and implement the health-care rights of Aboriginal people as identified in international law, constitutional law, and under the Treaties.	Indigenous determinants of health including racism and colonialism have a significant impact on the Indigenous child health outcomes
	19. We call upon the federal government, in consultation with Aboriginal peoples, to establish measurable goals to identify and close the gaps in health outcomes between Aboriginal and non-Aboriginal communities, and to publish annual progress reports and assess long term trends. Such efforts would focus on indicators such as: infant mortality, maternal health, suicide, mental health, addictions, life expectancy, birth rates, infant and child health issues, chronic diseases, illness and injury incidence, and the availability of appropriate health services.	Chapter 3 Programs focused on obesity prevention and health-related behaviours had modest impact on health outcomes and behaviour changes. Further understand of changes over time will be important to inform future health
	21. We call upon the federal government to provide sustainable funding for existing and new Aboriginal healing centres to address the physical, mental, emotional, and spiritual harms caused by residential schools, and to ensure that the funding of healing centres in Nunavut and the Northwest Territories is a priority.	Chapter 4 Care by traditional health care providers, including Indigenous midwives had a direct impact on positive infant dietary outcomes.
	22. We call upon those who can effect change within the Canadian health-care system to recognize the value of Aboriginal healing practices and use them in the treatment of Aboriginal patients in collaboration with Aboriginal healers and Elders where requested by Aboriginal patients.	Chapter 4 The care of Indigenous midwives had a direct impact on positive infant dietary outcomes.

	23. We call upon all levels of government to: i. Increase the number of Aboriginal professionals working in the health-care field. ii. Ensure the retention of Aboriginal health-care providers in Aboriginal communities. iii. Provide cultural competency training for all healthcare professionals.	Chapter 4 The care of Indigenous midwives had a direct impact on positive infant dietary outcomes.
	24. We call upon medical and nursing schools in Canada to require all students to take a course dealing with Aboriginal health issues, including the history and legacy of residential schools, the United Nations Declaration on the Rights of Indigenous Peoples, Treaties and Aboriginal rights, and Indigenous teachings and practices. This will require skills-based training in intercultural competency, conflict resolution, human rights, and anti-racism.	Chapter 2 Indigenous determinants of health including racism and colonialism have a significant impact on the Indigenous child health outcomes
Sports & Reconciliation	89. We call upon the federal government to amend the Physical Activity and Sport Act to support reconciliation by ensuring that policies to promote physical activity as a fundamental element of health and well-being, reduce barriers to sports participation, increase the pursuit of excellence in sport, and build capacity in the Canadian sport system, are inclusive of Aboriginal peoples.	Chapter 2 A central theme included: *Indigenous ways of life include traditional foods and physical activities* **and** *Woven through all participants' narratives, there was an awareness and deep consideration of how community and contextual factors, specifically geographic, historical, and cultural factors, influence nutrition and physical activity within the community.*