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Assessing the Role of a School-Based Nutrition Program in Reducing Obesity Risk Among Children From Low-Income Neighbourhoods in Toronto: A Research Protocol

Vikram S. Brar, BSc Student [1]*

[1] Department of Medical Sciences, University of Western Ontario, London, Ontario, Canada N6A 3K7

*Corresponding Author: vbrar6@uwo.ca

Abstract
Introduction: Childhood obesity is a significant public health concern in Canada, particularly in low-income, highly populated neighbourhoods with limited access to affordable, nutritious food. Given the considerable time children spend in school, educational institutions are well-positioned to provide healthy food alternatives for those from low-income communities. The objective of this pilot study is to evaluate the feasibility of a school-based nutrition program in low-income Toronto neighbourhoods and examine its preliminary effects on BMI. The study will assess secondary outcomes, including dietary quality and nutritional literacy, while controlling for baseline physical activity levels and household food security as covariates.
Methods: Forty children aged 4 to 13 will be randomly recruited from a single elementary public school. Participants will be randomly assigned to intervention and control groups: 10 boys and 10 girls will receive the intervention, and 10 boys and 10 girls will be controls. Within each group, one child from each age will be selected. The intervention group will receive a school-based nutrition program for eight months, consisting of daily breakfast and snack meals aligned with the 2020 Ontario Student Nutrition Program Guidelines. Controls will continue their usual diet. BMI will be measured at baseline and eight months, then compared between intervention and control groups using independent-sample t-tests and analysis of covariance (ANCOVA), and within individuals pre- and post-intervention using paired t-tests.
Anticipated Results: Children who receive the school-based nutrition program are predicted to have lower BMI scores after eight months compared to those who do not. The intervention group is expected to show a reduction in BMI from baseline measurements.
Discussion: This study will pilot a school-based nutrition program to evaluate its feasibility, acceptability, and preliminary effects on childhood obesity in low-income neighbourhoods in Toronto. The primary purpose is to refine the intervention procedures to inform a future, large-scale randomized control trial.
Conclusion: The findings from this study will inform policymakers and educators about the viability and potential impact of school-based nutrition programs, providing the evidence to support the design of a future randomized controlled trial assessing the effectiveness of school-based nutrition programs.

Keywords: childhood obesity; school-based nutrition programs; body mass index; low-income neighbourhoods; public health

Introduction

Childhood obesity has emerged as a significant public health concern over the 21st century, particularly in Canada, where approximately 13% of Canadian children are affected [1, 2]. This is largely due to poor dietary habits, as less than one-third of Canadian children consume the recommended daily servings of vegetables and fruit, while on average they consume five times more sugar than recommended by national guidelines and obtain more than half of their daily calories from ultra-processed foods [3]. These patterns, characterized by frequent consumption of foods high in saturated fats and carbohydrates, increase obesity risk by approximately 30% compared to diets rich in whole grains and produce. Therefore, establishing healthy nutrition habits is essential for reducing obesity risk and supporting overall well-being in children and adolescents [4].

Childhood obesity is classified as excess body weight in children and adolescents relative to their physical traits such as age, gender, and height, and is commonly assessed using body mass index (BMI) percentiles [5]. Specifically, a child is considered obese when their BMI is at or above

the 95th percentile for their age and sex. [6]. The rising prevalence of obesity poses serious long-term health risks such as type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD). Excess adiposity caused by obesity contributes to adipocyte dysfunction, leading to elevated levels of free fatty acids and adipokines. These changes increase the risk of developing T2DM and CVD, which can in turn result in other related complications, such as hypertension [7]. Furthermore, research indicates that children with obesity are significantly more likely to remain obese as adults, compounding the risk of developing chronic illnesses and reducing overall life expectancy [2].

Beyond the physical health consequences, childhood obesity can lead to a range of psychological challenges for affected individuals such as low self-esteem, eating disorders, anxiety, and depression, which can affect social development, academic performance, and overall quality of life [5]. Obesity imposes a substantial financial burden on individuals, families, and healthcare systems. In Canada alone, the fiscal burden of obesity was estimated to be approximately $22.974 billion in 2021 [8]. Timely and effective interventions for childhood obesity are therefore essential, as they can help offset the health, psychological, and economic consequences for children, their families, and society as a whole.

Although the health and economic burdens of childhood obesity are widely recognized, disparities in obesity prevalence among children from different socioeconomic backgrounds remain a pressing public health concern. Children living in low-income neighbourhoods have twice the risk of developing obesity compared to those from higher-income areas, largely due to limited access to affordable, nutritious foods, reduced opportunities for physical activity, and lack of nutritional education [5, 9]. This socioeconomic divide is further reflected in nutritional patterns, as evidence shows that increasing household income adequacy is associated with healthier dietary habits, including higher intakes of milk and alternatives among both adults and children, greater consumption of fruits and vegetables among adults, and increased intake of dark green and orange vegetables among children and women. [10]. Given that children spend a significant portion of their day at school and often rely on schools for one or more daily meals, educational institutions provide an ideal setting to implement interventions that can help mitigate these disparities, which is why nationally funded school-based nutrition programs have become so prevalent in many countries around the world [3].

School-based nutrition programs are comprehensive interventions that combine the provision of nutritious meals with nutrition education to improve children's dietary intake and overall health. These programs typically provide healthy breakfasts, lunches, or snacks aligned with established dietary guidelines and incorporate education on balanced diets and healthy lifestyle behaviours [4].

Evidence shows that such programs improve dietary behaviours, reduce obesity risk, and support the development of long-term healthy habits among children. A study conducted by Hollar et al. found that among low-income children, significantly more children from schools with nutrition programs remained within the healthy BMI percentile range compared to those from schools without such interventions [11]. Similarly, Veugelers et al. reported that school-based nutrition programs increased fruit and vegetable consumption, reduced caloric intake from fat, and promoted participation in physical activities [12].

Despite this evidence, few studies have specifically evaluated the effectiveness of school-based nutrition programs in reducing obesity among children in low-income neighbourhoods in Canada, particularly in heavily populated cities such as Toronto. This research protocol aims to conduct a preliminary evaluation of a school-based nutrition program to assess its practicality and potential influence on BMI and dietary habits among children in low-income Toronto neighbourhoods. By gathering essential data, this study serves as a foundational step towards the development of a randomized control trial designed to evaluate the efficacy of school nutrition programs.

Methods
Study Design
This pilot study will employ a true experimental design to evaluate the viability and preliminary impact of a school-based nutrition program on the BMI and dietary habits of children from low-income neighbourhoods. Participants in the school will be randomly assigned to either a structured nutrition program (intervention group) or a control group that continues their usual dietary habits. Random assignment enhances the study's internal validity by minimizing potential selection bias, allowing for stronger causal inferences regarding the effect of the intervention on BMI change [13].

Study Population and Sampling
The study will recruit 40 children aged 4 to 13 years from one public elementary school located in a low-income neighbourhood in the City of Toronto. The neighbourhood will be classified as low-income based on a combination of City of Toronto 2021 Census Ward Profiles and the Government of Canada Low-Income Cut-offs (LICOs) 2023. Specifically, data on median household income, average household size, and total population will be obtained from the census ward profiles. This data will be cross-referenced with the LICOs, which provide income thresholds below which families are considered to be experiencing financial strain relative to community and household size [14, 15]. Median household income is a reliable socioeconomic indicator because it reflects the typical earnings within a geographic area while minimizing the influence of extreme outliers. Considering household size ensures that income is evaluated relative to the

number of people supported by that income, while including community population allows for adjustment based on the size of the ward, which can influence access to resources such as schools, grocery stores, and recreational facilities.

From an eligible school within a qualifying low-income ward, 40 students will be randomly recruited per school, with 20 assigned to the intervention group (10 boys, 10 girls) and 20 to the control group (10 boys, 10 girls). Within each subgroup, one child from each age between 4 and 13 years will be selected to ensure balanced age representation.

The study's inclusion criteria include enrollment as a full-time student in the participating elementary school, parental or guardian consent, age-appropriate child assent, and absence of medical conditions or medications that significantly affect growth or metabolism. Children will be included regardless of BMI, allowing the study to assess the practicality of the intervention across a range of weight statuses. Exclusion criteria include children with chronic illnesses, food allergies that prevent participation, or inability to complete follow-up measurements.

A total of 40 participants from one school were selected for this study, reflecting feasibility and logistical considerations in implementing the program at one site. While smaller than the median sample size of approximately 600 children reported across 15 school-based nutrition and obesity interventions in a meta-analysis published by Cai et al., this study will provide preliminary data to inform program practicality and outcomes. In a future definitive randomized controlled trial, a sample closer to 600 children would be expected to evaluate program effectiveness [16].

Intervention

The intervention group will participate in a school-based nutrition program for eight months, consisting of daily breakfast, snack, and lunch meals designed according to the sample menus found in 2020 Ontario Student Nutrition Program Guidelines [17]. To account for variance in energy expenditure, portion sizes will be scaled using Health Canada's dietary reference intakes tables for vitamins and macronutrients. Vitamin and macronutrient targets will be set using the Estimated Average Requirements (EARs) to ensure the intervention meets the median nutritional needs of the age and sex cohorts. Additionally, macronutrient ratios will be maintained within the Acceptable Macronutrient Distribution Ranges (AMDRs); specifically, 45–65% carbohydrates, 10–30% protein, and 25–35% fats, to ensure a balanced distribution of energy [18]. Meals will be consumed under staff supervision and tracked using daily food logs. The control group will continue their usual diet and school meal arrangements without access to the structured nutrition program; a supplemental nutrition program will be offered after the study.

Data Collection

The BMI of each participant will be measured at baseline and after eight months using standardized digital scales and stadiometers. Height and weight will be recorded in duplicate to ensure accuracy, and BMI will be calculated as weight in kilograms divided by height in meters squared (kg/m²). Staff will be trained to collect these measurements consistently and accurately to minimize measurement error. BMI measurements will be compared to the World Health Organization (WHO) BMI percentiles for boys and girls aged 5–19 years [19]. These percentiles will be cross-referenced with the Centers for Disease Control and Prevention (CDC) BMI percentile categories for children and adolescents aged 2-19 to classify weight status and assess obesity risk [6].

BMI is selected as the primary indicator of childhood obesity due to its simplicity, cost-effectiveness, and practicality for large-scale field studies. Unlike direct measures of body fat distribution or composition, BMI requires only height and weight measurements, making it non-invasive, inexpensive, and easily standardized across multiple school sites. Moreover, BMI has demonstrated strong correlations with adiposity and metabolic risk factors in children and remains the most commonly used indicator in epidemiological and intervention studies [20].

An eight-month intervention period was selected to align with the length of a typical school year, providing sufficient time to observe meaningful changes in participants' dietary behaviours and BMI. While a meta-analysis of 27 school-based nutrition interventions by Klein et al. reported a median duration of approximately 12 months for significant BMI reductions, the current eight-month design avoids the confounding variables associated with summer holidays, during which children's dietary and activity patterns differ substantially. [5]. To ensure the intervention is recorded accurately, adherence will be monitored through staff-supervised consumption and daily food logs, where staff document the specific proportion of provided meals and snacks consumed by each participant. To reinforce these dietary changes and maintain consistency during school breaks, the program includes a nutritional literacy component consisting of monthly take-home information sheets. These resources provide families with nutritional education, budget-friendly recipes, and meal planning guidance, ensuring ongoing engagement, and minimizing potential confounding variables during non-school days, such as winter and spring holidays.

Recognizing that BMI alone is an insufficient indicator of obesity risk, the study will include several secondary outcomes and baseline assessments to provide a comprehensive view of participant health. At baseline, sociodemographic data such as age, sex, ethnicity, and household income and the Household Food Security Survey Module (HFSSM) will be administered to assess how home environments and food stability influence intervention outcomes [21].

Furthermore, to account for variance in energy expenditure, physical activity levels will be assessed at baseline using the Physical Activity Questionnaire for Younger Children (PAQ-YC) will be used for participants aged 5–7, while the Physical Activity Questionnaire for Children (PAQ-C) will be utilized for those aged 8 and older. These baseline measures provide essential data to control for pre-existing lifestyle factors that contribute to weight status [22].

Statistical Analysis

Descriptive statistics will be used to summarize participant characteristics, including age, sex, and baseline BMI, for both intervention and control groups. Continuous variables such as age and BMI will be presented as means and standard deviations or medians and interquartile ranges, as appropriate based on data distribution. Categorical variables such as gender will be summarized as frequencies and percentages. Between-group differences in BMI change for the intervention and control groups will be assessed using independent-sample t-tests to evaluate unadjusted differences, as well as analysis of covariance (ANCOVA) to account for baseline BMI, age, and sex. Within-group pre- and post-intervention changes in BMI will be evaluated using paired t-tests. All statistical tests will be two-tailed, with significance set at $p < 0.05$. All analyses will be conducted using SAS version 9.4 [23].

Anticipated Results

It is anticipated that the school-based nutrition intervention will result in measurable improvements in BMI among children in the intervention group compared to the control group. Within-group analyses are expected to show a reduction or stabilization of BMI percentiles among intervention participants, whereas control participants are expected to show either no change or an increase in BMI percentiles. Between-group comparisons are anticipated to reveal slight differences favouring the intervention group [5, 11, 12]. In addition to anthropometric outcomes, the intervention group is expected to demonstrate improved dietary habits and increased nutritional literacy, reflected in healthier food choices and greater understanding of balanced nutrition compared to the control group.

Discussion

This research protocol aims to pilot a school-based nutrition program to assess its feasibility, acceptability, and preliminary impact on BMI and dietary behaviours among children in low-income neighbourhoods in Toronto. The primary objective is to evaluate trial processes to refine the protocol for a future randomized control trial. While this pilot study does not prove efficacy, anticipated findings, based on prior school-based interventions, suggest that structured nutrition programs can stabilize or reduce BMI percentiles [5, 11, 12]. Beyond BMI reduction, these programs may improve long-term dietary habits, potentially

reducing the risk of developing chronic conditions such as type 2 diabetes and cardiovascular disease later in life [6].

If the anticipated results are observed, they will demonstrate the viability of implementing a structured nutrition program and demonstrate its potential to address childhood obesity risk and its associated health, psychological, and economic burdens. In particular, early exposure to nutritious foods has been shown to establish lifelong healthy eating patterns and may help reduce obesity risk at a young age. Additionally, improved nutrition is associated with enhanced concentration, promoting better academic performance. Internationally, school meal programs have also been linked to broader economic benefits, with evidence suggesting a return of $3 to $10 for every dollar invested [3, 11, 12].

However, several limitations should be acknowledged. First, although BMI is a widely accepted and cost-effective measure of obesity, it does not always accurately represent overweight and obesity status, particularly among children with a higher proportion of body fat or greater muscle mass. This limitation can lead to misclassification, where some children are categorized as overweight or obese despite having a healthy body composition, or vice versa [24]. Second, potential confounding factors such as physical activity outside of school and family dietary habits may influence BMI outcomes and reduce the measurable impact of the intervention [25].

Conclusions

In conclusion, the rationale underlying this study is grounded in the need to address childhood obesity among children from low-income communities, a population disproportionately affected due to limited access to nutritious foods, reduced opportunities for physical activity, and lack of nutritional education [5, 9]. While previous research has demonstrated the benefits of school-based nutrition programs in improving dietary habits, few studies have specifically evaluated their effectiveness within low-income neighbourhoods located in Toronto, where obesity risk is markedly higher [1]. This study aims to conduct a preliminary evaluation of structured, school-based nutrition intervention to assess its viability and potential influence on BMI and dietary behaviours among children facing these socioeconomic challenges.

The anticipated findings are expected to provide evidence on the feasibility of implementing a school-based nutrition program, alongside its potential influence on BMI and dietary behaviours. These insights will serve as the necessary frameworks to develop a large-scale randomized control trial, informing essential parameters such as sample size, logistics, and primary outcome measures. Ultimately, the results from the future randomized control trial will inform policymakers and educational institutions on how to design nutrition programs that address health disparities, ultimately supporting improved physical health and long-term well-being for children in disadvantaged communities.

List of Abbreviations
AMDRS: acceptable macronutrient distribution ranges
ANCOVA: analysis of covariance
BMI: body mass index
CDC: centers for disease control and prevention
CVD: cardiovascular disease
EARs: estimated average requirements
HFSSM: household food security survey module
LICOS: low-income cut-offs
PAQ-C: physical activity questionnaire for children
PAQ-YC: physical activity questionnaire for younger children
T2DM: type 2 diabetes mellitus
WHO: world health organization

Conflicts of Interest
The author declares that they have no conflict of interests.

Ethics Approval and/or Participant Consent
This research protocol did not require ethical approval or participant consent as it is a proposed study. This research protocol provides a potential study design and anticipated results based on peer-reviewed scientific articles.

Authors' Contributions
VB: made substantial contributions to the design of the protocol, drafted the manuscript, revised the manuscript, and gave final approval of the version to be submitted.

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