

# **Early impact of a new food store intervention on health-related outcomes**

**A Thesis Submitted to the**

**College of Graduate Studies and Research in Partial Fulfillment of the**

**Requirements for the Degree of Master of Science in the Department of**

**Community Health and Epidemiology, College of Medicine,**

**University of Saskatchewan,**

**Saskatoon, Canada**

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## Abstract

Neighbourhood food environments influence what people choose to eat and consequently affect their health. Literature suggests that having supermarkets/grocery stores with healthier food options in a neighbourhood supports intake of healthy food as opposed to having abundance of fast food and convenience stores.

This thesis systematically reviewed published literature on new food store interventions on health-related outcomes (manuscript 1), and examined early health-related impact of a community-based food intervention in Saskatoon (manuscript 2).

The systematic review addressed the question 'How do new food store (supermarket/grocery store) interventions influence health-related outcomes in adults?' The review followed the guidelines recommended by the Effective Public Health Practice Project (EPHPP) and identified 11 records representing 7 interventions. The methodological quality rating found that 6 studies were of 'weak' methodological quality, one was of 'moderate' and two studies had 'strong' methodological quality. Relevant outcomes reported by these studies were fruit and vegetable consumption, self-rated health, psychological health, BMI, perceptions of food access, and household food availability. Of these outcomes, perceptions of food access and psychological health showed significant improvement; however, other outcomes showed mixed results.

A prospective longitudinal study was conducted to investigate the health-related impact of a new food store in a former food desert in Saskatoon. One hundred and

fifty-six shoppers of the new food store were followed-up repeatedly and their health-related outcomes were assessed using a questionnaire. A generalized estimating equations approach was used for data analysis. Study participants were mainly female, Aboriginal, of low income, and had high school and some post-secondary education. They showed dose-response associations between the frequency of use of the new grocery store and the odds of reporting household food security, mental health, and BMI over time, and these associations were significantly modified by participants' level of education, household income, and pre-existing chronic conditions, respectively. Further, having multiple disadvantaged conditions (Aboriginal ethnicity, seniors, low-income and low-education) significantly modified the effect of the new grocery store use on participants' mental health.

Although the systematic review suggested that previous studies yielded conflicting findings, this thesis research revealed convincing results. In contrast to the limited body of literature, this study found that when the shopping frequency is taken into account, the new grocery store did have a positive effect on mitigating household food security, mental health, and BMI. Further, socioeconomic status, multiple disadvantage, and previous chronic diseases moderate these effects. The results are valuable to advance the knowledge in food environment interventions research.

## Acknowledgements

I am sincerely grateful to many wonderful people who supported me throughout my Masters research studies.

My supervisor, Dr. Nazeem Muhajarine, for his confidence in me and giving me the opportunity to undertake graduate studies, for invaluable support and encouragement throughout the process, for those insightful discussions that enlightened me with his research knowledge and expertise, for helping me learn and improve valuable research and personal skills, for giving me the freedom to take on a three-month externship and various other programs and projects, and for being my primary resource whenever I needed advice on academic as well as non-academic related subjects.

My thesis committee member, Dr. Rachel Engler-Stringer, for her much-valued support and advice throughout.

My thesis committee chair, Dr. Hyun J. "June" Lim, for spending her time to help me understand the concepts of statistical analyses.

Research assistants, Melissa Gan, Amanda Guthrie, Jacinda Sigurdson, Elsie Piche-Johnson, Tracy Ridalls, for spending enormous amounts of time in recruiting and following up of study participants.

ITraP program, for funding support for my MSc program.

Former Liaison Librarian for Community Health and Epidemiology, Lukas Miller, for generously teaching me the methods of the systematic literature review.

The faculty and staff of the Department of Community Health and Epidemiology, for their lovely smiles, and support since I stepped into graduate studies.

All my dear friends in Saskatoon, for being there to share better and the worst moments, for being my 'family' away from family, and for helping me easily pass those hard days with laughter and prolonged evening tea times.

My beloved parents and sister, for their endless love, encouragement, and instilling in me the value of education over the years.

Finally, and above all, my dearest husband, Mohamed Manazil, even though thousands of miles away, for always being there for me, for giving me the strength to continue when I was weak and almost gave up, and for constant support, hope, and prayers which made completion of this thesis possible.

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## **Abbreviations**

NCD = Non communicable diseases

GFJ = Good Food Junction

CVD = Cardiovascular disease

EPHPP = Effective Public Health Practice Project

FV = Fruit and vegetable

PPD = Portions per day

BMI = Body Mass Index

ITT = Intention-to-treat analysis

CCHS = Canadian Community Health Survey

GEE = Generalized estimating equations

CATPCA = Categorical principal component analysis

## CHAPTER 1: Introduction

### 1.1. Background

Food is fundamental for human survival. Yet over the last several decades we have seen the rise of unhealthy eating patterns among children, youth, and adults equally. Health consequences such as obesity, diabetes, and heart conditions have been closely linked to dietary behaviours. Today these chronic non-communicable diseases (NCDs) are a major threat to human health. These NCDs have reached epidemic levels, and the reasons, although not clearly understood, could at least be partially attributed to modern day eating behaviours. (1) Etiology of these conditions are highly complex and intertwined with various determinants of health. There is a large body of research tries to unravel these causal pathways but the literature continues to develop and expand.

Whilst understanding of these causal pathways is developing, many researchers and policy makers have started to find ways to intervene on these unhealthy behaviours. Food environments have received attention in the recent past with the rise of overweight and obesity, as programs and policies intervening on eating patterns at the individual-level have not shown to be effective. (2) Continuously changing built environments have also changed the food environment resulting in lower accessibility to healthy food in many urban, inner-city compared to suburbs. Using an ecological metaphor, terms such as 'food deserts' and 'food swamps' (see pages 6 and 7 for definitions of these terms) are now in use to describe these transformed food environments. (3-5) Both food deserts and food swamps contribute to food insecurity and unhealthy eating patterns.

Food environments research is a fairly recent, but rapidly growing field of study in Canada. Although evidence suggests that 'food deserts' are a reality in the United States, Canadian food environment situation is unique, and 'food swamps' appropriately describes the food environment situation. (6) Further, food environment of northern and remote Canada still need more exploration and evidence. Therefore, recommendations made in other contexts and regions, such as in the United States, would be useful with explicit limitations in the Canadian context. (6) This leaves a pressing need to enhance Canadian food environment research to inform policy decisions and recommendations that work to improve Canadian's health. A recent scoping review of Canadian retail food environment research found that out of studies that explored links between food environment and weight-related outcomes, dietary behaviours, disease outcomes, majority found mixed results, while slightly lesser percentage of studies reported statistically significant relationships, and null associations were reported by few. (6) These Canadian evidence suggest that food environments have collectively shown influence health, however, further studies are warranted.

Food (in)security (see pages 7 and 8 for definitions of these terms) is multifaceted and is intertwined with the economy, health, environment, and trade. (7,8) While food security is a social determinant of health, it is also a prerequisite and sometimes a determinant of other determinants of health, (9) and has been shown to influence physical and mental health. (10) Therefore, this study identified food security as an intermediate health-related outcome.

While there are numerous reasons behind changes in the food environment, the impact on residents' health due to these changes is a major concern. There is a rapidly expanding literature on food environments including a number of observational and analytical studies

that are exploring different aspects on various outcomes. However, there is a limited literature to date examining the impact of newly established food store interventions on health-related outcomes. The present study fills a gap in this small body of evidence on new supermarket/grocery store interventions, and investigates the health-related impacts of a new food store intervention in inner-city on its users.

Determinants of food insecurity are low income and low income related factors. (7,11-14) Food insecurity among Aboriginal people is unique and is tangled with varying access to traditional food systems in addition to other determinants. (14) Another important dimension which exacerbates food insecurity is spatial disparities in food access. Although Canada is rich regarding food availability at the national level, food access at the neighbourhood level is unequal. For instance, in Saskatchewan geographic location influences food choice which makes transportation, and walking/moving important for diet.(15,16) Moreover, the cost of a National Nutritious Food Basket for an average family varies based on where they live; a large or small city, rural, town or the North. (15)

## **1.2. Context for the research**

This study is focused on a community-based food store intervention in Saskatoon, Saskatchewan, Canada. The intervention was a full-service cooperative grocery store called the Good Food Junction (GFJ) which opened in September of 2012 in a former food desert in Saskatoon's inner city. (17) It is one component of a social enterprise known as "Station 20 West," a building that co-locates the grocery store, along with health services, community-based organizations working in the areas of food access, housing, community economic development and peer support, the University of Saskatchewan's Office of Outreach and Engagement, and a cafe. Station 20 West and the GFJ are the result of nearly a decade long

effort by community-based organizations, community members and a variety of partners including the Saskatoon Health Region, the University of Saskatchewan, and others to address, among other things, the lack of a full-service grocery store in the core neighbourhoods of Saskatoon.

The core neighbourhoods are located to the West of downtown Saskatoon have poor health outcomes, and are socioeconomically disadvantaged compared to Saskatoon's average. (18) This study anticipated that the GFJ would improve healthy eating among its users and that this would be reflected as improved health-related outcomes over-time. After a period of 3 years and 4 months of service to the residents in the core neighbourhoods (and beyond), the GFJ was closed in late January 2016 due to insufficient sales and profit. (19)

### **1.3. Purpose**

The purpose of this study is to investigate the early impact of the GFJ on the health-related outcomes of GFJ users over time. This study represents part of a larger approach to examine the impact of the GFJ on its users, and is in response to the call for further research to determine health-related outcomes of the GFJ intervention in the core neighbourhoods. (20)

This thesis will first systematically review relevant literature. Then it will investigate the health-related impact of the GFJ on users longitudinally. Further, this study will investigate if psychosocial variables (such as individuals' perceived neighbourhood connectedness) and manifested determinants (such as being a member of a disadvantaged sub-population) modify the main relationship. A comprehensive analysis including socioeconomic, demographic, and psychosocial factors will help expand our understanding of the nature of

linking pathways that connect food environment interventions to health. These investigations will add to and strengthen the current limited body of literature and is relevant to population health, urban planning, public policy, and public health nutrition.

#### **1.4. Hypothesis, objectives and research questions**

This study seeks to answer the following two major and supplemental research questions presented in subsequent chapters in the form of two manuscripts. The objective of the first manuscript is to systematically review current literature on the impact of new food store (supermarket/grocery store) interventions on health-related outcomes. The objective of the second manuscript, informed by the results of the first, is to investigate early health-related impact of the GFJ among its users' longitudinally, and then to identify the significance of specific risk factors in this relationship.

Underlying hypotheses for these research questions are shown in Figure 1.

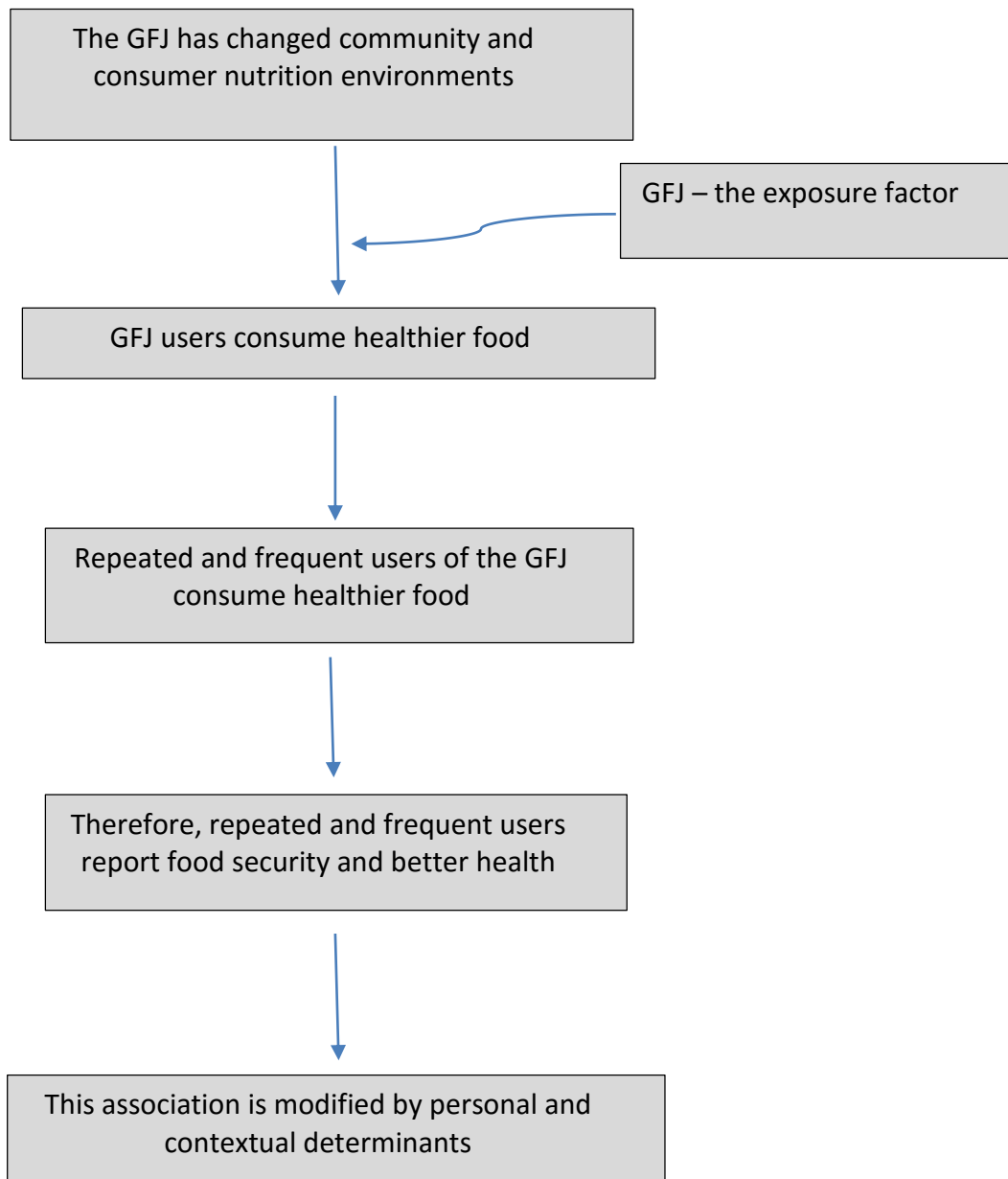


Figure 1: Research hypothesis

#### 1.4.1. Research question 1

The specific question for the systematic literature review is: “How do new food store (supermarket/grocery store) interventions influence health-related outcomes in adults?”



#### 1.4.2. **Research question 2**

1.4.2.1. Does higher exposure to the GFJ intervention (defined as more frequent shopping) result in positive health-related outcomes in GFJ users compared to those with low exposure?

**Hypotheses:** Among GFJ users, health-related outcomes will be improved over three longitudinal time points. For GFJ users who shop more frequently (higher exposure) health-related outcomes will be improved more, compared to those who shop less frequently (lower exposure) over time.

Does individuals' perceived neighbourhood connectedness modify the above relationship?

**Hypothesis:** Among GFJ users, health-related outcomes will be improved more positively among those with higher perceived neighbourhood connectedness compared to those with low neighbourhood connectedness.

1.4.2.2. Does exposure to the GFJ intervention significantly improve health-related outcomes among GFJ users with single/none of the disadvantaged conditions (Aboriginal ethnicity, seniors (older age/over 65 years), low-income and low-education levels) compared to those with multiple disadvantaged conditions?

**Hypotheses:** Guided by intersectionality theory, health-related outcomes will be improved more positively among those who experience single/none of the disadvantaged conditions in comparison with those who experience multiple disadvantaged conditions.

## 1.5. Terminology

**Community nutrition environment:** The component of the nutrition environment that defines the number and variety of food stores and their location and accessibility to users in a neighbourhood. (21) This includes the hours of operation and availability of drive-through set-up for example. (21)

**Consumer nutrition environment:** This aspect of the nutrition environment includes what shoppers experience within available food stores. (21) These include qualities of available food choices such as the options available, their nutrition content and information, freshness, prices, as well as promotions and placement of food types. (21)

**Food desert:** This is a term first emerged during the mid-1990s in Scotland. (3) It generally refers to deprived urban regions without healthy food access. (4)

**Food environment:** Food environments are generally broader in scope than nutrition environments and have physical and social components. Food environments encompass most of the components of the food chain such as food production, distribution and marketing. (2) Food environments are very different from place to place. (2)

**Food insecurity:** This term describes the opposite aspect of food security and is defined as “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways”. (22) Like food security, food insecurity can also be examined at different levels from individual through household, community and national levels. (22)

**Food security:** Food security is defined as “all people, at all times, having physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. (23) Food security can be discussed at “the individual, household, national, regional and global levels”. (23)

**Food swamp:** This is a newer term considered to be more appropriate to describe certain food environments. Food swamps are characterized by availability of energy-dense, low nutritious and unhealthy food choices in relatively greater quantities compared to healthy food choices. (5) This may be a more problematic situation compared to food deserts as frequent availability of unhealthy food may increase consumption. (5)

**Healthy food:** These are foods that are high in nutrients and lower in calories, fats, sodium, and additives/processed ingredients. (24) Fruits, vegetables, low fat milk and milk products, and lean meat with minimum processing can be identified, among others, as healthy food.

**Nutrition environment:** Nutrition environments are the environments that closely influence our everyday food choices, such as community nutrition environment, organizational nutrition environment, consumer nutrition environment and information environment. (21) Opening of the GFJ with many healthy food options in core neighbourhoods exemplifies both community and consumer nutrition environments. Therefore, this term is appropriate to describe the present research in most instances; thus the term ‘nutrition environment’ is mainly used throughout this text. However, where necessary, both terms ‘food environment’ and ‘nutrition environment’ are used interchangeably.

## **CHAPTER 2: How does opening a new supermarket/grocery store influence health-related outcomes? A systematic review**

### **Introduction**

Spatial disparities in neighbourhood food access are linked through unhealthy dietary patterns to chronic diseases. (25,26) Although exact causal pathways are yet to be identified, the association between residential access to retail food and risk of chronic diseases is recognized throughout the literature. A recent review from the United States reported that greater supermarket and lower convenience store access was associated with healthier diets and lower levels of obesity among neighbourhood residents. (27) Spatial inequalities stratified by income, race, ethnicity, and urbanization of neighbourhoods are significant; (27) this has also been recognized as a population health equity concern. This situation of inequity has been reported in various developed nations, particularly in Australia, New Zealand, the United Kingdom, the United States, and Canada. (27-30)

Local food environments, where people can conveniently shop for food, include all food sources, from retail stores to restaurants. ‘Local’ indicates the availability of shops with food in the immediate geographic vicinity where one resides or works. (31)

Neighbourhood food access, availability and affordability influence food choices and therefore dietary quality. The presence of supermarkets/grocery stores<sup>1</sup> in a neighbourhood, preferably within walking distance, is associated with buying and

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<sup>1</sup> According to the North American Industry Classification System (NAICS) supermarkets and grocery stores are those that are “primarily engaged in retailing a general line of food, such as canned, dry, and frozen foods; fresh fruits and vegetables; fresh and prepared meats; fish, poultry, dairy products, baked products, and snack foods. These establishments also typically retail a range of non-food household products...” (32) Hereafter the term ‘grocery store’ is used in this thesis to refer to both store types.

consuming healthier food. (33) Grocery stores typically sell healthier food items such as fresh and frozen fruits and vegetables (FV), low-fat dairy products and meat products at affordable prices compared to convenience stores and fast food outlets. (34,35) Grocery stores offer a range of food choices, typically fresher products, lower price points, and visually appealing presentation of food options which are all associated with greater availability of healthy food options leading to healthier pathways. (36)

Food deserts, deprived urban regions without or with limited healthy food access, are a barrier to accessibility and affordability of healthy food and contribute to unhealthy eating patterns and related poor health outcomes in residents. (37) A qualitative study conducted with residents in a food desert in the United Kingdom reported that poor neighbourhood healthy food access influences their behaviour in a variety of ways. (38) Mothers of younger children were mostly constrained by economic access to food while physical access was the main barrier for the elderly. (38) These barriers ultimately contribute to food insecurity with quality and/or quantity of food consumed affected. (38,39)

Many major grocery stores have moved away from urban locations, leaving inner-city low-income neighbourhoods to be fed by either convenience stores and fast food restaurants, or grocery stores situated at significant distance away. Although an examination of reasons for grocery stores moving out of certain neighbourhoods is not the focus of this article, these may include lower costs of land, store development planning, regulatory issues, and potential higher sales in the suburbs. (40)

Reducing inequalities in neighbourhood food access is increasingly identified as a major health priority owing to the associated diet-related health burden. Limited access to grocery stores leads to poor diet quality and ultimately results in chronic conditions such as obesity, heart diseases, and diabetes. (41,42) These health problems are greater than ever before and are a major threat. While the spatial disparity in food access is explicitly seen as a threat to health, social exclusion that results from socioeconomic and cultural segregation should also not be underestimated. Literature reveal that low-income disadvantaged neighbourhoods are the most affected when it comes to poor grocery store access. (27,39,43) These deprived communities often have higher physical and economic access to fast food outlets,(27) where high fat, sugar, salt, and minimally nutritious food is sold. Further, studies from the United States report that neighbourhoods with predominantly Black populations are more likely to not have healthy food access, highlighting further the disparities that exist. (39,44,45)

Eating behavior is complex and is shaped by many factors. Glanz et al. (21) conceptualized that eating patterns are affected by government and industry policies, environmental variables, and individual variables. The environmental factors, in turn, are four-fold and include the community, consumer, and organizational nutrition environments, as well as the information environment.(21) These are further modified by individual variables such as the sociodemographic, psychosocial, and perceived nutrition environment.(21) While disparities in these nutrition environments leading to health inequity have been widely identified, attempts are being made to find the most effective ways to address them. Guided by an ecological framework, the most

successful levels at which to intervene have been recognized as environmental and policy levels. (46) One such effort to improve healthy food access is the development of grocery stores in underserved communities. Due to the complex nature of these interventions, involving many parties, such operations are few in number or small in scope.

This systematic review intends to begin to address the knowledge gap on systematically developed evidence on the effectiveness of newly-opened grocery stores in deprived neighbourhoods. Although there are systematic reviews available on interventions based in small food stores, (47) and grocery stores, (48) there have been no reviews of the literature to our knowledge, examining the impact of newly-opened grocery stores. The objectives of this review are to systematically synthesize information from all published peer-reviewed literature on the effectiveness of new grocery stores in disadvantaged neighbourhoods in terms of health-related outcomes, and to identify areas that need further research. It is anticipated that these efforts will inform evidence-based public health practice, policy and programs, and consequently reduce inequality in healthy food access. The specific research question to be addressed is “How do new food store (grocery store) interventions influence health-related outcomes in adults?”

## **Methods**

This review followed the steps for conducting systematic reviews summarized by the Effective Public Health Practice Project (EPHPP). (49) The EPHPP recommends seven steps, namely i) question formulation, ii) literature retrieval, iii) developing relevance criteria, iv) assessing studies for relevance and then for methodological quality, v) data

extraction and narrative synthesis, vi) peer review of the report, and vii) dissemination.(49)

### *Question formulation and establishing relevance criteria*

The research question was developed to represent the population (adults), the intervention (new food store interventions) and the outcome (health-related outcomes). The research question did not name a specific comparison group, although it was understood that individual studies may have chosen a comparison group (e.g. area with no grocery store). In addition, some studies investigated the impact of newly opened grocery stores as well as these together with in-store interventions. In order to include these relevant studies, the research question was purposefully framed in broad terms.

Inclusion criteria were set as: i) the targeted study population were adults, ii) intervention of interest were newly opened grocery store or a combination of store opening and in-store interventions, iii) assessment of any of the following health-related outcomes: physical or psychological health, either self-reported or not (i.e. diagnosed by a physician), e.g. obesity (BMI), obesity related chronic diseases, psychosocial factors, food security, dietary habits (FV consumption, FV purchase, food related behaviour), and iv) peer-reviewed scholarly articles that were published in or after 1995 in the English language.

The decision to include adults as the study population was due to children's dietary behaviour and food choices being highly influenced by and dependent on factors including but not limited to parents' food habits and school food programs. Therefore,



in order to have comparable results, adults were chosen. Grocery stores were selected as they sell and promote a greater variety of 'healthy' food options compared to other types of food stores. The objective was to review evidence on how new grocery store interventions influence health-related outcomes in shoppers; therefore, all outcomes that are related to health were included in the review.

Pre-set exclusion criteria were: i) study populations that specifically include only pregnant women, overweight or obese populations, or populations with one or more chronic disease conditions ii) interventions which focus solely on organizational nutrition environments (e.g. schools, hospitals) or the information environment, and iii) studies with specific focus on ready-to-eat/ take-away food outlets such as restaurants or cafeterias.

#### *Literature retrieval and search strategy*

Eight electronic databases were searched, namely: Ovid MEDLINE, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), ProQuest Public Health, Web of Science, Scopus, PsycINFO, and Cochrane Library. The search strategy was developed on MEDLINE and was adapted to the other seven databases. The search strategy was developed for three concepts; i) food/ nutrition environment, ii) intervention, and iii) health-related outcomes. (The search strategy developed on MEDLINE is shown in Appendix 1 and the comprehensive search strategy is shown in Appendix 2). Once the relevant records were identified during the initial search, reference lists of these records were manually searched in order to identify any further records. All the records were imported into one RefWorks folder and duplicates were removed systematically. A comprehensive search and article retrieval

was conducted between the 22<sup>nd</sup> and 24<sup>th</sup> of August, 2015 and email alerts were requested from databases to identify any new publications until November, 2015.

Due to the large number of records involved, it was difficult to have two reviewers work on the initial article screening process. Initial title screening was carried out by HA, TR, JH, MG and MC<sup>2</sup>. At this point the reviewers were asked to be overly inclusive and only to remove records that were clearly not relevant considering the inclusion and exclusion criteria. Afterwards, abstract screening, full article review for eligibility and a manual search of reference lists of identified records were carried out by HA.

Grocery store intervention records retrieved were expected to be of three types: i) new-store openings, ii) in-store interventions, and iii) new-store openings with in-store intervention components. This review focused only on new grocery store opening interventions. Records which were not clearly within the exclusion criteria were reviewed by a second reviewer.

#### *Quality assessment and data extraction*

Eligible studies were assessed for their quality using the EPHPP Quality Assessment Instrument for quantitative studies and the accompanying dictionary. (50) This standardized tool has been tested and shown to have adequate content and construct validity and acceptable levels of inter-rater reliability. (49,51)

Each quantitative study was independently assessed and scored by two raters for quality with respect to selection bias, study design, confounding, blinding, data collection method, and rates of withdrawal/dropouts.(50) The instrument allocated a

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<sup>2</sup> HA=Hasanthi Abeykoon, TR= Tracy Ridalls, JH= Joel Heitmar, MG= Melissa Gan, MC= Mike Chouinard

global rating for each study as either 'strong', 'moderate' or 'weak' based on the ratings for the above six components.(50) If the study did not yield any 'weak' rating for the above six components, it was rated as 'strong'. If there was only one 'weak' component rating, the study was scored as 'moderate' in quality, and if there were two or more 'weak' ratings the study was scored as 'weak'. (50) Disagreements between raters were discussed with a third rater for that study. Data extraction was carried out and results were synthesized narratively.

## **Results**

### *Selection of studies*

The search of eight databases identified 12972 prospective records. Out of these, 4290 records were systematically removed during de-duplication. The remaining 8682 records initially underwent a title screening and 8583 records, for the purpose of this study, were excluded as they fell clearly outside of the topic of interest. Then abstract screening was carried out on 99 articles at which time 43 additional records were eliminated leaving only 56 articles for full text review for eligibility against pre-set inclusion and exclusion criteria. Fifty records were excluded during full article review because they did not meet inclusion criteria, specifically 9 were reviews, 7 were small food store interventions, 5 were discussion/position papers, and 29 were grocery store in-store interventions only. The eligible 6 records were retrieved and their reference lists were searched, and this identified 4 more records. Further, one more record was identified through the email alerts set during initial article search. This resulted in 11 eligible articles representing 7 interventions meeting all inclusion

criteria, which were then included in this systematic review. Appendix 3 shows the flow diagram of this study selection process.

#### *Quality of included studies*

Nine of the eligible records were quantitative studies and they were subjected to methodological quality assessment.(52-60) Of the two records that were not assessed for methodological quality, one was comprised of a combination of qualitative and quantitative methodology, (61) while the other was purely qualitative in nature.(62) The quality assessment revealed that the majority of the records (six) were of 'weak' methodological quality, (52,53,55-58) while two studies scored 'strong' (59,60) and one study was of 'moderate' methodological quality. (54)

Regardless of the level of methodological quality rating, all records were included in this review due to the reasons discussed below. Food environment interventions such as new grocery store openings in neighbourhoods with limited healthy food access are relatively uncommon natural experiments. As such, manipulating the intervention exposure, in a similar way to randomized controlled trials or other types of planned experiments, is rarely if ever achieved.(63) Nevertheless, evidence produced by natural/observational studies at a population-level on non-health care interventions is extremely useful when crucial confounding variables are known and controlled.(63,64) The component ratings used in the EPHPP Quality Assessment Instrument focused specifically on selection bias, study design, confounding, blinding, data collection methods, and rates of withdrawal/dropouts, which are barriers that observational studies typically encounter. Therefore, it would be inappropriate to exclude studies from this review based solely on methodological quality.

Among the eleven records covering seven interventions, most of them included study designs that controlled for known and potential confounders during either the design or analysis phase. Five of the studies had comparison groups, which were matched with intervention neighbourhoods at the design phase for known risk factors such as low income, neighbourhood deprivation, low education, minority race/ethnicity, and geographical distance from majority of households to main healthy food store.

(53,54,57,59-61)

All studies with more than one data collection wave made an effort to address confounders during analysis. In the case of Seacroft intervention, where one sample was followed up from baseline to after the intervention, Wrigley et al. and Gill & Rudkin explicitly discussed and controlled for known risk factors within participant groups.(52,55,58) However, Wang et al. with a one-time survey of residents living close to the intervention store, failed to report any adjustment for external risk factors. (56) In the study by Cummins et al. (2014), confounders were addressed at multiple stages, such as at the design phase by matching and at the analytical phase by selection, and then adjusting for confounders.(53) Several factors prevented Sadler et al. from repeating the follow-up on the same sample of the study population. (57) They identified this limitation and took several measures to control the variability that resulted. For example, they asked additional questions about previous shopping behaviour of participants in the second phase, and further, treated them as four different samples in the analysis rather than two samples which were followed-up.(57)

Analytical methods used by the studies include intention-to-treat (ITT) and on-treatment analysis. ITT analysis evaluates population/community-level impact by

comparing intervention and comparison neighbourhoods without disregarding non-compliance. On-treatment analysis, in contrast, evaluates individual or subgroup level impact by comparing participants who adhere to treatment exactly as assigned with those who are not assigned the treatment. (65) Among the interventions included in this review, five had comparison groups, (53,54,57,59-61) while two interventions did not. (52,55,56,58,62) Among studies with a comparison, three had presented both forms of analytical results, (53,54,60,61) while Elbel et al. reported ITT analysis only. (59) Wrigley et al.'s study and secondary analysis of data by Gill and Rudkin presented results of switchers vs. non-switchers, (52,55,58) while the other two studies used other methods. (56,57)

Statistical power was at least mentioned by five out of nine records, (53-55,59,61) although explicit power calculations were reported by none. Wrigley et al. and Elbel et al. considered statistical power for sample size calculations at the design phase. (55,59) Some authors suspected that the small number of switchers might have led to the attenuated statistical power. (53,54,56,59,61)

#### *Measures used to assess outcomes*

Data collection tools utilized to assess outcomes in these studies also different among studies. In most cases they included modules adapted from pre-validated surveys such as Behavioral Risk Factor Surveillance System (BRFSS) to assess FV consumption and food security, (57) Automated Self-Administered 24-Hour Dietary Recall (ASA24) to assess dietary intake information, (60) Eating and Physical Activity Questionnaire (EPAQ) to assess food consumption, (59) General Health Questionnaire (GHQ-12) to assess general health and psychological health, (54,61) and Block Food Frequency

Questionnaire to assess FV intake. (53) In some other interventions new questionnaires were developed and tested for content, clarity and sensitivity of wording prior to use in the study. (56) BMI where evaluated were either based on objectively measured height and weight, (60) or self-reported. (53) Cummins et al. assessed FV consumption using a single question where they inquired, 'how many portions of FV participants usually eat per day?'. (54)

### *Health-related outcomes*

Many of the studies included findings not of interest to this review, and reported below are the outcomes that are within the scope of this review. A summary of study characteristics is given in Table 1.

**Fruit and vegetable consumption:** The most frequently investigated outcome was the impact of the new grocery store on FV consumption. This was reported by all studies, and the results are diverse. Cummins et al. reported findings from an intervention in a deprived neighbourhood in Glasgow where a new hypermarket was built. (54,61) The quantitative research revealed, after adjusting for baseline consumption and other relevant confounders, a borderline non-significant increase of fruit consumption (0.03 portions per day [ppd]) and a small (negative) impact on vegetable and FV consumption in the intervention compared to comparison neighbourhoods. (54,61) Separate analyses into 'switchers' (study participants who had a different primary grocery store and who said that the new store was their primary grocery store during the follow-up) compared to 'non-switchers' showed a slight increase (but not significant) in all the above three consumption levels.(54,61)

Another study, also by Cummins et al. (2014), examining the impact of a supermarket built in Philadelphia, reported that in unadjusted analyses, comparing the intervention and comparison neighbourhoods ( $p=0.84$ ) and switchers and non-switchers, there were no significant difference-in-differences in the FV consumption. (53) As well, another intervention in the United States (Flint, Michigan) failed to detect any improvements in healthy eating behaviour; (57) in fact, they detected that the post-intervention group was significantly more likely to either eat out at restaurants or to purchasing prepared (usually less healthy) meals from the new store, than during the pre-intervention period. (57) Similarly, no significant associations with food consumption behaviour were identified by Wang et al. due to a new grocery store in California. (56) A recent intervention, where the effect of a government-subsidized grocery store was examined, discovered a decline in self-reported FV availability in households with children of 3-10 years of age in both intervention (from 77% to 68%;  $p<0.05$ ) and comparison (from 78% to 65%;  $p<0.001$ ) groups. (59) However, salty snack availability in the intervention group was reported to be reduced to 23% from 32% ( $p<0.01$ ) during the first follow-up. (59)

Another very recent grocery store intervention in Pittsburgh, Pennsylvania monitored consumption of components of diet including FV. (60) They found that the intervention neighbourhood consumed significantly ( $p<0.05$ ) fewer kilocalories (-222 Kcal/day), added sugars (-2.75 teaspoons/ day), and calories from solid fats, alcohol and added sugars (-1.38 percent of Kcal/ day) compared to the comparison neighbourhood. They measured these outcomes using the difference-in-differences method. The amount of FV and whole grain consumption, however, also was reported



to be reduced (non-significantly) at -0.14 servings per/day and -0.05 ounces/day, respectively in the intervention vs control groups. All these outcomes were reduced among regular users of the new grocery store compared to others in the intervention group, as well, although these were statistically not significant.(60)

Research on the impact of a new superstore in Seacroft, Leeds, provided 4 out of the 11 studies included in this review. (52,55,58,62) The initial analyses by Wrigley et al. (2002 and 2003) revealed a slight increase (but not significant) in FV consumption from 2.88 to 2.92 portions per day (ppd). (55,58) Respondents with poor (2 or less ppd) and the worst (less than 1 ppd) pre-intervention diets improved by 0.44 and 0.83 ppd during post-intervention, respectively. Further, analyses into switchers showed a significant ( $p=0.034$ ) 0.23 ppd rise in FV consumption. (55,58) As well, Gill and Rudkin, in re-analyzing the data, supported Wrigley et al. by reporting a significant ( $p<0.05$ ) increase in FV consumption in switchers, however, only in those who already consumed more during the pre-intervention. (52) Moreover, according to both Cummins et al. and Gill and Rudkin, residents living close to the store benefited the most. A significant (at 10%;  $p=0.077$ ) increase from 2.56 to 2.81 ppd in FV consumption was revealed in respondents within a 750m radius of the store using a straight line distance approach, (55,58) while a significant 0.7 ppd increase was reported among those who lived in close proximity to the store and did not have a motor vehicle, using a road network measurement.(52) Focus group discussions post-intervention in Seacroft revealed that young (17 to 34 years) respondents had negative attitudes about healthy eating, and in households with children, that the children had a bigger influence on their food purchasing and consumption

patterns.(62) However, older switchers noted a positive influence on their eating habits due to the new store, while some other participants (35 – 54 years old) learned about healthy eating only after the intervention.(62)

**Self-rated health and psychological health:** Cummins et al. reported an increased odds (1.52) of fair-to-poor self-rated health (adjusted for baseline and for confounders) in the intervention vs control groups, although this was not statistically significant.(54,61) Nevertheless, there was an improvement in psychological health in the intervention vs control groups (odds ratio 0.57; not significant) as well as in switchers vs non-switchers (odds ratio 0.24; significant).(54,55,61)

**BMI:** Two studies measured the Body Mass Index (BMI); neither of them found significant difference-in-differences through ITT analyses or on-treatment analyses.(53,60)

**Perceptions of food access:** Interestingly and importantly, two studies measuring perceptions of food access revealed positive impacts. One intervention revealed a significantly high difference-in-differences in perceptions of food access (1.47;  $p < 0.001$ ; adjusted) among the intervention vs comparison groups. (53) Another intervention showed significantly (at  $p < 0.05$  and  $p < 0.001$  levels) greater difference-in-differences for a variety of components related to ‘perceived access to healthy food’ among both the intervention vs comparison and regular users vs others in the intervention area.(60)

**Other outcomes:** Wang et al. found increases in walking among those who switched to the new store, (56) while the focus group discussions highlighted improvements in

self-esteem among neighbourhood residents due to the new store.(62) Cummins et al. also monitored the level of neighbourhood satisfaction in the Pittsburgh intervention and found a significant ( $p<0.05$ ) improvement (11.10%) in the intervention vs comparison groups. However, the improvement was not significant among regular users vs others in the intervention group. (60)

## **Discussion**

Review of eleven records of seven interventions revealed that new grocery store interventions have in general had an inconclusive influence on health-related outcomes in adults. Of the seven interventions, all have reported FV consumption as a proxy for healthy eating behaviour while few studies examined self-reported health, psychological health, BMI, perceptions of food access, and self-reported household food availability. Significant increases in FV consumption were detected in only one intervention among switchers who already consumed more FV during the pre-intervention, and who lived near the new store. (52,55,58) Conversely, one study reported significantly lower household FV availability, (59) while another reported a non-significant decline in daily FV consumption in both intervention and comparison neighbourhoods. (60) Further, one more intervention found that the intervention group was significantly more likely to consume unhealthy food. (57) Among other health-related outcomes, there were significant improvements in perceived food access, (53,60), neighbourhood satisfaction,(60) and poor psychological health.(54,61) One intervention did not have any impact at all on healthy eating behaviour.(56) Among the two studies that measured BMI, they failed to detect any significant changes. (53,60)

Health disparities arising due to unhealthy behaviours including unhealthy dietary patterns are becoming a serious public health issue. The abundance of energy-dense, low nutritious food at lower prices and associated limited physical activity contributes to chronic health conditions such as obesity, diabetes, and cardiovascular diseases. Overcoming these serious health issues is critical, and food store interventions are identified as one of the potential means to effectively address the problem. All interventions included in the review were carried out in areas designated as food deserts and socioeconomically disadvantaged or low-income neighbourhoods. The people living in these neighbourhoods were considered at risk for poor diet due to factors such as poor healthy food access, abundance of unhealthy food at lower cost, and poor accessibility due to geographic distance and poor public transit options.(17,66) As well, these communities were at higher risk of developing diet-related and other chronic health conditions than the general population. Apart from poor healthy food access, many of these neighbourhoods also suffer from low basic public and private services, social exclusion and associated oppressions.(67) These accumulated deprived conditions contribute to major grocery store retailers locating further away, partly due to business and other economic strategies.

Studies have also reported other outcomes that are not the focus of this review. For example, improved walking for food shopping was identified as an added advantage of a new grocery store in the neighbourhood, as this increases out of home physical activity.(55,56) Moreover, some residents also noted improved self-esteem in the community due to the new store and associated regeneration in the area,(62) neighbourhood satisfaction, (60) their children's dietary intake,(59) and food

insecurity. (57) It is surprising that only one study in this review looked at food insecurity (although the intervention's impact on the food insecurity was not clearly stated), (57) as it is acknowledged in the literature that poor healthy food access is one of the determinants of food insecurity.(30) Finally, some interventions looked at the level of awareness of the new food store among the participants. (59)

Food consumption behaviour is influenced by multiple factors, including environmental variables (community nutrition environment, consumer nutrition environment, organizational nutrition environment, and information environment), government and industry policies, individual variables (such as psychosocial factors and perceived nutrition environment), and behaviours.(21) Establishing a new grocery store particularly alters community and consumer nutrition environments. This modified nutrition environment leaves the relationship between eating behaviour and individual factors to remain unchanged, making it hard to achieve any change in health behaviour by modifying only one component i.e. environmental determinants. Some authors already identified this notion and acknowledged the importance of combined efforts to address healthy eating. For example, Wang et al. recognized the importance of combining traditional public health individual- and family-focused perspectives into these interventions if any effect is to be detected.(56) Likewise, independent associations between healthy food access and healthy eating are yet to be uncovered and understood.(68)

Another important aspect of this debate is the price of healthy food. Healthy food basket pricing in Flint, Michigan found that the price was significantly higher in a food desert than the rest of the city.(69) The higher price was reduced after opening two

grocery stores in the food desert but remained higher than the remainder of the city on average. (69) Further, exposure to a grocery store with a large variety of products, may contribute to buying products that are not core food items, thereby overspending on non-essential items. In fact, focus group discussions by Wrigley et al. revealed that although the new store increased accessibility and convenience, some residents were concerned about “temptation to overspend” when they used the new store.(62)

Financial difficulties that may be associated with consuming a healthy diet, while trying to balance a tight budget for other essentials such as housing and transport, might not be a simple task for low-income households. Spending a limited budget on transport could affect the amount of money that is spent on food, and ultimately reflect as lower FV consumption contributing to poorer health. Focus groups, in fact, revealed that the new food store within walking distance saved them transport cost previously used for travelling to get groceries.(62)

Despite the fact that grocery stores promote healthy food options, many also offer a variety of highly processed, ready to eat products high in sugar, salt, and fat.(57,59)

This reality might be a response to high demand for such products by people with busy, stressful lives. Further, although the main food shopper for households were the participants of these studies, they mentioned that their food buying patterns were influenced by food preferences of family members, in particular those of their children.(56,62)

Five of the studies from the United States reported that the majority of the participants were African American, (53,56,57,59,60) while one study from the UK had a White majority. (52,55,58,62) Having a large minority ethnic group as participants

might have skewed the health-related outcomes reported, as it is widely known that low-income minority subgroups reportedly have poor health outcomes such as obesity than the White majority. (70) Therefore, one could argue that not showing any significant impact in these studies might be due to the combined low socioeconomic and racial/ethnic health disparities that already exist and that intervention impacts on other groups in the population might bear different results. According to intersectionality theory, multiple disadvantaged conditions might result in worse health outcomes than when each condition is taken singly.(71) As such, detection of any subtle effects of interventions might need diverse subgroups of the population, larger samples and longer durations.

### **Strengths**

Although the quality of the majority of studies reviewed was 'weak', they present some of the highest quality evidence ethically possible because the nature of these interventions is such that it is not possible to conduct randomized controlled trials. In fact, natural observational experiments are the preferred method to evaluate this type of population health interventions. Moreover, majority of studies used well tested and standardized, which ensures high quality of data collected. Wrigley et al. conducted a 'repeatability study' which showed a high degree of reliability of their survey instrument. (54)

Further, all studies investigated individual shopping behaviour where participants' primary grocery shopping details were examined, which ensured that the health-related behaviour and outcomes were reported at the individual level and not only at ecological level. Moreover, all, but one of the studies, (56) were prospective

observational studies, which facilitated reducing potential recall bias. Additionally, all studies were published within the past 14 years, suggesting that the evidence produced is current, and would be applicable to the present food environment discourse.

### **Limitations**

These studies have varied follow-up periods from 1-4 months up to 12 months, and numbers of participants between 78 to 1009. Study designs used were also very diverse and included one-time surveys with retrospective (less than one year) data collection,(56) uncontrolled before/after studies, (52,55,58) before/after studies with different samples from the same population,(57) controlled pre-post quasi-experimental designs,(53,54,60,61) and a street-intercept survey with 24-hour dietary recalls. (59) These differences in follow-up periods, sample sizes, and study designs make the comparison of studies difficult.

Although the majority of interventions relied on detailed and well established measures to assess outcomes, some studies used single-item questions. (54) Using brief instruments to assess outcomes such as FV consumption and diet has shown to be less effective in assessing what need to be assessed than those tools with more detailed questionnaires. (72) The results produced would be more reliable if all studies used detailed and comprehensive measurement instruments.

Selecting areas with the highest level of deprivation might not be the best option to evaluate these interventions as healthy eating might be one out of many issues these deprived populations face in everyday life. For instance, food price is one of the major



limiting factors for low-income households when it comes to purchasing healthy food.

(73) Further, healthy food options cost more than less healthy options.(74) Recent literature indicates higher sensitivity to price reductions and monetary incentives among individuals than to other interventions. (75) Although food access is improved with grocery store interventions, the impact on food price might be limited, and therefore, low-income residents might not be able to change their diet due to their limited budgets. This assumption is supported by results showing that although neighbourhood residents have improved their perceptions of food access, they did not show any significant changes in FV consumption or BMI. In contrast, this could also be a function of BMI taking long periods of time to change while individuals' perceived food access, self-esteem and neighbourhood satisfaction could change sooner. Further studies in mixed socio-economic populations might provide balanced results that would provide more generalizable evidence as well as those that support causal pathways.

Changes in eating behaviour and subsequent health-related outcomes might also take a longer time to change and show any detectable effect. Some authors highlight this limitation of food environment interventions, specifically Cumming et al. argued that significantly improved perceptions of food access among participants is a positive indication of better health in the long run.(53) Elbel et al. proposed that more than one year might be necessary for neighbourhood residents to change eating behaviour and to subsequently see any impact on health-related outcomes. (59)

Further, these seven interventions took place in two countries; i.e. the United States (five) and the United Kingdom (two). The outcomes of these studies should also be

interpreted in the context in which they occurred. For instance, the intervention in Seacroft, England, which showed a significant impact on FV consumption among switchers was an initiative with enormous government advocacy and targeted poor neighbourhoods specifically.(67) It was not only an intervention to increase food access, but also a collection of efforts to combat social exclusion with a larger centre ('Seacroft green' Centre) and also had the intention to provide unemployed local residents with employment opportunities. (67) In contrast, the intervention in Flint, Michigan was a privately invested grocery store which was closed after one year in business, with no government support. (57) Complex and subtle health-related behaviour might have contextual effects, with acceptability of interventions by residents and subsequent change in behaviour influenced by many known and unknown factors. For instance, if a new grocery store was opened in a disadvantaged, predominantly low-income neighbourhood, and if the community had the understanding that the store was established primarily for low-income residents, some people might be reluctant to shop at the new store. Unknown factors such as above are difficult to capture and their effects on health-related outcomes might be considerable.

## **Conclusion**

As discussed, approaches which address single aspects of healthy eating (like improved access) do not seem to enhance health-related outcomes in adults in an effective manner over short durations up to one year. These interventions might prove successful and result in intended effects in the long-run, yet we do not have enough evidence to say whether this is the case. Conversely, as complex and

multifaceted eating behaviours and resulting health-related outcomes are, the interventions that aim to address these problems should also have multidimensional and multipronged approaches if any effect is to be seen. Presently the field of grocery store interventions to improve health-related outcomes is developing, and the complex linking pathways that connect the interventions to health outcomes are yet to be elucidated. Further evidence is needed in the form of high-quality research to uncover these complex associations, as well as interventions in different communities with longer periods of follow-up, to inform policy decisions and recommendations.

Table 1: Characteristics of selected studies

Author, Study location	Study design, intervention and control population characteristics	Period of data collection, intervention and comparison group numbers	Relevant outcomes	Methodological quality rating, comments
Wrigley N, Warm D, Margetts B. (2003) Wrigley et al. (2002)  Seacroft, Leeds, England	-A 'before/ after' study  -Opening a new food store (Tesco Superstore) in November 2000  -A low-income, deprived, white (ethnically less diverse than the city as a whole) area	-June - July 2000 (5 m before) and 2001 (7-8 m after intervention)  -Before =1009 After =615  -No comparison group	-Mean FV consumption increased from 2.88 to 2.92 (not significant) -FV consumption significantly increased among those who had poor (by 0.44 ppd) and worst (by 0.82 ppd) diets pre-intervention -FV consumption of switchers increased significantly by 0.23 ppd	-Weak quality (both articles)  -Most of the important confounders were included in the analysis
Wrigley et al. (2004)  Seacroft, Leeds, England	-A qualitative focus group study post intervention  -The above same intervention (Wrigley et al. 2002 and Wrigley et al. 2003)	-September 2002 (22 m post intervention)  -Eight focus groups (each with up to 8 participants; total n=49)  -Five of them were "switchers" to the new store  -Age gradient: 17-34, 35-54, >55	-Switching due to convenience, accessibility and sense of potential saving money -Temptation to overspend -Self-esteem and alienation created, intimidated by 'outsider' shoppers -Negative attitude towards healthy eating among younger participants, few middle aged and older participants improved healthy eating after intervention	-Did not undergo quality assessment
Gill L, Rudkin S. (2014) Seacroft, Leeds, England	-Secondary analysis of data from Wrigley et al.'s study	-599 observations from the second wave of the Seacroft Intervention Study	-FV consumption improved among those who lived near the new store, those who previously consumed more FV, and those who choose to use it (switchers)	-Weak quality

<p>Cummins S, Flint E, and Matthews SA. (2014) Philadelphia</p>	<p>-Controlled pre-post quasi-experimental longitudinal study -Opening a new supermarket (41,000 feet<sup>2</sup>) in December 2009, a Pilot study -'food desert' -low-income, Black</p>	<p>-Pre: June-Sept 2006 Post; June-Nov 2010 (6M later)  -Intervention: Pre; (n=723), Post; (n=311)  -Comparison: Pre; (n=717), Post; (n=345)</p>	<p>-No significant difference-in-differences for BMI &amp; FV intake in the intervention vs comparison  -Adjusted difference-in-differences for perceptions of food access 1.47 (p&lt;0.01)</p>	<p>-Weak quality  -Matched intervention and comparison groups</p>
<p>Wang et al. (2007) California</p>	<p>-One-time survey  -Opening a full-service grocery store in the neighborhood center in mid-2004  -A low socioeconomic neighborhood in a moderate-sized city; the nearest full-service grocery store was located &gt; a mile away from most residences (before intervention)</p>	<p>-n=78 adults (&gt;18 yr) lived within a two-mile radius of the new grocery store  -6 months after the intervention  -No comparison group</p>	<p>-No increase in FV consumption  -42% who received nutrition education consumed fruit 2 or more times/day vs. 17% who never had nutrition education (p=0.549) marginal evidence</p>	<p>-Weak quality  -No reported adjustments for confounders</p>
<p>Sadler RC, Gilliland JA and Arku G. (2013)  Flint, Michigan</p>	<p>-A 'before/after' study  -Opening an independent grocery store (Witherbee's Market) in June 2010 (and closed November 2011) -Intervention neighbourhood: socioeconomically disadvantaged; high</p>	<p>-Pre: April-June 2009, post; April-June 2011 (1y after opening the grocery store)  -Pre (n=186)  -Post (n=166)</p>	<p>-Food consumption: no significant differences between intervention and comparison groups  -Significant increase in prepared food consumption in intervention group</p>	<p>-Weak quality  -Random selection of participant from the intervention &amp; comparison sites  -15% response rate</p>

	proportion of black residents and was a 'food desert' while comparison neighbourhood was served by a grocery store			
-Cummins et al. (2005) and Cummins et al. (2008)  -Springburn, Glasgow, UK	-Prospective controlled "before and after"; a quasi-experimental design and a qualitative focus group study  -A new Tesco hypermarket opened in November 2001	-Pre; October 2001 Post; October 2002 (follow-up period 10 m) -Qualitative component=6-7 m after opening store  -Intervention; Pre (n=293); Post (n=191)  -Comparison; Pre (n=310); Post (n=221)	-The intervention vs comparison FV consumption: -0.10ppd (95% CI -0.59 to 0.40) -Mean fruit consumption: 0.03ppd (95% CI -0.25 to 0.30) -Mean vegetable consumption: -0.11ppd (95% CI -0.44 to 0.22) - Fair to poor health: Adjusted OR increase in the intervention vs comparison 1.52 (95% CI 0.77 to 2.99) NS -Poor psychological Health: Adjusted OR reduced in the intervention vs comparison =0.57 (95% CI 0.29 to 1.11) NS -Qualitative study: increased variety & availability, no report of change in diet due to new store, improve social inclusion and employment	-Moderate quality (Cummins et al. 2005)  -Random sampling of households  -Control for confounders at design (matching by the level of deprivation) and analysis phases
Elbel B et al. (2015)  -Morrisania, South Bronx, New York City	-Difference-in-difference study design - A new supermarket opening (17 000 ft <sup>2</sup> ) in August 2011 - largely African-American or Hispanic/Latino, low-income neighbourhoods with comparatively low grocery	- Baseline; March-August 2011, Second round; September-December 2011, Third round; August-2012 (1y after the supermarket opened)  -Intervention: Pre (n=412), post1 (n=421), post2 (n=239)	-Household FV availability declined in both groups during post2 from 77 % to 68 % (P<0.05) in intervention and from 78 % to 65 % in comparison (P<0.001).  -Household availability of salty snacks decreased in intervention at	-Strong quality  -Matched intervention & comparison groups  -Participants are not aware of the intervention

	store area availability per person; -‘Supermarket High Need Areas’	-Comparison: pre (n=423), post1 (n=407), post2 (n=270)	post1, from 32 % to 23 % (P<0.01). At post2 not significant.	
Dubowitz et al. (2015)  -Pittsburgh, Pennsylvania	- A quasi-experimental longitudinal - A Healthy Food Financing Initiative-funded full-service supermarket opened in October 2013 -Socioeconomically and geographically matched intervention and comparison neighbourhoods - African-American, low-income food desert at baseline	- Baseline—May to Dec 2011 - Follow-up—May to Dec 2014 - Intervention: n=571 - Comparison: n=260	- Significant difference-in-differences between the intervention vs comparison in mean daily intake of Kilocalories= -178 (p<0.05), added sugars in teaspoons= -3.34 (p<0.05), solid fats, alcohol and added sugars= -3.11 (p<0.05) and neighbourhood satisfaction %= 11.10 (p<0.05) and all the components of perceived access to healthy food at p<0.001 significance level. - No significant changes in FV intake or average BMI between the intervention vs comparison - No significant changes in components of diet, neighbourhood satisfaction or average BMI between regular shoppers vs others in intervention group. Perceived access to health food was significantly increased in regular users.	- Strong quality  -Random sampling  -87% of eligible participated  -Control of confounders during design (matching) and analyses

## **CHAPTER 3: Early impact of a new food store intervention on health-related outcomes**

### **Introduction**

The burden of diet-related chronic NCDs is rising. (76-78) Current eating patterns, particularly, fast and easily-accessed food with higher levels of fat, sugar, salt, and energy are comparatively more affordable, available and accessible than healthier food. (79)

These foods play a vital role in etiology of NCDs through excess weight gain, intake of a surplus of energy without essential nutrients and suppressing appetite control. (1,46,80)

Poor grocery store access, but abundant fast food restaurants and convenience stores in deprived urban inner cities (food deserts and food swamps) are linked with this public health concern. (81-83) Grocery stores, in contrast, may offer a wider array of food choices, (84,85) thereby promote 'healthy eating', and consequently contribute to lower NCD incidence.(86,87) However, not all studies concur with these findings. (88,89)

Practices of food procurement and eating are two of the most highly variable human activities with direct health consequences. Therefore, they are also among the most valuable targets to direct preventive strategies. (76)

To date, a limited number of studies have investigated the impact of new food store interventions in deprived, urban regions that had low grocery store access previously (see the previous chapter for a review of this literature). Given the nature of these interventions in terms of study design, strength and consistency of results, inferring causation based on available evidence to guide programs and policies is challenging. In order to exclusively appreciate the impact of these population health interventions, a holistic approach should



be employed. For instance, improved food access, as created by opening a new grocery store in a food desert, might improve food security within households, which might then lead to changes in health-related outcomes. However, sociodemographic and psychosocial risk factors that determine health such as living with multiple disadvantaged conditions (for example, poor housing, lack of employment opportunities, low income), individuals' social connectedness, and beliefs and motivation to change health behaviour may continue to shape health-related outcomes (figure 2). In either case, such evidence would be of utmost importance for integrated and targeted health promotion strategies and policies to prevent chronic NCDs.

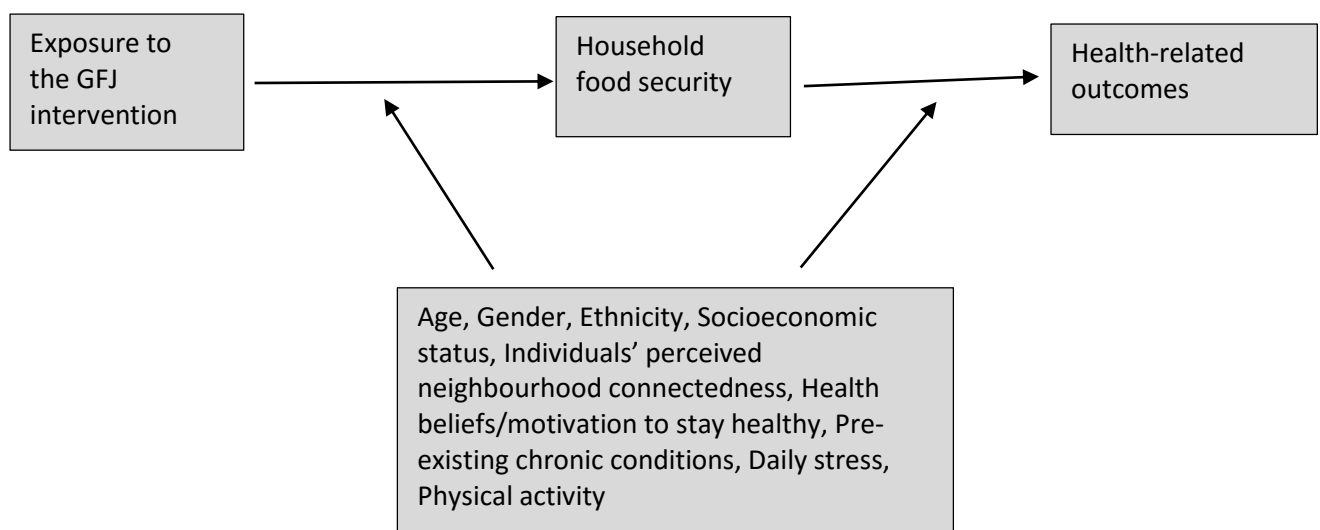


Figure 2: Hypothesized causal pathway from GFJ use to health-related outcomes

**The intervention: The Good Food Junction cooperative grocery store**

Saskatoon, a mid-sized city in Saskatchewan, Canada with a population of 260,900, (90) has seen substantial changes in poverty rates, health, and food access at neighbourhood level over the last decades. From 1986 to 2001 the number of high-poverty neighbourhoods

increased by two, while 6 out of 7 of these in 2001 were concentrated on the West side of the South Saskatchewan River. (91) These neighbourhoods are part of the 'core neighbourhoods' of Saskatoon (hereafter known as core neighbourhoods) and are near and to the west of downtown. (91) These neighbourhoods have higher rates of unemployment, houses needing major repair, single parent families, and people declaring Aboriginal ancestry. (91)

Grocery stores began to close in the core neighbourhoods in the mid-1980s, and no new stores had opened since that time. (91) Interestingly, other food sources such as fast food outlets, convenience stores and small grocers concentrated in the western half of the city, (92) which created a food balance ratio (the ratio of access to healthy food [i.e. proximity of supermarkets and larger grocery stores] to that of unhealthy food [i.e. proximity of convenience stores, small grocers and fast food outlets]) of almost 59; much greater than the Saskatoon average of 2.3 in 2006-2008. (17,92)

Core and surrounding neighbourhoods were identified as Saskatoon's primary food desert (Figure 3). (92)

**LEGEND**

**Food deserts**

-  Primary desert
-  Secondary deserts
-  Residential neighborhood
-  Non-residential neighborhood



Figure 3: Food deserts in Saskatoon in 2008

Further studies found high concentrations of unhealthy food outlets in core neighbourhoods suggesting that the primary food desert was more of a food swamp, (17,91,93-95) with an abundance of convenience stores (Figure 4). (96)

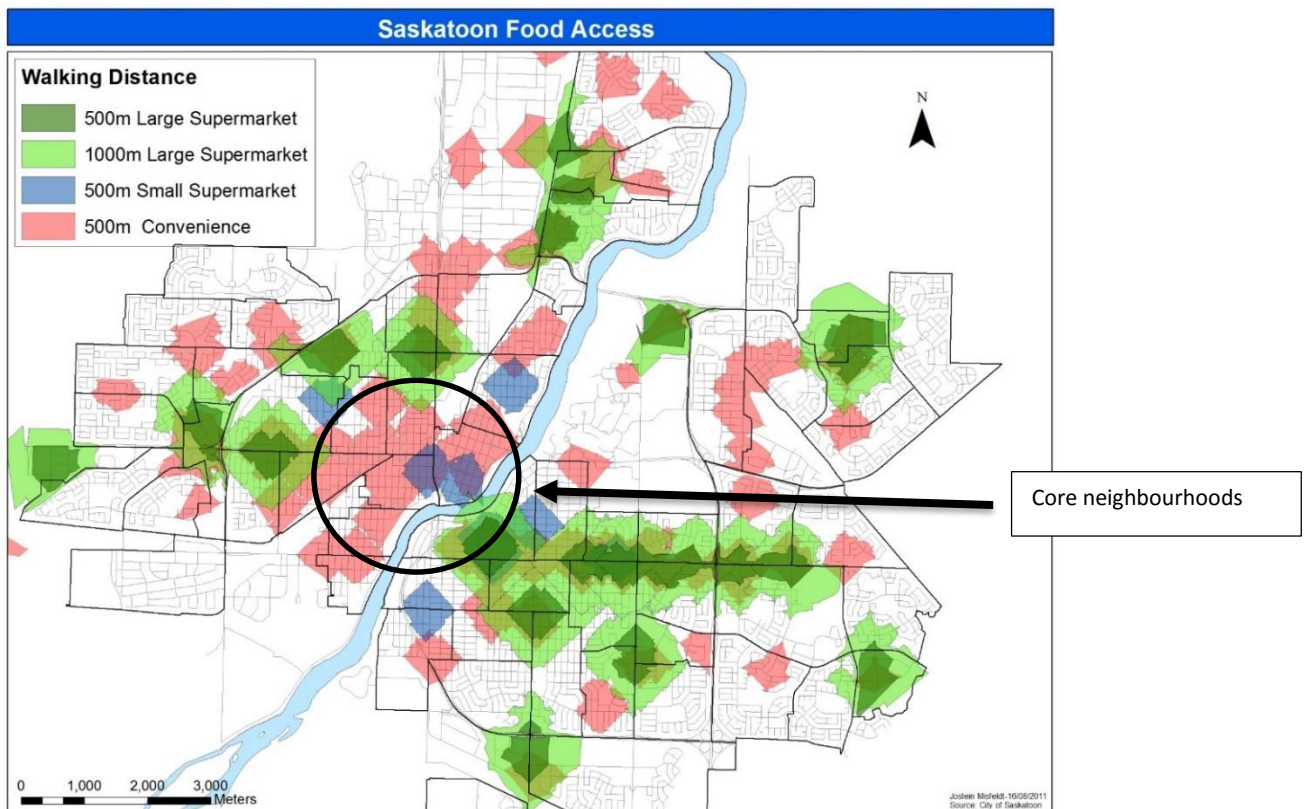


Figure 4: Small and large supermarket and convenience store access in Saskatoon (2011)

Core neighbourhood residents also suffer higher levels of chronic NCDs such as diabetes, heart disease, mental health conditions, and all-cause mortality among others when compared to the most affluent neighbourhoods in Saskatoon. (18,97) Moreover, Saskatoon has a large population of people of Aboriginal ethnicity who live predominantly in these low-income neighbourhoods. (98) Prior research has shown that this Aboriginal population had a higher likelihood of poor health outcomes compared to the rest of the population, (99) contributing to significant health disparities at the neighbourhood level.

Saskatoon’s core neighbourhoods drew the attention of community-based organizations and the health system, who (among others) introduced various interventions over the years. (98) An important community level intervention that primarily addressed food security and

health of core neighbourhood residents was opening a grocery store called the Good Food Junction Cooperative (GFJ). (17,100)

The GFJ opened in September 2012. It was a large scale (4900 sq ft), full service, not-for-profit cooperative grocery store with a community-led business model and represented a much needed intervention for core neighbourhoods as identified in previous studies.(16,101) The opening of this food store was a unique food environment intervention and consequently created an opportunity for research, practice and policy analysis. (101)

The GFJ was a part of Station 20 West ([www.station20west.org](http://www.station20west.org)), located in the center of core neighbourhoods. (102) Station 20 West is a neighbourhood revitalization project which facilitates access to services such as housing/employment/economic development, women's/mothers' needs, early childhood development, health services, community outreach and engagement, space for community events, in addition to improving access to healthy food. (102) Discussions about establishing Station 20 West started in 2003/04 when a grocery store was identified as one of the topmost priorities of the community. (16,101-103) Discussions among the community, University and other local organizations on opening a grocery store evolved into what became Station 20 West, of which one component was the GFJ.

The opening of the GFJ modified the community and consumer nutrition environments. These two nutrition environments have been identified as the most important due to the wide impact they could have on health and wellbeing. (21,104)

Within a year of GFJ opening, the residents of four neighbourhoods living within 10-minute walking distance of the GFJ were surveyed, a large majority (95%) were aware of its

existence, and 69% had used the store at least once. (20) Moreover, this cross-sectional study found that significantly more of the residents who used the GFJ were Aboriginal, had low-incomes and used other food-based programs, while recent immigrants to Canada used the store significantly less. (20) Another interesting finding was that a small proportion of households, 8.2 percent, had shifted to GFJ as their primary grocery store at the end of the first 12-month period after opening. (20)

Another study investigated sales data of GFJ members for one full year starting from eight months after its establishment (lifetime membership of this cooperative store was 5 dollars). (105) This study revealed that GFJ members living in core neighbourhoods spent more food dollars on vegetables and less on meat and prepared foods compared to residents living outside of the core neighbourhoods. (105) Taken together these results suggest that the GFJ intervention reached the populations who needed it the most and for whom it was intended. However, any impacts it could have on health-related outcomes remain unanswered, which is the objective of the present study.

The objective of this study is to answer two research questions: i) Does higher exposure to the GFJ intervention result in more positive health-related outcomes in GFJ users compared to those with lower exposure? Does individuals' perceived social connectedness modify the above relationship? ii) Does exposure to the GFJ intervention significantly improve health-related outcomes for GFJ users with two or more disadvantaged conditions (Aboriginal ethnicity, seniors (65 years and older), low-income, and low-education levels) simultaneously as compared to having single or none of the of these conditions?

### **Theoretical perspectives**

The theoretical perspectives that guide this set of research questions are intersectionality theory, the social ecological framework, and the population health approach.

A population health approach provides a basis for identifying the underlying intertwined physical, economic, and social determinants of populations' health. (106) This approach shifts the focus from high-risk groups to the population generally with the objective of reducing the risk of the entire population. (107) One of the premises that informs this approach is that an individual's disease risk is closely tied to the populations to which he/she belongs.(108) These populations, stratified by various social factors such as income and education levels, ethnic and cultural identities, and place, differentially confer risk to individuals leading to observed health outcomes.

Intersectionality theory postulates three principles namely, directionality, simultaneity, and multiplicativity, that help understand the complex interactions of various axes of oppression. (71)

Directionality assumes that disadvantaged and marginalized social identities such as women and cultural minorities are considered as oppressed groups in a society, and, they generally experience poorer health outcomes compared to those who are more powerful. In other words, being a member of an oppressed group leads to poorer life chances, and then to poorer life outcomes, including health. Simultaneity speaks to multiple disadvantaged identities needing to be considered together when analyzing their possible effects. For example, when the impact of being an Aboriginal person in Canadian society is studied, one should also consider simultaneous other identities (and their joint effects) such as low-income and low-education. Multiplicativity explains that these multiple social identities may

not only act in an additive manner, but rather in an exponential manner through complex interactive effects.

These multiple social stratifications are interdependent, and synergistically affect health, (109) therefore, the effects cannot be fully understood nor appreciated if taken as single separate entities.

In this study, GFJ users with disadvantaged conditions such as low-income, low-education, Aboriginal status, and seniors<sup>3</sup> might experience poor food security and other health-related outcomes, while those participants with two or more of these conditions simultaneously will experience negative health outcomes in a manner greater than if considered individually.

The social-ecological approach connects individuals' behaviours with environmental influences, which operate at different levels; intrapersonal (biological, psychological), interpersonal (social, cultural), organizational, community, and public policy levels.

(110,111) Similar to other human behaviours, health-related behaviours are also influenced and shaped by physical, social, cultural, and policy environments that function at these different levels. Therefore, this approach has been increasingly used in studying health-related behaviour. (111,112)

Social ecological models of health behaviour encompass four fundamental principles: 1) health behaviours have multiple levels of influence, 2) influential factors interact across these levels, 3) specific behaviours at the individual level will have specific relevant influences at each level, and 4) factors operating at multiple levels produce the most effective results. (111) The impact of an intervention is stronger when a combination of

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<sup>3</sup> Although being a senior is not the same disadvantage condition as being an Aboriginal, having low-income and low-education, it was included after considering the outcomes being measured in this study.



both active (i.e. behavioural) and passive (i.e. environmental) approaches are used.

(110,112) In this case, motivated individuals will actively make the decision to shop at the GFJ which promotes healthy food as opposed to shopping at a convenience store.

Further, the residents of the former food desert are passively exposed to the GFJ because the store is situated in their neighbourhood, highly visible, close to where they live or is on the way to other destinations nearby.

Figure 5 illustrates factors at multiple levels that affect eating behaviour and potentially use of the GFJ. At the intrapersonal level, income, education, preference, health-related practices and beliefs, use of other community-based food programs, media advertising that influences an individual's knowledge and attitudes play roles. At the interpersonal level, the influences would be household socioeconomic status, the influence of family members, friends, and peers, and informal discussions among neighbours, friends, and peers about the grocery store. At the organizational/institutional level the factors would be organizational structure, membership, and educational/promotional activities at the GFJ. Finally, the community level influences would be public awareness events, formal public discussions, and neighbourhood social ties. Interventions at multiple levels are expected to act in concert and in combination to change the diet-specific behaviour, and therefore in this case health-related outcomes of GFJ users.

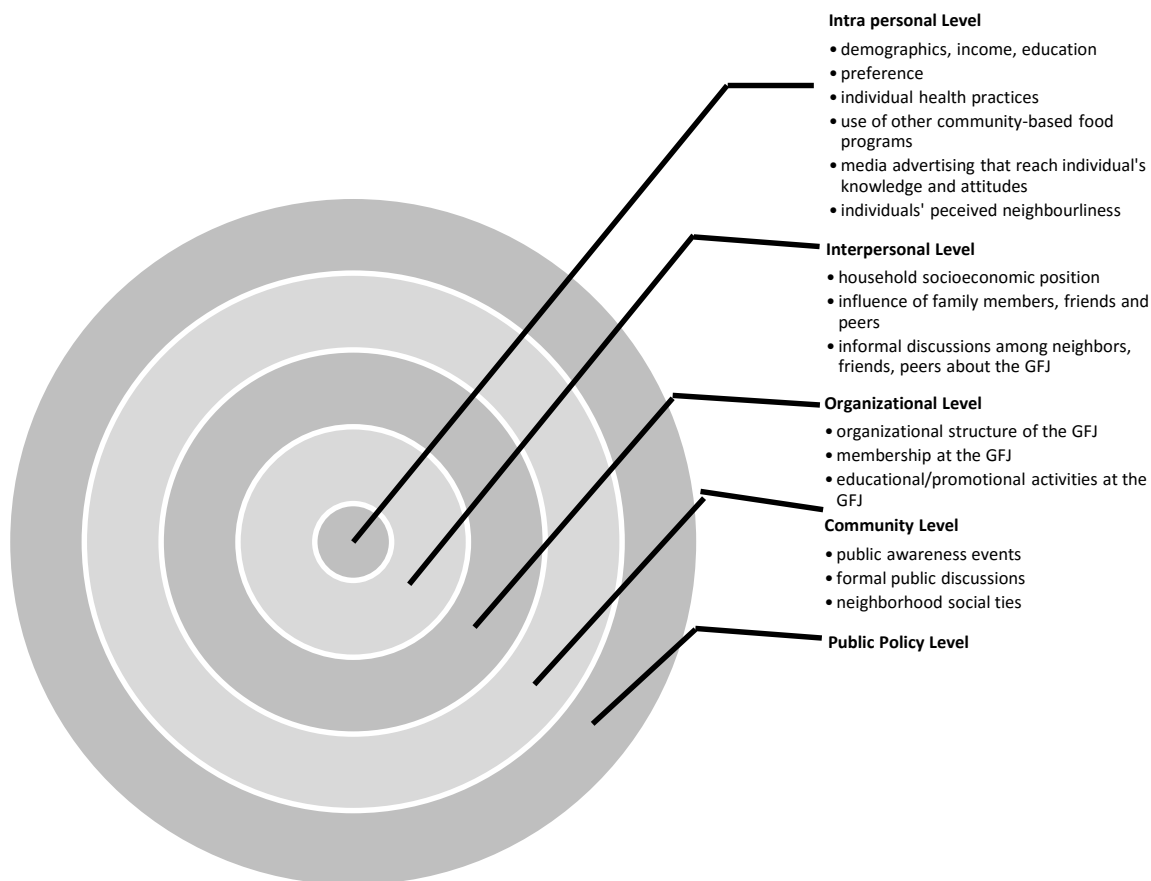


Figure 5: Factors at multiple levels potentially affecting eating behaviour and GFJ use

## Methods

### *Recruitment*

A longitudinal study followed up GFJ users who had shopped at least three times at the GFJ during previous six months before the baseline recruitment into the study, and who were the primary food shoppers for their household. The study started 10-13 months after opening the GFJ (July-September, 2013) and was repeated at 17-19 (February-April, 2014), and 23-25 (August-November, 2014) months post-opening of the GFJ. Participant recruitment was done in four ways; 1) research assistants approaching shoppers in the store, at various times and on different days over a two-week period, 2) identification of further participants referred by already recruited participants, 3) distribution of flyers

throughout the neighborhood near the store, and 4) further recruitment during the GFJ one-year anniversary celebration. Informed consent was obtained from all the participants before commencing the study.

### ***Data collection***

A closed-ended survey was administered either in person at the store (or elsewhere in the Station 20 West building) or if participant preferred later on over the telephone or in person. The survey primarily consisted of several modules of the Canadian Community Health Survey (CCHS) including household sociodemographics (age, sex, Aboriginal status, highest education attained and annual household income), general health, changes made to improve health, chronic conditions, and household food security questions. The survey also asked participants how often they shopped at the GFJ, about their participation in other food-based programs, and their self-reported height and weight. Further, participants' sense of belonging to their neighbourhood was assessed using 4 questions (Appendix 4 shows the questionnaires used for data collection).

Ethics approval for secondary use of data for this study was obtained from Behavioural Research Ethics Board of the University of Saskatchewan (Appendix 5).

### ***Measures***

**Dependent variables:** Two types of health-related outcomes were assessed in this study:

1) Intermediate health-related outcomes and 2) General health-related outcomes. The intermediate outcome was household food security status (this was hypothesized to be a change due to the exposure to GFJ intervention, and, in turn, a factor that plays a role

midway between the exposure and general health-related outcomes). General health-related outcomes measured were: i) self-reported general health, ii) self-reported health compared to one year ago, iii) self-reported mental health, and iv) BMI. BMI, which is a risk factor for many NCDs including coronary heart disease and high blood pressure, (113) is related to diet and caloric intake; however, it was anticipated that this outcome would not change during the short period of this study as body mass change overtime in apparently healthy people is gradual. (114)

**Independent variable:** Exposure to the GFJ intervention was captured using the item ‘how often have you shopped at the GFJ since it opened’. Based on the distribution of responses to this question a new variable, ‘dose’ of exposure, was created with three levels: low, moderate and high (Table 2).

Table 2: Creating a 'level' of exposure to the GFJ intervention

<b>Frequency of shopping at the GFJ</b>	<b>'level' of exposure to the GFJ</b>
Less than once a month since it opened	'low'
About once a month since it opened	'moderate'
More than once a month since it opened	'high'

**Covariables:** Health-related outcomes that were examined among GFJ users may be influenced by other factors in addition to the primary independent variable of interest. Four types of such risk factors were identified:

1. Sociodemographic risk factors: age (senior vs not), gender (male vs female), ethnicity (Aboriginal vs non-Aboriginal), annual household income (low—\$30,000 or less vs high—more than \$30,000), education (less than high school, high school and some post-secondary vs university)

2. Pre-existing health conditions (ever vs never diagnosed by a medical provider to have diabetes, high blood pressure, heart disease or cancer) and health behaviour-related risk factors (level of daily stress, level of daily physical activity) and beliefs in changing health behaviour (motivation and willingness to improve own physical health)
3. Perceived neighbourhood sense of belonging (a categorical principal component analysis [CATPCA] was used to derive a single neighbourhood component using the four questions on neighbourliness)
4. Other (chose GFJ as the primary grocery store, how long lived in the neighbourhood and use of other community-based food programs)

### ***Analysis***

Distributions pertaining to study population characteristics, independent, dependent, and covariables were examined using graphs and frequency tables. During this step, creating new variables and categorizing existing variable options were done.

Four items used to capture perceived neighbourhood social ties were highly correlated, which necessitated the use of a CATPCA to obtain a single score.

A series of bivariate and multivariate logistic regression analyses were conducted in order to identify the independent associations at three time points separately.

In order to account for different types of variables (binary and ordinal) with missing values, a generalized estimating equations (GEE) approach was used. GEE efficiently estimates regression parameters of longitudinal (therefore correlated and not independent, but

independent across individual participants) data using a quasi-likelihood function, and considers within-subject correlation as a 'nuisance' variable. (115,116)

When empirical within-subject correlations were considered against different working correlation structures, both 2-dependent and exchangeable structures fit the observed data. However, by considering the number of parameters that need to be estimated, an exchangeable working correlation structure was selected (data not shown).(116)

*Research question 1:* Standard model building strategies were followed to model the five outcomes. Briefly, the procedure was: an initial univariate GEE selected those covariables with  $p < 0.25$  which were retained for multivariate GEE together with the main predictor. The multivariate GEE selected those covariables with  $p < 0.05$  which were retained for the preliminary final model. (117) The main predictor (GFJ exposure) was retained regardless of its level of statistical significance. The preliminary final model was then subjected to assessment of two-way interactions between i) the longitudinal 'time' and other covariables and ii) the main predictor and other covariables tested one at a time. Interactions significant at  $p < 0.05$  were retained for the final model.

Model fit was determined using Quasi-Likelihood under Independence Model Criterion (QIC) and Corrected Quasi-Likelihood under Independence Model Criterion (QICC) values. The smaller QIC and QICC values show 'better' model fit, and the final models were adjusted accordingly.(118,119)

*Research question 2:* the study sample was stratified based on having disadvantaged conditions—Aboriginal ethnicity, seniors<sup>4</sup>, low-income, and low-education. The stratifications were;

- 1) Those with one or none of the disadvantaged conditions
- 2) Those with two or more of the disadvantaged conditions

This new variable was tested as an effect modifier with the primary predictor in models obtained from research question 1; however, the four individual risk factors (which constitute this new variable), were removed, and the new ‘multiple disadvantaged’ variable instead was entered. Other covariables in initial models were retained.

Estimation of specific odds ratios in the presence of interaction was initially calculated manually by writing down the expressions for the logit at the two levels of risk factors being compared, and then subtracting and taking the difference between the two equations. (117) These calculations are presented in the appendix at the end of relevant models.

SPSS (version 23, IBM) was used for all analyses. SAS 9.4 and Microsoft Excel 2016 software were used to confirm the odds ratios of the interaction terms, which were calculated by hand. The standard threshold of  $p < 0.05$  was used to determine the statistical significance of the results.

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<sup>4</sup> As already noted, being a senior was identified to invoke a different disadvantaged condition than being Aboriginal, having low-income, and low-education. With this in mind, analyses were also carried out without having ‘seniors’ in the new disadvantaged category variable, but included as a main effect where relevant. However, the two models did not differ from each other significantly (data not shown). Therefore, it was decided to report the above analysis in this thesis.

## Results

### *Characteristics of participants recruited during round 1 and round 2*

The study initially enrolled 156 GFJ shoppers. By round 2 and 3, there were 27 and 37 participants lost to follow-up, respectively. Reasons were death (n=2), refused further participation (n=1) and unable to establish contact using the contact information provided.

The sample was replenished by recruiting 24 new participants during round 2. The characteristics of the round 1 and round 2 recruited participants are given in Appendix 6.

### *Loss to follow-up*

A comparison between study completers and non-completers along the sociodemographic, independent and dependent variables are given in Table 3. Participants who were food insecure, Aboriginal, had low household income, experienced multiple disadvantaged conditions, and who had lived in their neighbourhood less than 5 years were statistically more likely to not complete all three follow-ups in this study.

Table 3: Characteristics of study completers and non-completers (based on round 1 data)

Characteristic	Study completers (%)	Non-completers (%)	Chi-Square p-value
GFJ exposure <ul style="list-style-type: none"><li>• Low</li><li>• Moderate</li><li>• High</li></ul>	19 16 65	26.8 16.1 57.1	0.508
Food security <ul style="list-style-type: none"><li>• Food secure</li><li>• Food insecure</li></ul>	53 47	32.1 67.9	<b>0.012</b>
General health <ul style="list-style-type: none"><li>• Fair to poor</li><li>• Good to excellent</li></ul>	23 77	33.9 66.1	0.140



Health compared to one year ago			0.547
<ul style="list-style-type: none"> <li>• Worse than an year ago</li> <li>• Better than an year ago</li> </ul>	11 89	14.3 85.7	
Mental health			0.555
<ul style="list-style-type: none"> <li>• Fair to poor</li> <li>• Good to excellent</li> </ul>	12 88	8.9 91.1	
BMI			0.777
<ul style="list-style-type: none"> <li>• Overweight/obese</li> <li>• Underweight/normal weight</li> </ul>	62 38	64.3 35.7	
Use of other food programs			0.512
<ul style="list-style-type: none"> <li>• None</li> <li>• 1-2</li> <li>• 3 or more</li> </ul>	12 66 22	10.7 58.9 30.4	
GFJ primary store			0.700
<ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	76 24	73.2 26.8	
Aboriginal status			<b>0.000</b>
<ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	64 36	23.2 76.8	
Level of education			<b>0.000</b>
<ul style="list-style-type: none"> <li>• University</li> <li>• High sch&amp; some post sec</li> <li>• Less than high school</li> </ul>	31 49 20	5.4 50 44.6	
Household income			<b>0.020</b>
<ul style="list-style-type: none"> <li>• High</li> <li>• Low</li> </ul>	43.3 56.7	22.7 77.3	
Disadvantaged category			<b>0.000</b>
<ul style="list-style-type: none"> <li>• Single/none</li> <li>• Multiple</li> </ul>	64 36	33.9 66.1	
Length of time lived in nbhd			<b>0.003</b>
<ul style="list-style-type: none"> <li>• Less than 5 years</li> <li>• 6 or more</li> </ul>	59 41	82.1 17.9	

### *Sociodemographic characteristics of the GFJ shoppers*

The majority of study participants were female (74.8% to 75.2%), about one-half self-identified as Aboriginal (40.4% to 52.9%), had low incomes (54.5% to 60.8%), and had at

least a high school or some post-secondary education (49.4% to 53%). Table 4 shows characteristics of the study population.

Table 4: Study population characteristics

Wave of data collection	Round 1	Round 2	Round 3
Number of participants	156	153	115
Age [median (min, max)]	42 (21, 90)	43 (21, 91)	44 (22, 91)
Gender [n (%)]			
▪ Male	39 (25)	38 (24.8)	29 (25.2)
▪ Female	117 (75)	115 (75.2)	86 (74.8)
Self-identified Ethnicity [n (%)]			
▪ First Nations Status	53 (32.5)	60 (38.2)	34 (28.1)
▪ First Nations Non-Status	8 (4.9)	3 (1.9)	2 (1.7)
▪ Metis	19 (11.7)	19 (12.1)	12 (9.9)
▪ Inuit	-	-	-
▪ Total Aboriginal (%out of total sample)	79 (50.6)	81 (52.9)	46 (40.4)
Newcomers to Canada (<5 years in Canada) [n (%)]	4 (2.5)	-	1 (0.8)
Annual household income [n (%)]			
▪ Less than \$30,000	85 (54.5)	93 (60.8)	69 (60.0)
▪ \$30,000 or more	49 (31.4)	44 (28.8)	38 (33.0)
▪ Don't know or decline to answer	22 (14.1)	16 (10.5)	8 (7.0)
Highest level of education [n (%)]			
▪ Less than high school	45 (28.8)	43 (28.1)	22 (19.1)
▪ High school & some post-secondary/ technical college	77 (49.4)	78 (50.9)	61 (53)
▪ Completed university	34 (21.8)	32 (20.9)	32 (27.8)

*Independent and dependent variable distributions of the GFJ shoppers*

Table 5 illustrates the distribution of the primary independent and dependent variables among study participants during three rounds. The level of GFJ exposure increased positively except high exposure in round 3. As well, household food security followed a positive trend with a gradually increasing food security (from 45.5% to 63.5%) and

concomitant falling food insecurity (from 54.5% to 36.5%) over three-time points. Other self-reported health-related outcomes fluctuated over the follow-up period without a particular pattern, except for BMI, which showed improvement.

Table 5: Primary independent variable and dependent variables distributions

Characteristic n (%)	Round 1	Round 2	Round 3
Level of GFJ exposure			
• Low	34 (21.8)	23 (15)	11 (9.9)
• Moderate	25 (16)	30 (19.6)	34 (30.6)
• High	97 (62.2)	100 (65.4)	66 (59.5)
Household food security			
• Food secure	71 (45.5)	81 (52.9)	73 (63.5)
• Food insecure (moderate & severe)	85(54.5)	72 (47.1)	42 (36.5)
General health			
• Fair to poor	42 (26.9)	42 (27.5)	24 (20.9)
• Good to excellent	114 (73.1)	111 (72.5)	91 (79.1)
Mental health			
• Fair to poor	17 (10.9)	18 (11.8)	13 (11.3)
• Good to excellent	139 (89.1)	135 (88.2)	102 (88.7)
Health compared to 1 year ago			
• Worse than 1 year ago	19 (12.2)	21 (13.7)	22 (19.1)
• Better than/ same as 1 year ago	137 (87.8)	132 (86.3)	93 (80.9)
BMI			
• Underweight/normal weight	58 (37.4)	62 (41.6)	47 (42)
• Overweight/obese	97 (62.6)	87 (58.4)	65 (58)

### *Derived variables*

The CATPCA: The correlations of the 4 items used for CATPCA are given in Appendix 7 table

7.1. The scree plot (Appendix 7 figure 7.1) revealed that one principal component suffices these data, therefore, a single object score was obtained to represent individual participants' perceived connectedness to their neighbourhood. This principal component represented 53%, 55.2% and 57.56% of the total variance in three-rounds respectively (Table 6).

Table 6: Chronbach's Alpha, Eigen values and the variance accounted for by the principal component

Data collection wave	Cronbach's Alpha	Eigenvalue	Variance accounted for
1	0.704	2.120	53%
2	0.729	2.208	55.2%
3	0.755	2.306	57.56

The distribution of the derived object score is shown in Table 7 below. This continuous variable was grouped into three equal groups (tertiles, using 33<sup>rd</sup> and 66<sup>th</sup> percentile as cut points) to have low, moderate and high neighbourhood connectedness which was used in further analysis.

Table 7: Distribution of neighbourhood connectedness score

Data collection wave	Min, Max	Mean	Std. deviation
1	-1.730, 2.203	.00093	1.000243
2	-1.402, 1.979	.00376	1.009327
3	-1.216, 2.255	.00492	1.009843

Stratification by disadvantaged conditions: In order to address research question 2, the data set was divided into two groups: those who had 0-1 disadvantaged conditions out of Aboriginal ethnicity, seniors, low-income and low-education, and those who had 2-4 conditions. The percentage of participants in each group are given in Table 8 by each data collection wave.

Table 8: Disadvantaged category by data collection wave

Data collection wave	Round 1	Round 2	Round 3
0-1 disadvantaged conditions	83 (53.2%)	73 (47.7%)	65 (56.5%)
2-4 disadvantaged conditions	73 (46.8%)	80 (52.3%)	50 (43.5%)

### *Health-related outcomes*

Tables 9-13 present summarized odds ratios (ORs), their 95% confidence intervals (CIs) and significance levels in univariate and multivariate GEE analyses along two research questions.

Appendices 8 (research question 1) and 9 (research question 2) give detailed model building results of these five models.

**Household food security:** At the level of univariate analysis (Table 9), the level of exposure to the GFJ, senior age, annual household income, the level of education, gender, Aboriginal ethnicity, neighbourhood connectedness, and use of other food-based programs were significant at  $p < 0.25$  level. The final model showed that Aboriginal ethnicity and senior age no longer significantly contributed in predicting household food security in this group of GFJ shoppers. The level of education significantly modified the effect of GFJ exposure in predicting household food security.

A dose-dependent association between the frequency of GFJ use and the odds of reporting food security was detected, and this association was significantly modified by participants' education level (figure 6). Participants with high school or some post-secondary education showed the most influence out of the three levels of education on household food security. The likelihood of reporting food security among participating GFJ shoppers increased dramatically for those who shopped often or moderately (OR=7.43 CI 1.81, 30.44,  $p=0.005$ ; OR=6.89 CI 1.57, 30.20,  $p=0.010$ ) at the GFJ if they had at least a high school or some post-secondary education, compared to those who shopped least frequently. As shown in figure 6, the likelihood of reporting food security increased slightly among frequent and moderately frequent GFJ shoppers (OR=1.81 CI 0.42, 7.74,  $p=0.425$ ; and OR=1.06 CI 0.17, 6.48,  $p=0.948$ ) if they had less than a high school education. In contrast, those who had university level education had the least impact on household food security by shopping at the GFJ. They were 26% and 20% less

likely to be food secure over three-time points if they shopped at the GFJ in moderate and high frequency, respectively, compared to low frequency.

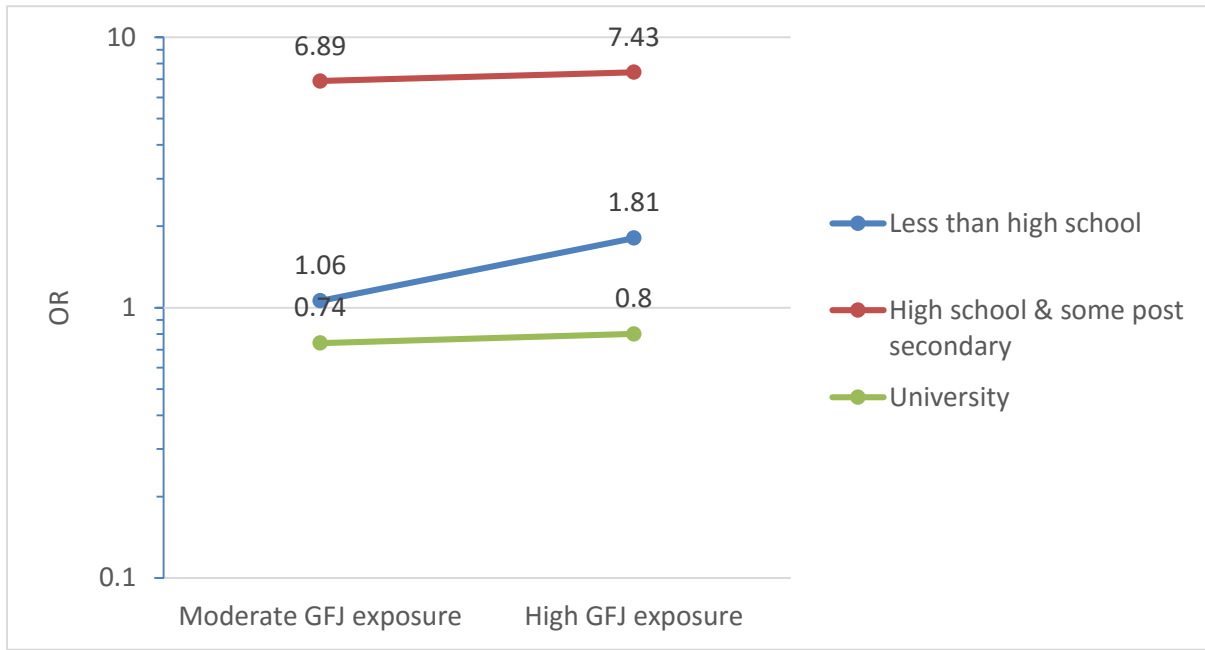


Figure 6: GFJ exposure by level of education on household food security

Participants with low income (less than \$30,000 household income per year) were approximately 76% less likely to be food secure (lower odds) over three-time points compared to participants with higher incomes. The 95% confidence intervals indicate that 95 out of 100 times similar tests would show a value equal to or more extreme than an odds ratio of 0.24 falling within 0.12 and 0.50 ( $p < 0.000$ ). Further, male participants were approximately 2.32 times (95% CI 1.16, 4.66;  $p = 0.018$ ) as likely to be food secure over three-time points as female participants.

Participants with high and moderate level of connectedness to the neighbourhoods they lived in were 2.04 times (CI 1.09, 3.83;  $p = 0.027$ ) and 1.33 times (CI 0.75, 2.37;  $p = 0.331$ ) as

likely to be food secure, respectively, over three-time points as participants with low level of neighbourhood connectedness. Moreover, those who used 3 or more other food-based programs were approximately 65% less likely (OR=0.35 CI 0.13, 0.96; p=0.041) to be food secure, while those who used only 1 or 2 of those programs were 73% less likely (OR=0.27 CI 0.09, 0.79; p=0.017) to be food secure compared to participants who did not use any of the other food-based programs.

As to multiple disadvantage modifying the association between frequency of shopping at the GFJ and food security, the multivariable model showed no effect modifying relationship. However, frequency of shopping at the GFJ showed an independent effect on household food security. In addition, participants with multiple disadvantaged conditions (2-4 conditions) were 62% less (OR=0.38, CI 0.23, 0.63; p<0.000) likely to be food secure over three-time points as participants with 0-1 disadvantaged conditions.

Table 9: Univariate and multivariate model building for household food security

Household food security status: 2 categories; 1=food secure   indicator & 0= moderate& severe food insecure   reference		Univariate		Multivariate (research question 1)		Multivariate (research question 2)	
Variable	Reference category	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Exposure level to GFJ • High • Moderate	low	1.65 (0.98, 2.79) 1.74 (0.97, 3.12)	0.060 0.063	0.80 (0.31, 2.03) 0.74 (0.30, 1.84)	0.634 0.520	<b>1.74 (1.00, 3.02)</b> <b>2.15 (1.16, 3.97)</b>	<b>0.049</b> <b>0.014</b>
Senior	Not senior	2.44 (1.33, 4.5)	0.004				
Low income	High	0.18 (0.09, 0.34)	0.000	<b>0.24 (0.12, 0.50)</b>	<b>0.000</b>		
Education • Less than high sch • High sch & some post second	university	0.16 (0.07, 0.35) 0.22 (0.11, 0.42)	0.000 0.000	0.13 (0.02, 0.70) 0.04 (0.01, 0.19)	0.017 0.000		
Male	Female	1.97 (1.09, 3.59)	0.026	<b>2.32 (1.16, 4.66)</b>	<b>0.018</b>	<b>2.10 (1.14, 3.86)</b>	<b>0.017</b>
Aboriginal identity	Non-Aboriginal	0.35 (0.21, 0.58)	0.000				
Daily stress	Not stressful	0.88 (0.65, 1.19)	0.414				
Physical activity	Low	0.89 (0.64, 1.24)	0.493				
Pre-existing chronic conditions	Never	1.25 (0.79, 1.98)	0.347				
Believe in changing health behaviour	Low	0.93 (0.69, 1.26)	0.621				
How long lived in the neighbourhood	<5 years	1.16 (0.80, 1.69)	0.427				
Neighbourhood connectedness • High • Moderate	Low	1.79 (1.12, 2.84) 1.15 (0.76, 1.75)	0.016 0.500	<b>2.04 (1.09, 3.83)</b> 1.33 (0.75, 2.37)	<b>0.027</b> 0.331	<b>1.66 (0.99, 2.80)</b> 1.08 (0.67, 1.75)	<b>0.056</b> 0.753
GFJ primary grocery store	No	0.98 (0.68, 1.42)	0.917				
Use of other food-based programs • 3 or more programs • 1-2 programs	None	0.54 (0.27, 1.07) 0.44 (0.22, 0.86)	0.079 0.016	<b>0.35 (0.13, 0.96)</b> <b>0.27 (0.09, 0.79)</b>	<b>0.041</b> <b>0.017</b>	0.58 (0.26, 1.29) <b>0.43 (0.19, 0.96)</b>	0.180 <b>0.039</b>
High GFJ exposure*less than high sch education				2.27 (0.42, 12.19)	0.340		



High GFJ exposure*high sch & post sec education				<b>9.32 (1.76, 49.23)</b>	<b>0.009</b>		
Moderate GFJ exposure*less than high sch education				1.43 (0.19, 10.55)	0.726		
Moderate GFJ exposure*high sch & post sec education				<b>9.28 (1.66, 51.69)</b>	<b>0.011</b>		
2-4 disadvantaged conditions	0-1 disadv conditions					<b>0.38 (0.23, 0.63)</b>	<b>0.000</b>

**General health:** Table 10 presents univariate and multivariate model building results for self-rated general health. When tested one at a time senior age, annual household income, level of education, Aboriginal ethnicity, experiencing stress daily, pre-existing chronic conditions, neighbourhood connectedness, and use of GFJ as the primary grocery store significantly (at  $p < 0.25$  level) predicted self-rated general health. The final model showed that participants who were seniors, of low income, and experiencing daily stress were 55% ( $p = 0.086$ ), 70% ( $p > 0.000$ ), and 40% ( $p = 0.053$ ) less likely to report good to excellent health over three-time points as participants who were not seniors, of high income, and not experiencing stress daily, respectively. Further, participants with less than high school education, and high school and some post-secondary education were 68% ( $p = 0.021$ ), and 31% ( $p = 0.373$ ) less likely to report good to excellent health over three-time points as participants with a university education, respectively. Participants with ever having pre-existing chronic conditions were 63% ( $p = 0.002$ ) less likely to report good to excellent health over three-time points as participants who never had chronic conditions.

The multiple disadvantage variable (for research question 2) neither as a main effect, nor in interaction with the GFJ exposure, significantly contributed to predict general health.

Table 10: Univariate and multivariate model building for general health

General health: 2 categories; 1=good to excellent  indicator & 0=fair to poor  reference		Univariate		Multivariate (research question 1)		Multivariate (research question 2)	
Variable	Reference category	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Exposure level to GFJ • High • Moderate	low	0.92 (0.55, 1.54) 0.99 (0.57, 1.72)	0.749 0.980	0.82 (0.43, 1.57) 0.86 (0.45, 1.64)	0.553 0.630	0.94 (0.54, 1.64) 0.94 (0.52, 1.70)	0.831 0.840
Senior	Not senior	0.63 (0.30, 1.35)	0.239	<b>0.45 (0.18, 1.12)</b>	<b>0.086</b>		
Low income	High	0.32 (0.17, 0.60)	0.000	<b>0.30 (0.16, 0.57)</b>	<b>0.000</b>		
Education • Less than high sch • High sch & some post second	university	0.01 (0.11, 0.67) 0.05 (0.21, 1.00)	0.005 0.047	<b>0.32 (0.12, 0.84)</b> 0.69 (0.30, 1.58)	<b>0.021</b> 0.373		
Male	Female	1.28 (0.71, 2.31)	0.404				
Aboriginal identity	Non-Aboriginal	0.69 (0.37, 1.29)	0.246				
Daily stress	Not stressful	0.75 (0.50, 1.13)	0.170	<b>0.60 (0.35, 1.01)</b>	<b>0.053</b>	0.69 (0.45, 1.07)	0.098
Physical activity	Low	1.03 (0.69, 1.54)	0.895				
Pre-existing chronic conditions	Never	0.40 (0.23, 0.69)	0.001	<b>0.37 (0.19, 0.69)</b>	<b>0.002</b>	<b>0.39 (0.22, 0.68)</b>	<b>0.001</b>
Believe in changing health behaviour	Low	1.08 (0.77, 1.53)	0.646				
How long lived in the neighbourhood	<5 years	0.85 (0.55, 1.31)	0.455				
Neighbourhood connectedness • High • Moderate	Low	1.56 (0.93, 2.61) 1.27 (0.82, 1.97)	0.092 0.293				
GFJ primary grocery store	No	0.71 (0.46, 1.10)	0.130				
Use of other food-based programs • 3 or more programs • 1-2 programs	None	1.13 (0.49, 2.57) 1.02 (0.50, 2.07)	0.776 0.967				
2-4 disadvantaged conditions	0-1 disadv conditions					0.64 (0.37, 1.10)	0.107

**Mental health:** Table 11 summarizes the model building results for self-rated mental health among GFJ shoppers. When taken singly annual household income, daily stress, and pre-existing conditions were significant at  $p < 0.25$  level and were retained for the multivariate model together with the main predictor. Participants with daily stress were 68% ( $p=0.001$ ) less likely to report good to excellent mental health over three-time points compared to participants without stress.

Participants who had high incomes were 13% less ( $OR=0.87$ ;  $CI$  0.25, 2.96) likely to report good to excellent mental health if they had shopped moderately at the GFJ and they were 2.82 (95%  $CI$  0.42, 18.93) times more likely to report good to excellent mental health when they shopped at the GFJ in high frequency compared to those who shopped at low frequency; those who had low income, were 70% and 76% less likely to report good to excellent mental health (everything else being statistically equal) when they shopped at the GFJ in moderate and high frequency, respectively compared to those who shopped at the lowest frequency. This interaction is graphically presented in figure 7 below.

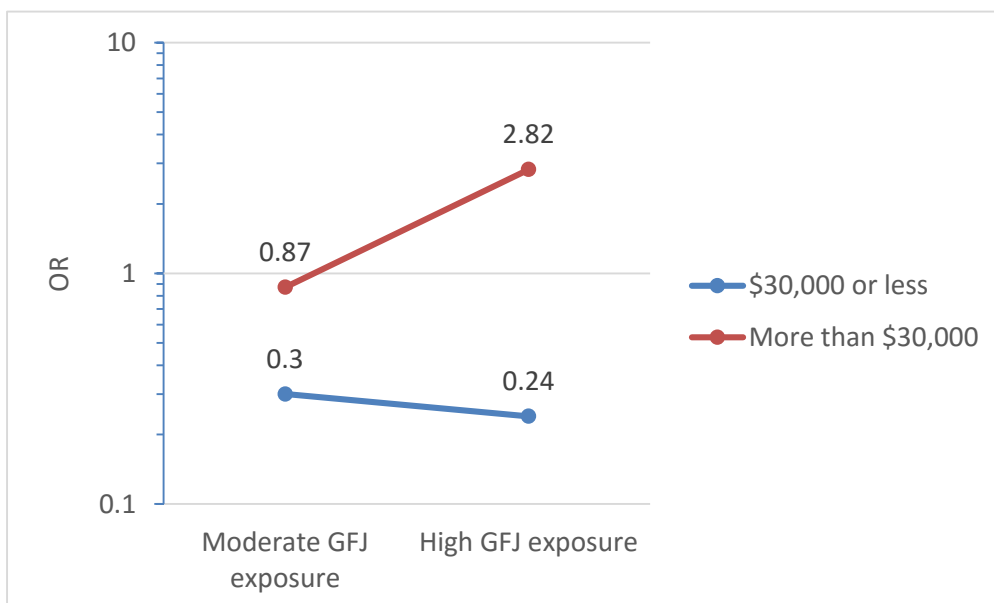


Figure 7: GFJ exposure by income on mental health

Participants who had single/none disadvantaged conditions were 1.13 (95% CI 0.47, 2.72) times more likely to report good to excellent mental health if they had shopped at moderate frequency at the GFJ; they were, 1.15 (95% CI 0.39, 3.45) times more likely to report good to excellent mental health if they shopped at the GFJ more often. Those who had multiple (2-4) disadvantaged conditions, as expected, were 72% (95% CI 0.08, 0.97) and 69% (95% CI 0.09, 1.12) less likely to report good to excellent mental health when they shopped at the GFJ in moderate or high frequency, respectively, compared to those who shopped least frequently. This interaction was marginally significant at 0.05 level. Figure 8 presents this interaction graphically.

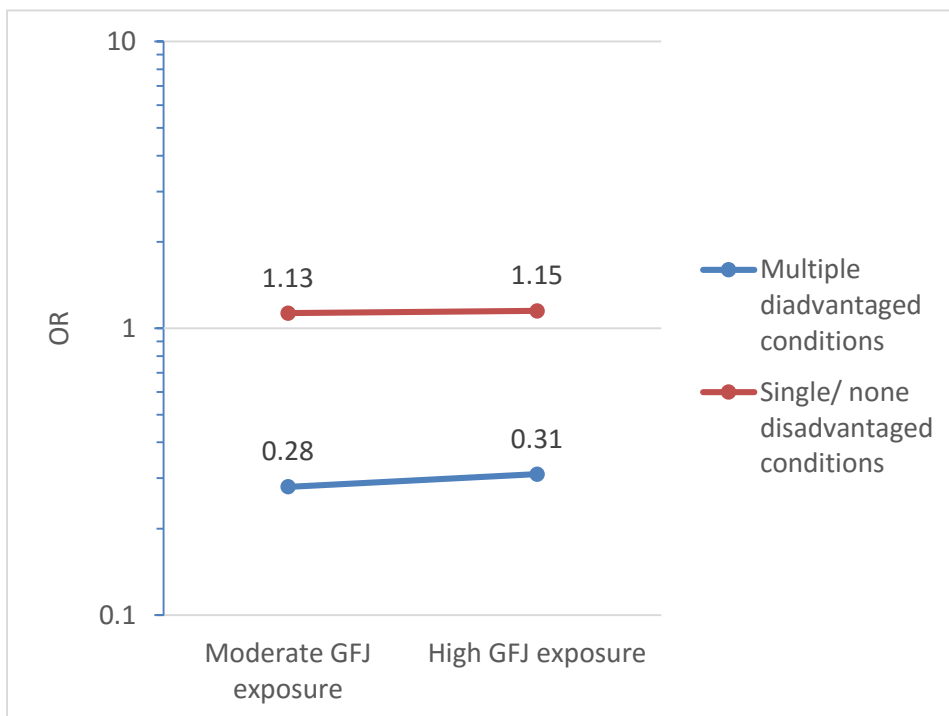


Figure 8: GFJ exposure by multiple disadvantaged conditions on mental health

Table 11: Univariate and multivariate model building for mental health

Mental health: 2 categories; 1=good to excellent  indicator & 0=fair to poor  reference		Univariate		Multivariate (for question 1)		Multivariate (for question 2)	
Variable	Reference category	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Exposure level to GFJ • High • Moderate	low	0.65 (0.27, 1.53) 0.68 (0.32, 1.47)	0.319 0.325	2.83 (2.96, 97.71) 0.87 (0.25, 2.96)	0.284 0.819	1.16 (0.39, 3.45) 1.13 (0.47, 2.72)	0.795 0.787
Senior	Not senior	0.76 (0.28, 2.08)	0.589				
Low income	High	0.38 (0.14, 1.04)	0.060	1.87 (0.25, 14.28)	0.546		
Education • Less than high sch • High sch & some post second	university	0.62 (0.21, 1.87) 1.06 (0.40, 2.83)	0.398 0.909				
Male	Female	1.38 (0.53, 2.63)	0.511				
Aboriginal identity	Non-Aboriginal	1.08 (0.53, 2.22)	0.835				
Daily stress	Not stressful	0.40 (0.21, 0.76)	0.005	<b>0.32 (0.16, 0.64)</b>	<b>0.001</b>	<b>0.39 (0.20, 0.74)</b>	<b>0.004</b>
Physical activity	Low	1.12 (0.62, 2.04)	0.705				
Pre-existing chronic conditions	Never	0.66 (0.34, 1.27)	0.212				
Believe in changing health behaviour	Low	0.99 (0.54, 1.80)	0.963				
How long lived in the neighbourhood	<5 years	1.30 (0.58, 2.93)	0.522				
Neighbourhood connectedness • High • Moderate	Low	1.23 (0.62, 2.48) 1.40 (0.77, 2.55)	0.554 0.273				
GFJ primary grocery store	No	1.10 (0.48, 2.51)	0.819				
Use of other food-based programs • 3 or more programs • 1-2 programs	None	0.83 (0.31, 2.22) 0.71 (0.28, 1.81)	0.706 0.478				

High GFJ exposure*low income				<b>0.08 (0.01, 0.83)</b>	<b>0.034</b>		
Moderate GFJ exposure*low income				0.34 (0.05, 2.18)	0.256		
2-4 disadvantaged conditions	0-1 disadv conditions					2.61 (0.56, 12.18)	0.221
High GFJ exposure*2-4 disadvantaged conditions						0.27 (0.05, 1.49)	0.133
Moderate GFJ exposure*2-4 disadvantaged conditions						<b>0.25 (0.05, 1.20)</b>	<b>0.083</b>

Table 12: Univariate and multivariate model building for health compared to one year ago

Health compared to 1 year ago 2 categories; 1=better to same  indicator & 0=worse  reference		Univariate		Multivariate (for question 1)		Multivariate (for question 2)	
Variable	Reference category	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Exposure level to GFJ • High • Moderate	low	1.35 (0.64, 2.84) 1.71 (0.67, 4.38)	0.432 0.263	1.23 (0.56, 2.70) 1.40 (0.49, 4.06)	0.609 0.533	1.33 (0.63, 2.79) 1.57 (0.59, 4.14)	0.458 0.366
Senior	Not senior	0.56 (0.24, 1.30)	0.177				
Low income	High	0.33 (0.15, 0.72)	0.005	<b>0.32 (0.15, 0.70)</b>	<b>0.004</b>		
Education • Less than high sch • High sch & some post second	university	0.62 (0.23, 1.65) 0.50 (0.21, 1.21)	0.335 0.124				
Male	Female	2.37 (1.03, 5.43)	0.042				
Aboriginal identity	Non-Aboriginal	0.62 (0.34, 1.14)	0.122				
Daily stress	Not stressful	0.45 (0.25, 0.81)	0.007	<b>0.42 (0.21, 0.84)</b>	<b>0.014</b>	<b>0.44 (0.24, 0.81)</b>	<b>0.009</b>
Physical activity	Low	0.93 (0.54, 1.59)	0.784				

Pre-existing chronic conditions	Never	0.51 (0.28, 0.96)	0.037	<b>0.40 (0.21, 0.77)</b>	<b>0.007</b>	<b>0.47 (0.25, 0.88)</b>	<b>0.018</b>
Believe in changing health behaviour	Low	0.98 (0.56, 1.70)	0.933				
How long lived in the neighbourhood	<5 years	1.01 (0.55, 1.86)	0.972				
Neighbourhood connectedness	Low						
• High		2.18 (1.02, 4.64)	0.044				
• Moderate		1.41 (0.69, 2.90)	0.348				
GFJ primary grocery store	No	1.28 (0.63, 2.60)	0.492				
Use of other food-based programs	None						
• 3 or more programs		0.68 (0.22, 2.16)	0.514				
• 1-2 programs		0.92 (0.32, 2.64)	0.874				
2-4 disadvantaged conditions	0-1 disadv conditions					0.6 (0.31, 1.13)	0.115



**Health compared to one year ago:** Table 12 presents the model building results for health compared to one year ago. Univariate analyses showed that senior age, household income, the level of education, gender, Aboriginal identity, daily stress, pre-existing chronic conditions, and neighbourhood connectedness were significant at  $p < 0.25$  level and were therefore retained with the main predictor for multivariate analysis. The final model showed that participants with low income, daily stress, and pre-existing conditions were 68% ( $p=0.004$ ), 58% ( $p=0.014$ ) and 60% ( $p=0.007$ ) less likely to report better or same health compared to one year ago over three time points as participants with high income, not experiencing stress daily and never having pre-existing chronic conditions, respectively. Having multiple disadvantaged conditions did not show any significant main effect or effect modifying relationship in the association between frequency of shopping at the GFJ and health compared to one year ago.

**BMI:** Table 13 shows model building results for BMI. Univariate GEE showed that the level of GFJ exposure, pre-existing chronic conditions, believing in changing health behaviour and the length of time lived in their neighbourhood were significant predictors of BMI when taken one at a time at  $p < 0.25$  level. At multivariate level, participants with higher levels of beliefs in changing their health behaviour were approximately 23% ( $p=0.039$ ) less likely to be in under/normal BMI over three-time points as participants who reported having lower levels of believes in changing health behaviour.

Participants who reported never having pre-existing chronic conditions were 41% ( $OR=0.59$ ,  $CI=0.29$ ,  $1.19$ ) less likely to report under/normal BMI if they had shopped moderately at the GFJ and they were 35% ( $OR=0.65$ ,  $CI=0.36$ ,  $1.15$ ) less likely to report under/normal BMI when shopped at the GFJ at a high frequency; those who ever had any chronic conditions,

were 1.08 (CI=0.83, 1.41) and 1.35 (CI= 0.97, 1.88) times more likely to report under/normal BMI when shopped at the GFJ in a moderate and high frequency, respectively compared to those who shopped at the least frequently. Figure 9 illustrates this interaction.

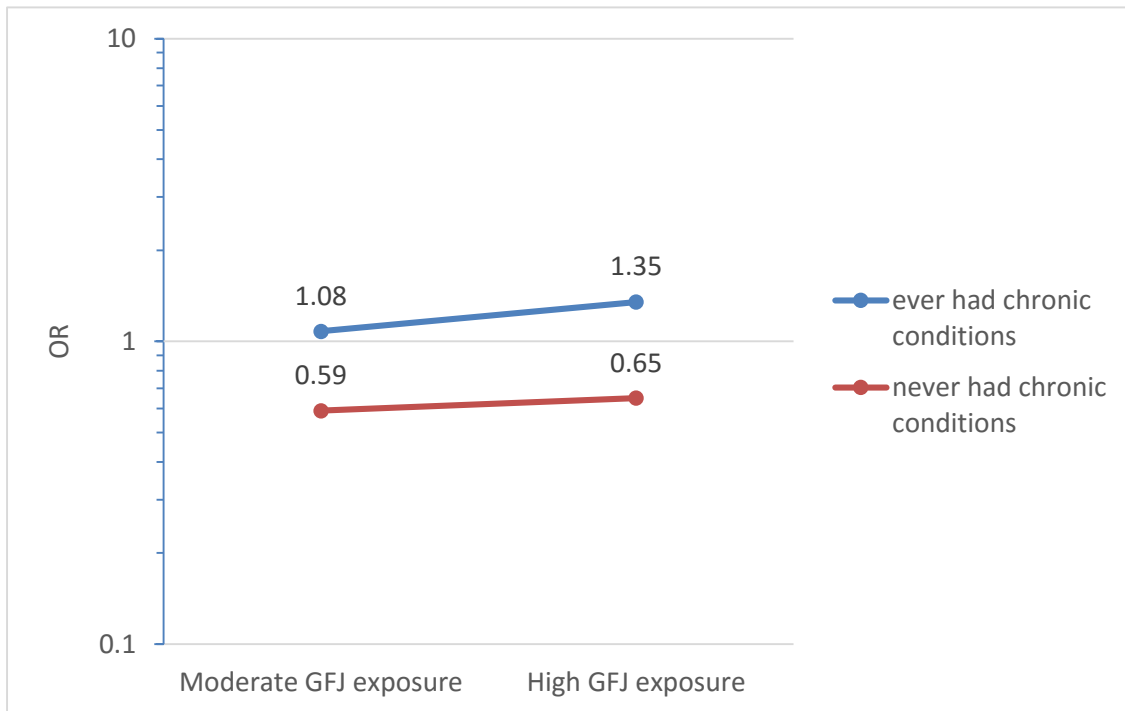


Figure 9: GFJ exposure by pre-existing chronic conditions on BMI

Participants who experienced multiple disadvantaged conditions were 38% ( $p=0.013$ ) less likely to report under/normal BMI compared to those who experienced single/none of the disadvantaged conditions. However, having multiple disadvantaged conditions did not modify the association between the level of GFJ use and BMI in this group.

Table 13: Univariate and multivariate model building for BMI

BMI: 2 categories; 1=underweight/normal weight   indicator & 0=overweight/obese   reference		Univariate		Multivariate (for question 1)		Multivariate (for question 2)	
Variable	Reference category	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value	Odds ratio (95% CI)	p-value
Exposure level to GFJ • High • Moderate	low	0.84 (0.55, 1.28) 0.74 (0.45, 1.20)	0.414 0.219	0.65 (0.36, 1.16) 0.59 (0.29, 1.20)	0.141 0.143	0.67 (0.38, 1.20) 0.62 (0.30, 1.25)	0.180 0.181
Senior	Not senior	0.84 (0.46, 1.53)	0.567				
Low income	High	0.88 (0.64, 1.20)	0.412				
Education • Less than high sch • High sch & some post second	university	0.88 (0.45, 1.72) 0.93 (0.68, 1.29)	0.701 0.675				
Male	Female	0.88 (0.57, 1.37)	0.569				
Aboriginal identity	Non-Aboriginal	0.94 (0.58, 1.52)	0.797				
Daily stress	Not stressful	0.85 (0.61, 1.20)	0.357				
Physical activity	Low	1.20 (0.88, 1.37)	0.421				
Pre-existing chronic conditions	Never	0.64 (0.45, 0.91)	0.013	0.40 (0.21, 0.75)	0.005	0.40 (0.21, 0.76)	0.005
Believe in changing health behaviour	Low	0.76 (0.59, 0.97)	0.027	<b>0.77 (0.61, 0.99)</b>	<b>0.039</b>	<b>0.75 (0.58, 0.97)</b>	<b>0.025</b>
How long lived in the neighbourhood	<5 years	0.85 (0.67, 1.06)	0.149	<b>0.78 (0.60, 1.00)</b>	<b>0.053</b>	<b>0.73 (0.56, 0.95)</b>	<b>0.019</b>
Neighbourhood connectedness • High • Moderate	Low	1.00(0.75, 1.34) 0.91 (0.71, 1.18)	0.980 0.486				
GFJ primary grocery store	No	1.11 (0.90, 1.37)	0.337				
Use of other food-based programs • 3 or more programs • 1-2 programs	None	1.09 (0.62, 1.93) 1.07 (0.58, 1.94)	0.770 0.837				

High GFJ exposure*pre-existing chronic conditions				<b>2.10 (1.09, 4.05)</b>	<b>0.027</b>	<b>2.06 (1.06,3.98)</b>	<b>0.032</b>
Moderate GFJ exposure*pre-existing chronic conditions				1.84 (0.86, 3.92)	0.114	1.78 (0.83, 3.82)	0.139
2-4 disadvantaged conditions	0-1 disadv conditions					<b>0.62 (0.42, 0.90)</b>	<b>0.013</b>

### *Goodness of fit*

At the end of research question 1, model fit of each final model was determined using QIC and QICC values. The working correlation matrix was selected based on a balance between the smallest QIC and the number of parameter estimates involved (data not shown). The best subset of a given model was chosen based on a balance between the smallest QICC and the significance (p-value at <0.05) of the variables involved. Some of the multivariate models selected, therefore, are the second best in terms of QIC and QICC.

### **Discussion**

The purpose of this study was to assess the early health-related impact of a new grocery store intervention, the GFJ, in a former food desert. The study longitudinally followed-up a sample of GFJ shoppers for one year and four months, and measured their household food security, and health-related outcomes, namely self-reported general health, mental health, health compared to one year ago, and BMI. The results showed positive impact (but not always statistically significant) of GFJ exposure among participants who shopped most frequently or moderately frequently compared to low. A few outcomes, however, did not corroborate the hypothesis.

Shoppers who shopped at the GFJ at least once a month since it opened (high and moderate frequency) were likely to report that their health-related outcomes having improved compared to those who shopped less than once a month. Participants with less than high school education were more likely to report food security over time when they shopped at the GFJ more frequently, and this improvement was dramatically heightened among participants who had high school or some post-secondary level education. Those shoppers

with a university level education, however, were the least affected by the intervention. They showed better household food security status at the baseline (data not shown), therefore, use of the GFJ at a moderate and high frequency improved food security only slightly. This cohort of participants may have had other options of healthy food sources that were not limited by the location or price, thus making them the group who least benefited from the GFJ intervention. It is an interesting and a useful finding that the shoppers with less than university level education benefitted the most from shopping at the GFJ in terms of household food security.

Similarly, those who shopped at the GFJ more often than once a month compared to those who shopped less than once a month was associated with a sharp rise in positive mental health among high-income participants. Low-income participants, however, had lower odds of positive mental health even when they shopped at the GFJ at a higher frequency. As well, participants' mental health was significantly influenced by living with multiple disadvantaged conditions. The implication being that all those who were exposed to this new food store intervention did not benefit equally in terms of improved health. The effect modification of the GFJ exposure on food security and mental health by education and low income, respectively, suggest that this intervention was more effective among those who had less than a university education (regarding food security) or among those with high income (regarding mental health). (120)

In fact, participants who shopped at the GFJ more often than once a month were more likely to report good to excellent mental health if they experience single/none of the disadvantaged conditions compared to those who shopped less than once a month.

Consistent with the principles of intersectionality theory, those who experienced multiple

disadvantaged conditions were less likely to report better mental health, taking into account all other factors. The effects of GFJ use on other health-related outcomes were not modified by experiencing multiple disadvantaged conditions assessed in this study.

The majority of shoppers (three-quarter of participants in each round) followed-up in this study did their primary grocery shopping at stores other than the GFJ. They might have used different types of stores, which was not explored in this study. “High level of GFJ exposure” in this study referred to ‘more than once a month’ shopping at the GFJ, which describes a biweekly or weekly or more trips. Although grocery shopping frequency depends on age, socioeconomic status, household size and ethnicity, many studies show that the majority of households grocery shop at a frequency of more than once a month, particularly biweekly or weekly. (121-126) The bulk of the study participants doing their primary shopping for groceries at food stores other than the GFJ is something that we did not control in this study.

Household food insecurity measured nationally in 2013 using the CCHS indicates that 12.5% (representing 1.4 million households with 2.4 million adults and one million children below 18 years) of Canadian households were food insecure (marginal, moderate or severe) during last year<sup>5</sup>. (7) In Saskatchewan, household food insecurity rose from 9.5% in 2007 to 12.2% in 2013. (7) This study used the three-group categorization—no food insecurity, moderate food insecurity, and severe food insecurity—proposed by Health Canada. (127) When an alternative 4-group classification of food security was used, the percentage of food insecure

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<sup>5</sup> Note: British Columbia, Manitoba, Newfoundland and Labrador and Yukon are not included in these estimates because they opted out of food insecurity measurement in 2013. (7)

participants was larger than what is currently reported in this study.<sup>6</sup> This group of participants showed a higher (54.5%) level of food insecurity (as expected) than the Saskatchewan or the national average at the start of the study which then reduced to 36.5% by round 3. Although food insecurity improved in these GFJ shoppers over the three longitudinal time points, it was still considerably larger than Saskatchewan and national food insecurity levels.

The apparent improvement in food security in these study participants may be explained using four reasons. First, as this study hypothesized, the opening of the GFJ in the former food desert and use of this store by study participants might have led to an improvement in their household food security status for some participants.

Second, participants used other community-based food programs such as gardens, CHEP Good Food Boxes, Food Bank, Farmers' Market, Collective kitchens, CHEP community markets, Seniors' markets or other food programs. Statistical analysis indicates that participants who used multiple food programs were less likely to be food secure compared to those who did not use any of them. These community-based food programs are diverse in many respects and simply counting how many programs a participant had participated in without taking into account the specific nature of the program, or its effectiveness to enhance food security, is a limitation in this study. The present study identifies this limitation and proposes that future studies could take community-based food programs with regard to their nature into account.

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<sup>6</sup> Analyses were also carried out taking the 4-group food security categorization into account. However, the 4-group categorization did not show any significant associations like the 3-group categorization (which is reported) for this set of data. Therefore, it was decided to use the Health Canada approved 3-group food security categorization.



Third, there is a possibility that the GFJ exposure may have also contributed to other health promoting services available through Station 20 West, which in turn could have contributed positively to food security. Further, a number of community based programs (specifically CHEP volunteers, clients of KidsFirst program, immunization program, Healthy Mother Healthy Baby program) were giving coupons that could be redeemed for food at the GFJ and CHEP garden markets. So it is possible that some people who frequently shopped at the GFJ may have done this because they had coupons that they could redeem at the GFJ. This could then show improvements in food security among frequent shoppers.

Finally, the selective loss of study participants over three data collection waves and the change in the study sample due to new participant recruitment during round 2 would have had an impact on the food security and health-related outcomes changes found in this study. As evidenced by the significant differences between study completers and non-completers, participants who were the most food insecure were the ones that were lost to follow-up, resulting possibly in an overestimation of food security. However, countering this, round 2 recruited participants were significantly food insecure compared to the cohort recruited at the study start.

National averages of perceived very good or excellent mental health in Canada (71.1% in 2014) are slightly lower than that reported by this study (88.2% to 89.1%). (128) As well, Saskatchewan averages (68.8% in 2014) are even lower than this study reports. (128) Overall GFJ shoppers reported slightly declining good to excellent mental health from first (89.1%) to third (88.7%) data collection waves.

The present study found that establishing a grocery store in a former food desert improved household food security, mental health and BMI of its users with time. Most importantly, participants who shopped at the new grocery store frequently were more likely to be food secure, report better mental health and had normal BMI than those who shopped at a moderate or low frequency (with these effects modified by a third variable). This 'dose-response' type association strengthens claims with regard to causation between the observed factors. Although graded relationships are not in the expected direction for all outcomes and other health-related outcomes such as perceived general health and health compared to one year ago did not show any significant improvements during the study period, the positive and dose-response association between food security and increasing levels of GFJ exposure might lead to improvements in other health-related outcomes later on.

As expected, low-income and low-education were significant independent predictors of at least one out of several of the outcomes studied—household food security, self-rated general health, mental health and health compared to one year ago, which is consistent with previous literature. The implication being that although physical access to food is improved, low socioeconomic status continues to be a major barrier to consuming healthy foods that are expensive and lower in caloric content than higher sugar, high fat processed food. (129) Many similar previous studies included study participants who were only low-income or living in deprived neighbourhoods expecting higher positive impacts. (56,59-61,68) Although the GFJ was also located in low-income neighbourhoods, participants of this study constituted GFJ shoppers from all over the city. Household income and the level of education of participants showed a fairly diverse distribution in this sample. This

combination opened up an opportunity to compare different socioeconomic groups exposed to the GFJ intervention.

Likewise, participants' BMI was significantly affected by ever having chronic conditions and belief regarding health behaviour change. Health behaviour change was measured using items from the CCHS that included self-reported changes made to improve health, individuals' motivation, intentions and beliefs to stay healthy, either by doing regular physical activity, losing weight, improving diet, reducing smoking and alcohol consumption, reducing stress levels, seeking medical treatment or taking vitamins. Participants who are already following or willing to follow one or few of these practices actively at a personal level would likely be motivated to shop at the GFJ. However, other individuals who do not have such personal motivation or beliefs would not have benefitted as much from mere passive exposure to the new grocery store in their neighbourhood as evidenced in this study.

It has long been identified that individuals' neighbourhood social ties play an important role in health. (130,131) At the level of univariate analysis, this study found that perceived neighbourhood connectedness significantly (at  $p < 0.25$  level) and in a dose-dependent manner predicted household food security, general health, and health compared to one year ago among this sample of GFJ shoppers. At the multivariate level, a higher level of neighbourhood connectedness showed higher odds of being food secure. Although this study did not find any significant moderating effect by neighbourhood connectedness on the outcomes assessed, the need to engage psychosocial moderators it is rapidly being recognized in the food environment research. (132) Future food environment interventions that accompany additional programs that engage the community, and build up

neighbourliness may, therefore, be more effective in promoting health than if these efforts were separated.

Analyses of multiple, intersectional disadvantaged conditions revealed that this group of participants' mental health was affected significantly by living with multiple disadvantaged conditions; namely either Aboriginal identity or senior age or low-income or low-education level. This is an important finding, as future non-health care interventions including food environment interventions that aim to improve health-related outcomes will find this evidence beneficial. The impact of improved food access in the form of a new grocery store seems to have little effect when participants are already struggling with multiple disadvantaged conditions simultaneously. However, their health-related outcomes were improved, although slightly, when exposed to the GFJ.

Although some core neighbourhood residents benefitted from the new grocery store, the GFJ did not survive long. The store closed at the end of January 2016 due to low sales nearly 3 and a half years after its opening.

### *Limitations*

The study would have been even more vigorous if a comparison group matched with the intervention cohort was used. A comparison group would eliminate any possible bias related to study design, conduct, and analysis. As well, not having baseline data of this sample of GFJ shoppers to compare their health before the opening of the GFJ is also identified as a limitation of this study.

The study sample from throughout Saskatoon, and not only from the surrounding neighbourhoods of the GFJ, makes the generalization of these findings difficult to similar inner-city low-income food deserts. This thesis did not evaluate the proportion of study participants living in the core neighbourhoods vs. the rest of Saskatoon. The neighbourhood of residence of participants and the transiency of their residency through the study period might have had an impact on the frequency of shopping at the GFJ and the outcomes measured, which could be addressed in future research. Nevertheless, the geographical heterogeneity of residence of this sample was also a strength. The study participants represented a mix of socioeconomic status and Aboriginal and non-Aboriginal ethnicity, which contributed to factors such as income and education emerging as statistically significant predictors, as well as contributing to the generalizability of findings to other similar settings.

The method of participant recruitment might have introduced a risk of selection bias as it might have led the GFJ shoppers who were motivated to stay healthy to participate in the study. As well, participation in the study itself might have led to increasing awareness of healthy eating and other health-related behaviours among the participants, which might have contributed to changes over the three longitudinal data collection waves.

Another important limitation of this study is the selective loss to follow-up. There were significant differences between study completers and non-completers regarding sociodemographic risk factors, the main predictor as well as some of the outcomes measured. Participants who were lost over the three-time points were those who were the most food insecure. This might have created estimates that are biased towards more positive results.

Although standard survey tools were used to collect data, there is the possibility of over-reporting of height and under-reporting of weight when self-reported data is used to assess BMI. (133) This might have resulted in lower reporting of overweight/obese category producing erroneous BMI. It would have provided more accurate BMI if actual body measurements were taken.

### *Strengths*

In addition to purely being a natural, real-life experiment, this population health intervention study brings many strengths regardless of above-mentioned limitations.

Based on participants reporting how often they shopped at the grocery store and using these data to create a 'dose' to assess the intervention 'exposure' is a key strength of this study. Prospective follow-up of study participants reduced any recall bias that may have arisen if retrospective methods were used. This key strength is intensified by the inferences derived using a GEE approach. GEE are based on marginal models and come up with population averages. Evidence produced from this study would therefore be useful in population-level policy, practice, and program planning.

Having an integrated approach by controlling for most of the known covariables that determines health in addition to improved food access, namely individuals' perceived neighbourhood connectedness, beliefs in changing health behaviour, socioeconomic status in the form of income and education, senior age, (in Canada) Aboriginal identity, daily experience of stress, physical activity, and pre-existing chronic conditions, provide a comprehensive picture. This type of analysis would be very useful for decision making around future interventions and targeted interventions. As well, in real life, we experience

multiple disadvantaged conditions simultaneously which highly influence our health. This was also addressed in this study which grants that interventions of this kind should also take a holistic approach if health at the population level is to be achieved.

### *Conclusion*

This food environment intervention study found that the opening of a grocery store in a former food desert improved the household food security, mental health and BMI of its users in a graded fashion. The establishment of the grocery store was originally a priority of the core neighbourhoods residents. The study evidence that improving food security is only one aspect of the bigger problem of nutrition-related NCDs and health-related outcomes. There are many other factors at play which need careful planning at more upstream level. For instance, low socioeconomic status continues to be a significant risk factor for health-related outcomes, so as simultaneous multiple disadvantaged conditions. Having chronic conditions previously, on the other hand, modifies health-related effects while individuals' health beliefs being another aspect of the dispute. Although reproduction of these findings in diverse contexts is highly recommended, a comprehensive approach in prevention program and planning strategies are emphasized. As exact causal pathways are yet to be identified, it is explicit that they are tangled with low socioeconomic status and multiple disadvantaged conditions among other things, in addition to low healthy food access.

## CHAPTER 4: Discussion and conclusion

### *The systematic review*

The systematic review was conducted to synthesize published scholarly literature on the effectiveness of new grocery store interventions on health-related outcomes. It addressed the specific research questions 'How do new food store (grocery store) interventions influence health-related outcomes in adults?'. Eleven studies representing seven interventions were identified from a search of 8 electronic databases. Nine of these records were subjected to methodological quality assessment, and revealed that six were of 'weak', one was 'moderate', and two were of 'strong methodological quality.

The range of study designs of the studies were diverse and included: a one-time survey, two before/after studies, two qualitative focus groups, three controlled pre-post quasi-experimental studies, and a difference-in-difference study. Five interventions had comparison groups out of which three studies conducted both ITT and on-treatment analysis. Others used one or the other methods. Most of the studies adequately controlled for potential confounders at either design or analysis phases.

Outcomes relevant to this study included FV consumption, self-rated health, psychological health, BMI, perceptions of food access, self-esteem, and neighbourhood satisfaction. FV consumption was the most frequently assessed outcome. The results varied among studies and included non-significant increases, no detectable impact, significant consumption of less healthy food, a significant decline in FV availability in households with children, and significant improvement in FV consumption among those who had poor diets prior to intervention or those who



lived close to the new food store. While studies were not completely comparable in terms of study designs, populations, and statistical analytical methods, the results on FV consumption were mixed and were not conclusive.

Further, slight significant improvement in psychological health among 'switchers' to the new store compared to 'non-switchers' was reported by one intervention.

Participants' BMI showed no detectable change. Perceptions of access to healthy food, however, were improved when tested in two of these interventions.

These interventions took place in socioeconomically disadvantaged neighbourhoods and increased access to healthy food by introducing a new grocery store. As reviewed above, it might yet be premature to state conclusively that improved healthy food access alone does not result in positive impact on health and health-related outcomes. As shown in the evaluation of the early impact of the GFJ in this thesis, clearly more studies with better designs including taking into account a 'dose' aspect of the intervention exposure, should be done. Although the results regarding health-related outcomes are inconclusive, positive effects on perceptions of food access and self-esteem might be the first steps in reaching health in the long run. Moreover, subgroup analysis and including psychosocial risk factors has shown to provide a better understanding of future food environment research. (132)

#### *The GFJ intervention*

The purpose of the second manuscript was to assess the early health-related impact of the GFJ intervention on its users longitudinally. It also explored if individuals' perceived neighbourhood ties modify the primary relationship and the role of

experiencing multiple disadvantaged conditions simultaneously in determining health-related outcomes.

The primary exposure variable accounted for the frequency of shopping at the GFJ reported by participants at each of the follow-up. Although only about one-quarter of participants chose the GFJ as their primary grocery store, it was expected that by taking into account the frequency of shopping, the exposure to the intervention was captured adequately. Further, participants' use of the GFJ as the primary grocery store was tested as an independent covariable during model building, which allowed estimation of effect of this variable on outcomes measured. Only one previous study had taken into account intervention exposure in this manner. (60) While they measured intervention exposure as a frequency, their analytical approach was different to the one used in this study, where they used frequencies of 'once per month or more' to group participants as 'regular users' of the new store and compared this group with 'others'. (60) This was demonstrably similar to many other studies that used 'switchers' vs 'non-switchers' comparisons.

The present study exhibits many improvements over other similar studies published to date, regarding comprehensiveness and analytical approach taken. Firstly, in addition to many known confounders, such as sociodemographic risk factors, it took into account other potential variables that might influence health-related outcomes, such as pre-existing chronic conditions, beliefs in/motivation to change own health through behaviour change, the amount of daily stress and level of physical activity experienced, choice of the GFJ as the primary grocery store, the length of time lived in the neighbourhood, and participation in other food-based programs. Each of these

variables measured and modeled conceivably represent an alternate, or complementary, explanation of the expected effects of the GFJ on health and health-related outcomes. None of the previous literature showed this breadth in terms of covariables explored.

Secondly, this study used longitudinal data flowed by a GEE approach to fit marginal models given the focus was on the population-average, to inform public policy and practice. It distinguishes the variation in outcome across time for one participant from the variation in the outcome among all participants. (134) repeated nature of the study, GEE approach (which incorporated the change in outcome and exposure longitudinally), and dose-response exposure pattern nudge the progress of an 'association' towards 'causation'.

Cummins *et al.* found significant borderline interactions of education on self-reported health and age on psychological health in their analysis of the intervention vs comparison neighbourhoods. (54,61) Although the study designs and analytical methods are not entirely comparable, the same was not detected in the present study. Instead, the effect of GFJ exposure was significantly modified by participants' level of education in determining household food security, while senior age (borderline) and education showed significance at  $p < 0.05$  level as a main effect in determining self-rated health. Moreover, it was also reported that psychological health in their study showed a positive effect (OR=0.24, 95% CI 0.09, 0.66) among switchers vs non-switchers. (54,61) This study did not find any significant independent association between the level of GFJ exposure and self-reported good to excellent

mental health, but there was a significant moderating effect by participants' level of income with a dose-response effect in the relationship.

Consistent with previous literature, (53,60) this study did not find an independent effect for changes in BMI due to the intervention. Dubowitz *et al.* objectively measured participants' height and weight, (60) while others, similar to the present study, did not. It was assumed that this outcome would show little or no change within the one-year follow-up period.

It was identified previously that the length of time individuals had lived in their neighbourhoods influences how they perceive their neighbourhood environment. (135) The length of time participants lived in their neighbourhoods, which was not accounted for by previous similar studies was addressed in this study. However, this was statistically significant (marginally) only in predicting BMI out of the five health-related outcomes measured.

This study did not assess the influence of distances between participants' residences and the new store. The participants in this study are from throughout Saskatoon, although the majority lived in the surrounding core neighbourhoods (data not presented). Future research is needed to examine if there is an influence on health-related outcomes by distance of residence to the new store, as it was shown in previous studies that those who live near to the new store benefitted more. (52,55)

Intersectionality theory has been identified to offer an alternative explanation for health inequalities, where multiple risk factors lead to ill-health not in an additive, but in an exponential manner. (109) This study examined low socioeconomic states,

captured by low-income and low-education, and in Canada Aboriginal ethnicity, and senior age, occurring singly compared to simultaneously influencing health-related outcomes. GFJ shoppers who experienced multiple disadvantaged conditions were 62% ( $p < 0.000$ ), and 87% ( $p = 0.013$ ) less likely report food security, and normal BMI, respectively, compared to those who had single or none of these conditions.

Moreover, those who had multiple disadvantaged conditions showed a marginally significant moderating effect on GFJ exposure in determining mental health. This is important in terms of policy and practice as multiple disadvantaged populations might need targeted interventions in order to show any improvements in their health. It is suggested that further research is required to replicate these findings.

Previous similar studies have chosen intervention areas that were socioeconomically disadvantaged, assuming that these populations would benefit the most from new food stores. (54,61) This study brings evidence that is both supportive of and in opposition to this hypothesis. For instance, low-educated participants improved food security, while high-income cohort reported positive mental health with the exposure to the GFJ. Further, experiencing multiple disadvantaged conditions simultaneously was associated with poorer mental health among GFJ users. Perhaps, future research could perform stratified analysis along sociodemographic characteristics such as gender, in order to find underlying yet undetected links between these variables.

(132) It is recommended to exercise caution when determining which populations to be served in future food store interventions.

*Considerations for future research and policy*

Results of this research contribute to the field of food environment interventions, and informs future research in terms of methodology and design. Further, the GFJ intervention informs public policy and health promotion. It is evident in recent literature that Canadian food environment is dissimilar to that of the United States where the majority of North American food environment literature comes from. (6) Since the field of study is fairly new in Canada, this research contributes to the rapidly growing retail food environment body of literature.

This rapidly expanding food environment literature informs public policy at city, region, and country levels. Although it is widely recognized that food environment features impact health through consumption, other mechanisms such as local economic growth and social justice are increasingly recognized, thus creating multi-disciplinary policy involvement. (136) These policy- and decision-makers could be urban/city planners (through land-use planning), public health nutritionists (through nutrition education programs), local food systems (through encouraging people to grow and consume locally available healthy food), and municipalities (through marketing, and organizational food and nutrition policies). (136)

Although this study showed that the GFJ contributed to improving health-related outcomes of shoppers, the store was closed in January of 2016 due to low sales and profit. In fact, the closure of the store predated the availability of these findings. It is commonly known that running a grocery store in inner-city low-income neighbourhoods such as in this case, is a challenging proposition. The majority of potential customers living within a walkable distance to the store have limited budgets to spend, thus contributing to low sales and low cash flow and profit. The business

model of a retail grocery store in inner-city, low-income neighbourhoods need to be thought through in the future. Financial stakeholders need to be found who would provide the necessary financial base for the store to run until the store is established and begins to turn a profit. The financial backing by stakeholders could, for example, cover employee wages of the grocery store, allowing net profits to be rolled back to the store to keep the product inventory and allocate money even for promotional activities. These promotional activities could attract even more customers which could help store's success. These actions imply that policies targeted towards nutritional health behaviour offers a wider array of options that go well beyond the grocery store. (136)

### *Conclusion*

The systematic review showed that perceptions of food access, neighbourhood satisfaction, and psychological health were significantly improved when new grocery stores were opened. However, FV consumption showed mixed results while BMI and self-rated health did not show any statistically significant improvements. The evaluation of the GFJ intervention showed that the store did benefit those who shopped frequently in terms of food security and some selected health-related outcomes and these benefits were differential for people with different educational levels, income levels, multiple disadvantage. The results highlight and encourage the need for further high-quality future research with longer follow-up periods in diverse populations. Empirical evidence using better study designs and analytical methods are needed to inform evidence-based public health policy and practice with the long-term goal of reducing health inequities.

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### Appendix 1: Search strategy (developed for MEDLINE)

Concept #1	Concept #2	Concept #3
Food/ nutrition environment	Intervention	Health-related outcomes
"nutrition environment*".mp. OR "food environment*".mp. OR Grocer*.mp. OR Supermarket*.mp. OR Hypermarket*.mp. OR "food retail*".mp. OR "healthy food store*".mp. OR Nutrition Policy/ OR Food Supply/ OR Food Industry/ OR "Food accessibility".mp. OR Food/ OR	Intervention Studies/ OR Intervention*.mp. OR Implement*.mp. OR Develop*.mp. OR Establish*.mp. OR Build*.mp. "Nutrition education" .mp. OR Nutritional sciences/ OR Marketing/ OR "Food advertis*" .mp. OR "point-of-purchase" .mp. OR "Food price" .mp. OR "Food cost" .mp. OR "Food promotion" .mp. OR "Food availability" .mp. Health Promotion/ OR	Health Status/ OR Mental Health/ OR Obesity/ OR Body Mass Index/ OR Food Habits/ OR "food security".mp. OR Diet/ OR Fruit/ AND vegetables/ OR Health food/ OR Eating/ OR Nutritional status/ OR

In addition, the search strategy was limited to 1. English language and 2. Published after 1995.

## Appendix 2: Comprehensive Search Strategy

Conducted between 22/08/2015 and 24/08/2015

### 1. MEDLINE

Date: 22/08/2015

Ovid MEDLINE(R) 1946 to August Week 2 2015

Results=1625

1. "nutrition environment\*".mp.
2. "food environment\*".mp.
3. grocer\*.mp.
4. supermarket\*.mp.
5. hypermarket\*.mp.
6. "food retail\*".mp.
7. "healthy food store\*".mp.
8. nutrition policy/
9. Food Supply/
10. Food Industry/
11. "food accessibility".mp.
12. Food/
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. intervention studies/
15. intervention\*.mp.
16. implement\*.mp.
17. develop\*.mp.
18. establish\*.mp.
19. build\*.mp.
20. "nutrition education".mp.
21. Nutritional sciences/
22. marketing/
23. "food advertis\*".mp.
24. "point-of-purchase".mp.
25. "food price".mp.
26. "food cost".mp.
27. "food promotion".mp.
28. "food availability".mp.
29. Health Promotion/
30. 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
31. 13 and 30
32. health status/
33. Mental Health/
34. Obesity/
35. body mass index/
36. Food Habits/
37. "food security".mp.

38. Diet/
39. fruit/ and vegetables/
40. health food/
41. Eating/
42. nutritional status/
43. 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42
44. 31 and 43
45. limit 44 to (english language and humans and yr="1995 -Current" and "all adult (19 plus years)")

## 2. Embase

Date: 22/08/2015

Embase Classic+Embase 1947 to 2015 August 21

Results= 1906

1. "nutrition environment\*".mp.
2. "food environment\*".mp.
3. grocer\*.mp.
4. supermarket\*.mp.
5. hypermarket\*.mp.
6. "food retail\*".mp.
7. "healthy food store\*".mp.
8. nutrition policy/
9. exp catering service/
10. exp food industry/
11. "food accessibility".mp.
12. food/
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. intervention study/
15. intervention\*.mp.
16. implement\*.mp.
17. develop\*.mp.
18. establish\*.mp.
19. build\*.mp.
20. nutrition education/
21. nutritional science/
22. marketing/
23. "food advertis\*".mp.
24. "point-of-purchase".mp.
25. "food price".mp.
26. "food cost".mp.
27. "food promotion".mp.
28. "food availability".mp.
29. health promotion/
30. 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29

31. 13 and 30
32. exp health status/
33. exp mental health/
34. obesity/ep, et, pc [Epidemiology, Etiology, Prevention]
35. exp body mass/
36. exp feeding behavior/
37. exp food security/
38. exp food insecurity/
39. exp diet/
40. fruit/ and vegetables/
41. exp health food/
42. exp eating/
43. exp nutritional status/
44. 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43
45. 31 and 44
46. limit 45 to (human and english language and yr="1995 -Current" and (adult <18 to 64 years> or aged <65+ years>))
47. limit 46 to article

### 3. PsycINFO

Date: 22/08/2015

PsycINFO 1806 to August Week 3 2015

Results= 891

1. "nutrition environment\*".mp.
2. "food environment\*".mp.
3. grocer\*.mp.
4. supermarket\*.mp.
5. hypermarket\*.mp.
6. "food retail\*".mp.
7. "healthy food store\*".mp.
8. "nutrition policy".mp.
9. "Food Supply".mp.
10. "Food Industry".mp.
11. "food accessibility".mp.
12. exp Food/
13. environment/
14. exp neighborhoods/
15. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
16. exp Intervention/
17. implement\*.mp.
18. develop\*.mp.
19. establish\*.mp.
20. build\*.mp.
21. "nutrition education".mp.
22. "Nutritional sciences".mp.
23. marketing/

24. "food advertis\* ".mp.
25. "point-of-purchase ".mp.
26. "food price ".mp.
27. "food cost ".mp.
28. "food promotion ".mp.
29. "food availability ".mp.
30. Health Promotion/
31. 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30
32. 15 and 31
33. "health status ".mp.
34. exp Mental Health/
35. exp Physical Health/
36. Obesity/
37. exp Body Mass Index/
38. "Food Habits ".mp.
39. "food security ".mp.
40. diets/ or eating behavior/
41. (fruit and vegetables).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]
42. "nutritional status ".mp.
43. exp Nutrition/
44. 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43
45. 32 and 44
46. limit 45 to (human and english language and adulthood <18+ years> and yr="1995 - Current")

#### 4. CINAHL

Date: 22/08/2015

Results= 875

- S1 "nutrition environment\*"
- S2 "food environment\*"
- S3 "grocer\*"
- S4 "supermarket\*"
- S5 "hypermarket\*"
- S6 "food retail\*"
- S7 "healthy food store\*"
- S8 (MH "Nutrition Policy")
- S9 (MH "Food Supply")
- S10 (MH "Food Industry")
- S11 "food accessibility"
- S12 (MH "Food")
- S13 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12
- S14 "intervention\*"
- S15 "implement\*"
- S16 "develop\*"

S17 "establish\*"  
S18 "build\*"  
S19 (MH "Nutrition Education")  
S20 "Nutritional sciences"  
S21 "marketing"  
S22 "food advertis\*"  
S23 "point-of-purchase"  
S24 "food price"  
S25 "food cost"  
S26 "food promotion"  
S27 "food availability"  
S28 (MH "Health Promotion")  
S29 S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25  
OR S26 OR S27 OR S28  
S30 S13 AND S29  
S31 (MH "Health Status")  
S32 (MH "Mental Health")  
S33 (MH "Obesity")  
S34 (MH "Body Mass Index")  
S35 (MH "Food Habits")  
S36 (MH "Food Security")  
S37 (MH "Diet")  
S38 "fruit\* AND vegetable\*"  
S39 (MH "Health Food")  
S40 (MH "Eating") OR (MH "Eating Behavior")  
S41 (MH "Nutritional Status")  
S42 S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41  
S43 S30 AND S42

S44 S30 AND S42 Narrow by Language: - English

S45 S30 AND S42 Limiters - Published Date: 19950101-20151231; English Language; Peer Reviewed; Human

## 5. Web of Science

Date: 22/08/15

Results= 1522

#1 TOPIC: ("nutrition environment\*") OR TOPIC: ("food environment\*") OR TOPIC: (grocer\*)

#2 TOPIC: (supermarket\*) OR TOPIC: (hypermarket\*) OR TOPIC: ("food retail\*")

#3 TOPIC: ("healthy food store\*") OR TOPIC: ("nutrition policy") OR TOPIC: ("Food Supply")

#4 TOPIC: ("Food Industry") OR TOPIC: ("food accessibility")

#5 TOPIC: (intervention\*) OR TOPIC: (implement\*) OR TOPIC: (develop\*)



#6 TOPIC: (establish\*) OR TOPIC: (build\*) OR TOPIC: ("nutrition education")

#7 TOPIC: (marketing) OR TOPIC: ("food advertis\*") OR TOPIC: ("Nutritional sciences")

#8 TOPIC: ("point of purchase") OR TOPIC: ("food price") OR TOPIC: ("food cost")

#9 TOPIC: ("food promotion") OR TOPIC: ("food availability") OR TOPIC: ("Health Promotion")

#10 TOPIC: ("health status") OR TOPIC: ("Mental Health") OR TOPIC: (Obesity)

#11 TOPIC: ("body mass index") OR TOPIC: ("Food Habit\*") OR TOPIC: ("food security")

#12 TOPIC: ("fruit\* AND vegetables\*") OR TOPIC: ("health food")

#13 TOPIC: ("nutritional status") OR TOPIC: ("food insecurity")

#14 #4 OR #3 OR #2 OR #1

#15 #9 OR #8 OR #7 OR #6 OR #5

#16 #13 OR #12 OR #11 OR #10

#17 #16 AND #15 AND #14

#18 #16 AND #15 AND #14 Refined by: LANGUAGES: ( ENGLISH ) AND DOCUMENT TYPES: ( ARTICLE )

#19 #16 AND #15 AND #14 Refined by: LANGUAGES: ( ENGLISH ) AND DOCUMENT TYPES: ( ARTICLE ) AND PUBLICATION YEARS: ( 2013 OR 2008 OR 2001 OR 2014 OR 2007 OR 2002 OR 2012 OR 2006 OR 2000 OR 1998 OR 2010 OR 2004 OR 1999 OR 1995 OR 2015 OR 2003 OR 1997 OR 2011 OR 2005 OR 1996 OR 2009 )

## 6. Cochrane Library

Date: 23/08/2015 [Cochrane Database of Systematic Reviews: Issue 8 of 12, August 2015]  
Results= 89

("nutrition environment\*") OR ("food environment\*") OR (grocer\*) OR (supermarket\*) OR (hypermarket\*) OR ("food retail\*") OR ("healthy food store\*") OR ("neighborhood food environment\*") OR ("nutrition policy") OR ("Food Supply") OR ("Food Industry") OR ("food accessibility") OR (food) in Title, Abstract, Keywords and (intervention\*) OR (implement\*) OR (develop\*) OR (establish\*) OR (build\*) OR ("nutrition education") OR ("Nutritional sciences") OR (marketing) OR ("food advertis\*") OR ("point of purchase") OR ("food price") OR ("food cost") OR ("food promotion") OR ("food availability") OR ("Health Promotion") in Title, Abstract, Keywords and ("Health Status") OR ("Mental Health") OR (Obesity) OR ("body mass index") OR ("Food Habits") OR ("food security") OR (diet) OR (fruit AND vegetables) OR ("health food") OR (eating) OR ("nutritional status") in Title, Abstract, Keywords , Publication Year from 1995 to 2015

## 7. Scopus

Date: 24/08/2015

Results= 3881

(( (( TITLE-ABS-KEY ( "nutrition environment\*" ) OR TITLE-ABS-KEY ( "food environment\*" ) OR TITLE-ABS-KEY ( grocer\* ) ) ) OR ( ( TITLE-ABS-KEY ( supermarket\* ) OR TITLE-ABS-KEY ( hypermarket\* ) OR TITLE-ABS-KEY ( "food retail\*" ) ) ) ) OR ( ( TITLE-ABS-KEY ( "healthy food store\*" ) OR TITLE-ABS-KEY ( "nutrition policy" ) OR TITLE-ABS-KEY ( "Food Supply" ) ) ) ) OR ( ( TITLE-ABS-KEY ( "Food Industry" ) OR TITLE-ABS-KEY ( "food accessibility" ) ) ) ) ) AND ( ( ( TITLE-ABS-KEY ( intervention\* ) OR TITLE-ABS-KEY ( implement\* ) OR TITLE-ABS-KEY ( develop\* ) ) ) OR ( ( TITLE-ABS-KEY ( establish\* ) OR TITLE-ABS-KEY ( build\* ) OR TITLE-ABS-KEY ( "nutrition education" ) ) ) ) OR ( ( TITLE-ABS-KEY ( "Nutritional sciences" ) OR TITLE-ABS-KEY ( marketing ) OR TITLE-ABS-KEY ( "food advertis\*" ) ) ) ) OR ( ( TITLE-ABS-KEY ( "point of purchase" ) OR TITLE-ABS-KEY ( "food price" ) OR TITLE-ABS-KEY ( "food cost" ) ) ) ) OR ( ( TITLE-ABS-KEY ( "food promotion" ) OR TITLE-ABS-KEY ( "food availability" ) OR TITLE-ABS-KEY ( "Health Promotion" ) ) ) ) ) ) AND ( ( ( TITLE-ABS-KEY ( "health status" ) OR TITLE-ABS-KEY ( "Mental Health" ) OR TITLE-ABS-KEY ( obesity ) ) ) ) OR ( ( TITLE-ABS-KEY ( "body mass index" ) OR TITLE-ABS-KEY ( "Food Habits" ) OR TITLE-ABS-KEY ( "food security" ) ) ) ) OR ( ( TITLE-ABS-KEY ( ( fruit\* ) AND ( vegetable\* ) ) OR TITLE-ABS-KEY ( "health food" ) OR TITLE-ABS-KEY ( "nutritional status" ) ) ) ) ) AND ( LIMIT-TO ( PUBYEAR , 2015 ) OR LIMIT-TO ( PUBYEAR , 2014 ) OR LIMIT-TO ( PUBYEAR , 2013 ) OR LIMIT-TO ( PUBYEAR , 2012 ) OR LIMIT-TO ( PUBYEAR , 2011 ) OR LIMIT-TO ( PUBYEAR , 2010 ) OR LIMIT-TO ( PUBYEAR , 2009 ) OR LIMIT-TO ( PUBYEAR , 2008 ) OR LIMIT-TO ( PUBYEAR , 2007 ) OR LIMIT-TO ( PUBYEAR , 2006 ) OR LIMIT-TO ( PUBYEAR , 2005 ) OR LIMIT-TO ( PUBYEAR , 2004 ) OR LIMIT-TO ( PUBYEAR , 2003 ) OR LIMIT-TO ( PUBYEAR , 2002 ) OR LIMIT-TO ( PUBYEAR , 2001 ) OR LIMIT-TO ( PUBYEAR , 2000 ) OR LIMIT-TO ( PUBYEAR , 1999 ) OR LIMIT-TO ( PUBYEAR , 1998 ) OR LIMIT-TO ( PUBYEAR , 1997 ) OR LIMIT-TO ( PUBYEAR , 1996 ) OR LIMIT-TO ( PUBYEAR , 1995 ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( LIMIT-TO ( SRCTYPE , "j" ) ) ) AND ( EXCLUDE ( SUBJAREA , "BIOC" ) OR EXCLUDE ( SUBJAREA , "EART" ) OR EXCLUDE ( SUBJAREA , "ENGI" ) OR EXCLUDE ( SUBJAREA , "ENER" ) OR EXCLUDE ( SUBJAREA , "CHEM" ) OR EXCLUDE ( SUBJAREA , "IMMU" ) OR EXCLUDE ( SUBJAREA , "PHAR" ) OR EXCLUDE ( SUBJAREA , "CENG" ) OR EXCLUDE ( SUBJAREA , "COMP" ) OR EXCLUDE ( SUBJAREA , "VETE" ) OR EXCLUDE ( SUBJAREA , "PHYS" ) OR EXCLUDE ( SUBJAREA , "DENT" ) OR EXCLUDE ( SUBJAREA , "MATH" ) OR EXCLUDE ( SUBJAREA , "MATE" ) ) )

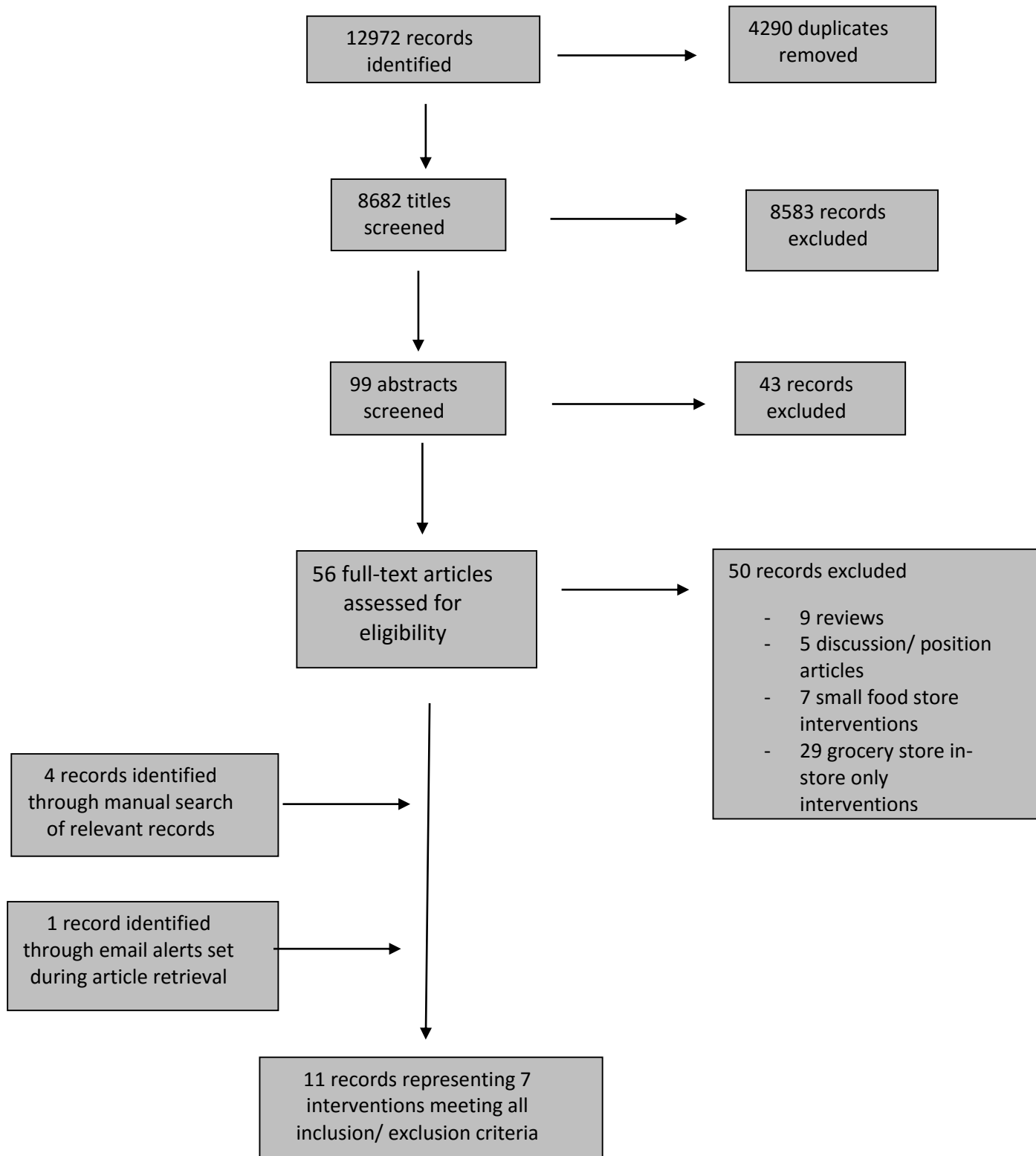
## 8. ProQuest Public Health

Date: 24/08/2015

Results= 6005

((mesh(health status) OR mesh(Mental Health) OR mesh((Obesity OR body mass index)) OR mesh(Food Habits) OR all(("food security" OR "food insecurity")) OR mesh(Diet) OR mesh(fruit AND vegetables) OR mesh(health food) OR mesh(nutritional status)) AND ((mesh(intervention studies) OR all((intervention\* OR implement\*)) OR all((develop\* OR establish\*)) OR all(build\*) OR all(("nutrition education" OR "food promotion")) OR all(("food advertis\*" OR "food availability")) OR all("point-of-purchase") OR all(("food price" OR "food cost")) OR mesh((marketing OR Nutritional sciences)) OR mesh(Health Promotion)) AND (all("nutrition environment\*") OR all("food environment\*") OR all(grocer\*) OR all(supermarket\*) OR all(hypermarket\*) OR all("food retail\*") OR all(("healthy food store\*" OR "food accessibility")) OR mesh(nutrition policy) OR mesh(Food Supply) OR mesh((Food Industry OR Food)))) AND yr(1995-2015) AND peer(yes) AND la.exact("ENG") AND at.exact("Article")

### Appendix 3: Flow diagram of the study selection process



## Appendix 4: Survey questionnaire used for data collection

Data Collector \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

### The Good Food Healthy Families Demographics Survey (4)

Participant \_\_\_\_\_ \*(ie. XX-X-XXXXX-X)

Code: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_

#### Survey Questions:

1. Have you heard of the Good Food Junction (GFJ) Cooperative grocery store?

\_\_\_\_\_ Yes \_\_\_\_\_ No (If no, go to question 12)

2. How did you hear about the GFJ?

- |  |                                   |
|--|-----------------------------------|
| a. word of mouth                           | f. saw construction of GFJ        |
| b. friends and family                      | g. media (news, radio, newspaper) |
| c. online (website, email, facebook, etc.) | h. other: _____                   |
| d. fundraising event                       |                                   |
| e. advertising                             |                                   |

3. Have you ever shopped at the Good Food Junction? \_\_\_\_\_ Yes \_\_\_\_\_ No

If yes, how often since it opened?

- a. once
- b. twice
- c. three to six times
- d. about once a month since it opened
- e. more than once a month since it opened

If not, why not?

- a. location
- b. cost/price too expensive
- c. 'I haven't had the opportunity'
- d. other: \_\_\_\_\_

(Now skip to question 9)

4. Would you consider GFJ your primary grocery store? \_\_\_\_\_ Yes \_\_\_\_\_ No

5. How do you usually travel to and from the GFJ?

To: \_\_\_\_\_ your car \_\_\_\_\_ got a ride \_\_\_\_\_ bus \_\_\_\_\_ bike \_\_\_\_\_ walk \_\_\_\_\_ cab \_\_\_\_\_ other

From: \_\_\_\_\_ your car \_\_\_\_\_ got a ride \_\_\_\_\_ bus \_\_\_\_\_ bike \_\_\_\_\_ walk \_\_\_\_\_ cab \_\_\_\_\_ other

6. What do you like best about shopping at the GFJ? Choose all that apply

- |                   |                      |                            |
|-------------------|----------------------|----------------------------|
| a. prices         | e. selection of food | i. there is nothing I like |
| b. location       | f. quality of food   |                            |
| c. attractiveness | g. customer service  |                            |
| d. business model | h. other: _____      |                            |

7. What do you like least about shopping at the GFJ? Choose all that apply

- a. prices
- b. location
- c. attractiveness
- d. business model
- e. selection of food
- f. quality of food
- g. customer service
- h. other: \_\_\_\_\_
- i. I like everything

8. What do you usually buy at the GFJ? Choose as many as you want.

- a. fresh vegetables and fruit
- b. dairy products
- c. meat products
- d. canned food
- e. items for baking (*flour, sugar, etc.*)
- f. snack foods (*chips, pretzels, nachos, etc.*)
- g. pre-made frozen meals (*lean cuisine, tv dinners, etc.*)
- h. frozen vegetables or fruit
- i. pop, iced tea or energy drinks
- j. hot or cold cereals
- k. bread and pre-made bakery items
- l. dry foods (*pasta, rice, dried beans*)
- m. other: \_\_\_\_\_

9. Are you aware of any educational or promotional activities (such as food tasting, cooking demonstrations, nutrition education messages, cooking classes) hosted by the GFJ?

\_\_\_\_\_ Yes \_\_\_\_\_ No (*If no, skip to question 12*)

10. Have you participated in any of these? \_\_\_\_\_ Yes \_\_\_\_\_ No

11. If so which activities have you participated in?

\_\_\_\_\_

*(If participant has indicated that GFJ is primary grocery store - Skip to question 14)*

12. What store would you consider your primary grocery store?

*(make sure to include name and location)* \_\_\_\_\_

13. How do you usually travel to and from your primary grocery store?

To:    \_\_\_ your car    \_\_\_ got a ride    \_\_\_ bus    \_\_\_ bike    \_\_\_ walk    \_\_\_ cab    \_\_\_ other  
From:   \_\_\_ your car    \_\_\_ got a ride    \_\_\_ bus    \_\_\_ bike    \_\_\_ walk    \_\_\_ cab    \_\_\_ other

14. How often do you shop for groceries? \_\_\_\_\_

Data Collector \_\_\_\_\_

Date \_\_\_\_\_

Time \_\_\_\_\_

Participant \_\_\_\_\_<sup>#</sup> (ie. XX-X-XXXXXX-X)

Code: \_\_\_\_\_

15. What are the most important things to you when choosing a grocery store? Choose all that apply

- a. prices
- b. location
- c. attractiveness
- d. business model
- e. selection of food
- f. quality of food
- g. customer service
- h. other: \_\_\_\_\_

16. Do you?... (Please answer yes or no to each option)

- \_\_\_\_\_ Grow vegetables in your own vegetable garden
- \_\_\_\_\_ Participate in Community garden or garden allotment
- \_\_\_\_\_ Buy CHEP Good Food Boxes
- \_\_\_\_\_ Use the Food Bank or other charitable food programs
- \_\_\_\_\_ Shop at the Farmer's Market
- \_\_\_\_\_ Buy food directly from farmers or producers other than at the farmer's market
- \_\_\_\_\_ Participate in the Collective kitchens program
- \_\_\_\_\_ Buy food at the CHEP community markets
- \_\_\_\_\_ Buy food at the Seniors' markets
- \_\_\_\_\_ Participate in any other food programs \_\_\_\_\_

Participant	*(ie. XX-X-XXXXXX-X)
Code:	_____

<i>[MAKE NOTE OF ADDRESS]</i>
Address: _____
_____

17. Would you be willing to be contacted to participate in further research? \_\_\_\_\_ Yes \_\_\_\_\_ No

*(If participant asks for more information)*

**Description: We will be doing further research on the Good Food Junction and Station 20 West and will still be interested in talking to people from your neighbourhood. Would you be willing to participate in another study on the Good Food Junction?**

Name:

Phone Number:

Email:

\*\*\**(Only for Health Status Survey participants)*

Alternate person to contact in case participant moves:

\*\*\**(Only for Health Status Survey participants)*

18. Would you be willing to participate in research using smart phones? \_\_\_\_\_ Yes \_\_\_\_\_ No

*(If participant asks for more information)*

**Description: Participants will be provided with smart phones in order to take pictures of what foods they are purchasing and eating. This study would use the smart phone camera as well as an app on the smart phone to collect data about what people are eating and their grocery shopping habits.**



**The Good Food Junction Research Health Status Questionnaire (8)**

Participant \_\_\_\_\_ \*(ie. XX-X-XXXXX-X)  
Code: \_\_\_\_\_

1. In general, would you say your health is?
  - a. Excellent
  - b. Very Good
  - c. Good
  - d. Fair
  - e. Poor
  
2. Compared to one year ago, how would you say your health is now? Is it?
  - a. Much better than 1 year ago
  - b. Somewhat better than 1 year ago
  - c. About the same as it was 1 year ago
  - d. Somewhat worse than 1 year ago
  - e. Much worse than 1 year ago
  
3. In general, would you say your mental health is?
  - a. Excellent
  - b. Very good
  - c. Good
  - d. Fair
  - e. Poor
  
4. Thinking about the amount of stress in your life, would you say that most days are?
  - a. Not at all stressful
  - b. Not very stressful
  - c. A bit stressful
  - d. Quite a bit stressful
  - e. Extremely stressful
  
5. In the past week, on how many days have you done a total of 30 minutes or more of physical activity, which was enough to raise your breathing rate? (Should not include housework or physical activity that may be part of your job)

0      1      2      3      4      5      6      7

6. In the past 12 months, did you do anything to improve your health? (For example, lost weight, quit smoking, increased exercise)

- a. Yes
- b. No

7. What is the single most important change you have made?

*(Wait for participant to reply before providing examples)*

- a. Increased exercise, sports/physical activity
- b. Lost weight
- c. Changed diet/improved eating habits
- d. Quit smoking/reduced amount smoked
- e. Drank less alcohol
- f. Reduced stress level
- g. Received medical treatment
- h. Took vitamins
- i. Other: \_\_\_\_\_

8. Do you think there is [anything else/anything] you could do to improve your physical health?

- a. Yes
- b. No *(Skip to question 12)*

9. What is the most important thing?

*(Wait for participant to reply before providing examples)*

- a. Start/increase exercise, sports or physical activity
- b. Lose weight
- c. Change diet/improve eating habits
- d. Quit smoking/reduce amount of smoking
- e. Drink less alcohol
- f. Reduce stress level
- g. Receive medical treatment
- h. Take vitamins
- i. Other: \_\_\_\_\_

10. Is there anything stopping you from making this improvement?

- a. Yes
- b. No

11. What is that? Choose as many as apply
- a. Too stressed
  - b. Too costly/financial constraints
  - c. Transportation problems
  - d. Weather problems
  - e. Lack of personal motivation/self-discipline
  - f. Family responsibilities
  - g. Work schedule
  - h. Addiction to drugs/alcohol
  - i. Physical condition
  - j. Disability/health problem
  - k. Not nearby or in neighbourhood
  - l. Other: \_\_\_\_\_

12. Is there anything you intend to do to improve your physical health in the next year?
- a. Yes
  - b. No

13. What is that? Choose as many as you apply
- a. Start/increase exercise, sports or physical activity
  - b. Lose weight
  - c. Change diet/improve eating habits
  - d. Quit smoking/reduce amount of smoking
  - e. Drink less alcohol
  - f. Reduce stress level
  - g. Receive medical treatment
  - h. Take vitamins
  - i. Other: \_\_\_\_\_

14. Have you ever been told by a medical provider that you have:

*Note: Pre-conditions for diabetes, cancer, etc. are not valid and should be marked as 'no'.*

- a. Diabetes?
  - I. Yes
  - II. No
- b. High blood pressure?
  - I. Yes
  - II. No
- c. Heart Disease?
  - I. Yes
  - II. No
- d. Cancer?
  - I. Yes
  - II. No

15. What is your height?

16. What is your weight?

The next section of questions is about the foods that you usually eat or drink. This includes all the foods you eat, both meals and snacks, at home and away from home.

17. How often do you usually drink (100%) fruit juices such as orange, grapefruit or tomato? (For example: once a day, three times a week, twice a month)

- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
- b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
- c. \_\_\_\_\_ Per month (Rarely – less than once a week)
- d. \_\_\_\_\_ Per year (Hardly ever)
- e. Never

18. Not counting juice, how often do you usually eat fruit?

- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
- b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
- c. \_\_\_\_\_ Per month (Rarely – less than once a week)
- d. \_\_\_\_\_ Per year (Hardly ever)
- e. Never

19. How often do you usually eat green salad?

- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
- b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
- c. \_\_\_\_\_ Per month (Rarely – less than once a week)
- d. \_\_\_\_\_ Per year (Hardly ever)
- e. Never

20. How often do you usually eat potatoes, not including French fries, fried potatoes, or potato chips?

- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
- b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
- c. \_\_\_\_\_ Per month (Rarely – less than once a week)
- d. \_\_\_\_\_ Per year (Hardly ever)
- e. Never

21. How often do you usually eat carrots?

- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
- b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
- c. \_\_\_\_\_ Per month (Rarely – less than once a week)
- d. \_\_\_\_\_ Per year (Hardly ever)
- e. Never

22. Not counting carrots, potatoes, or salad, how many servings of other vegetables do you usually eat?
- a. \_\_\_\_\_ Per day (Frequently – more than 5 x a week)
  - b. \_\_\_\_\_ Per week (Sometimes – 1 or 2 or 3 x a week)
  - c. \_\_\_\_\_ Per month (Rarely – less than once a week)
  - d. \_\_\_\_\_ Per year (Hardly ever)
  - e. Never

The following question is about the food situation for your household over the past 12 months.

23. Which of the following statements best describes the food availability in your household in the past 12 months, that is, since July of last year?
- a. You and other members of your household always had enough of the kinds of food you wanted to eat
  - b. You and other members of your household had enough to eat, but not always the kinds of food you wanted.
  - c. Sometimes you and other members of your household did not have enough to eat
  - d. Often you and members of your household didn't have enough to eat

Now I'm going to read you several statements that may be used to describe the food situation for a household. Please tell me if the statement was often true, sometimes true, or never true for you and others in your household in the past 12 months.

The first statement is:

24. You and other members of your household worried that food would run out before you got money to buy more. Was that often true, sometimes true, or never true in the past 12 months?
- a. Often true
  - b. Sometimes true
  - c. Never true
25. The food that you and other members of your household bought just didn't last, and there wasn't any money to get more. Was that often true, sometimes true, or never true in the past 12 months?
- a. Often true
  - b. Sometimes true
  - c. Never true

26. You and other members of your household couldn't afford to eat balanced meals. In the past 12 months was that often true, sometimes true, or never true?
- Often true
  - Sometimes true
  - Never true

**Do you currently have children living with you in your household? (No – Skip to question 30)**

**Now I'm going to read a few statements that may describe the food situation for households with children.**

27. You and other adults in your household relied on only a few kinds of low-cost food to feed your child(ren) because you were running out of money to buy food. Was that often true, sometimes true, or never true in the past 12 months?
- Often true
  - Sometimes true
  - Never true

28. You and other adults in your household couldn't feed your child(ren) a balanced meal, because you couldn't afford it. Was that often true, sometimes true, or never true in the past 12 months?
- Often true
  - Sometimes true
  - Never true

29. Your child did not have enough to eat because you and other adults in your household couldn't afford enough food. Was that often true, sometimes true, or never true in the past 12 months?
- Often true
  - Sometimes true
  - Never true

**The following section of questions is about the potential food situation in the past 12 months for you or any other adults in your household.**

30. In the past 12 months, since last July, did you and other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?
- Yes
  - No (Skip question to question 32)

31. How often did this happen – almost every month, some months but not every month, or only 1 or 2 months?
- a. Almost every month
  - b. Some months but not every month
  - c. Only 1 or 2 months
32. In the past 12 months, did you (personally) ever eat less than you felt you needed because there wasn't enough money to buy food?
- a. Yes
  - b. No
33. In the past 12 months, were you (personally) ever hungry but didn't eat because you couldn't afford enough food?
- a. Yes
  - b. No
34. In the past 12 months, did you (personally) ever lose weight because you didn't have enough money for food?
- a. Yes
  - b. No
35. In the past 12 months, did you or other adults ever not eat for a whole day because there wasn't enough money for food?
- a. Yes
  - b. No *(Skip to question 37)*
36. How often did this happen? Almost every month, some months but not every month, or only 1 or 2 months?
- a. Almost every month
  - b. Some months but not every month
  - c. Only 1 or 2 months

*(No Children in Household – Skip to question 42)*

Now, I am going to ask you a few questions on potential food experiences for children.

37. In the past 12 months, did you or other adults in your household ever cut the size of any child's meals because there wasn't enough money for food?
- a. Yes
  - b. No
38. In the past 12 months, did any child ever skip meals because there wasn't enough money for food?
- a. Yes
  - b. No *(Skip to question 40)*

39. How often did this happen? Almost every month, some months but not every month, or only 1 or 2 months?
- a. Almost every month
  - b. Some months but not every month
  - c. Only 1 or 2 months

40. In the past 12 months, was any child ever hungry because you couldn't afford more food.
- a. Yes
  - b. No

41. In the past 12 months, did any child ever not eat for a whole day because there wasn't enough money for food?
- a. Yes
  - b. No

The last section of questions is about your neighbours, your neighbourhood, and your sense of belonging.

42. How long have you been living in your neighbourhood? \_\_\_\_\_

43. In general, what kind of neighbourhood would you say you live in? Would you say it is a neighbourhood in which people do things together and try to help each other, one in which people mostly go their own way, or a mix of both?
- a. Help each other out
  - b. Go their own way
  - c. Mix of both
  - d. Refused
  - e. N/A

44. How much do you feel a part of your neighbourhood?
- a. Very much a part
  - b. Somewhat a part
  - c. Not very much a part
  - d. Refused
  - e. N/A

45. Do you feel comfortable calling upon your neighbours for assistance or help during a crisis?
- a. Yes
  - b. No
  - c. Refused
  - d. N/A



46. If there was a neighbourhood project organized, such as a block party or yard sale, how comfortable would you feel about participating?
- a. Very comfortable
  - b. Somewhat comfortable
  - c. Uncomfortable
  - d. Refused
  - e. N/A

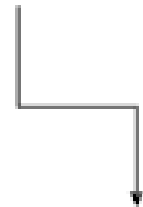
**FINISH DEMOGRAPHIC SURVEY QUESTIONS NOW**

Participant \_\_\_\_\_<sup>#</sup> (ie. XX-X-XXXXXX-X)  
Code: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_

Age: \_\_\_\_\_

Gender: \_\_\_\_\_

Occupation: \_\_\_\_\_



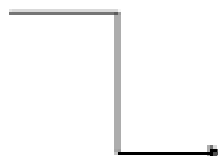
Do you identify as any of the following:

- \_\_\_\_\_ First Nations Status
- \_\_\_\_\_ First Nations Non-Status
- \_\_\_\_\_ Metis
- \_\_\_\_\_ Inuit
- \_\_\_\_\_ Senior Citizen (65+)
- \_\_\_\_\_ Newcomer to Canada (less than 5 years in Canada)
- \_\_\_\_\_ None of the above
- \_\_\_\_\_ Declined to answer



What is your marital status?

- \_\_\_\_\_ Married or living common law
- \_\_\_\_\_ Divorced
- \_\_\_\_\_ Separated
- \_\_\_\_\_ Widowed
- \_\_\_\_\_ Single - never married
- \_\_\_\_\_ Declined to answer



Who lives with you in this household? Check as many as apply

- \_\_\_\_\_ My partner or spouse
- \_\_\_\_\_ My children
- \_\_\_\_\_ Grandchildren
- \_\_\_\_\_ Other relatives (parents, grandparents, aunts, uncles, cousins, nieces, nephews)
- \_\_\_\_\_ Roommates
- \_\_\_\_\_ Foster children
- \_\_\_\_\_ Lives Alone
- \_\_\_\_\_ Other
- \_\_\_\_\_ Declined to answer

If children live in your house, how many are under the age of 18? \_\_\_\_\_  
\_\_\_\_\_ Declined to answer

Do you rent or own your home?  
\_\_\_\_\_

How much is your mortgage or rent each month? \_\_\_\_\_

What is the highest level of education that you have completed?

- \_\_\_\_\_ Less than high school
- \_\_\_\_\_ Completed high school
- \_\_\_\_\_ Some college (SIAST)
- \_\_\_\_\_ Completed college (SIAST)
- \_\_\_\_\_ Some university
- \_\_\_\_\_ Completed university
- \_\_\_\_\_ Declined to answer

Now I am going to ask you about your household annual income. Please stop me when I have read the category that you fall into. Was it...?

- \_\_\_\_\_ Less than \$5,000
- \_\_\_\_\_ \$5,000 to less than \$10,000
- \_\_\_\_\_ \$10,000 to less than \$15,000
- \_\_\_\_\_ \$15,000 to less than \$20,000
- \_\_\_\_\_ \$20,000 to less than \$30,000
- \_\_\_\_\_ \$30,000 to less than \$40,000
- \_\_\_\_\_ \$40,000 to less than \$50,000
- \_\_\_\_\_ \$50,000 to less than \$60,000
- \_\_\_\_\_ \$60,000 to less than \$70,000
- \_\_\_\_\_ \$70,000 to less than \$80,000
- \_\_\_\_\_ \$80,000 to less than \$90,000
- \_\_\_\_\_ \$90,000 to less than \$100,000
- \_\_\_\_\_ \$100,000 to less than \$150,000
- \_\_\_\_\_ \$150,000 or more
- \_\_\_\_\_ Don't Know
- \_\_\_\_\_ Declined to answer

Any other comments or concerns about the GFJ: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

***End of Survey***

## Appendix 5: Ethical approval



UNIVERSITY OF  
SASKATCHEWAN

Behavioural Research Ethics Board

### Certificate of Approval

PRINCIPAL INVESTIGATOR  
Nazem Muhsjarine

DEPARTMENT  
Community Health and Epidemiology

BEH#  
15-329

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED  
Saskatoon  
Saskatchewan, Canada

STUDENT RESEARCHER(S)  
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FUNDER(S)  
CANADIAN INSTITUTES OF HEALTH RESEARCH (CIHR)

TITLE  
The Good Food Junction: A Community-Based Food Intervention to Reduce Nutritional Health Inequities

ORIGINAL REVIEW DATE  
03-Feb-2016

APPROVAL ON  
03-Feb-2016

APPROVAL OF:  
Application for Behavioural Research Ethics  
Review  
Secondary Analysis: BEH 13-168

EXPIRY DATE  
02-Feb-2017

Full Board Meeting

Delegated Review


#### CERTIFICATION

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

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

#### ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month prior to the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: <http://research.usask.ca/for-researchers/ethics/index.php>

  
Vivian Ramsden, Chair  
University of Saskatchewan  
Behavioural Research Ethics Board

Please send all correspondence to:

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University of Saskatchewan  
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Saskatoon SK S7N 4J8  
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**Appendix 6: Characteristics of study participants recruited during round 1 and round  
2**

<b>Characteristic</b>	<b>Round 1 recruited sample (%)</b>	<b>Round 2 recruited sample (%)</b>	<b>Chi-Square p-value</b>
GFJ exposure <ul style="list-style-type: none"> <li>• Low</li> <li>• Moderate</li> <li>• High</li> </ul>	21.8 16 62.2	40 30 30	<b>0.000</b>
Food security <ul style="list-style-type: none"> <li>• Food secure</li> <li>• Food insecure</li> </ul>	45.5 54.5	15 85	<b>0.000</b>
General health <ul style="list-style-type: none"> <li>• Fair to poor</li> <li>• Good to excellent</li> </ul>	26.9 73.1	50 50	<b>0.015</b>
Health compared to an year ago <ul style="list-style-type: none"> <li>• Worse than</li> <li>• Better than</li> </ul>	12.2 87.8	25 75	0.116
Mental health <ul style="list-style-type: none"> <li>• Fair to poor</li> <li>• Good to excellent</li> </ul>	10.9 89.1	20 80	0.220
BMI <ul style="list-style-type: none"> <li>• Overweight/obese</li> <li>• Underweight/normal weight</li> </ul>	62.8 37.2	60 40	0.959
Use of other food programs <ul style="list-style-type: none"> <li>• None</li> <li>• 1-2</li> <li>• 3 or more</li> </ul>	11.5 63.5 25	5 70 25	0.205
GFJ primary store <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	75 25	60 40	0.153
Aboriginal status <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	49.4 50.6	5 95	<b>0.000</b>
Level of education <ul style="list-style-type: none"> <li>• University</li> <li>• High sch&amp; some post sec</li> <li>• Less than high school</li> </ul>	21.8 49.4 28.8	0 60 40	<b>0.042</b>
Household income <ul style="list-style-type: none"> <li>• High</li> <li>• Low</li> </ul>	36.6 63.4	12.5 87.5	0.074
Disadvantaged category <ul style="list-style-type: none"> <li>• Single/none</li> <li>• Multiple</li> </ul>	53.2 46.8	20 80	<b>0.008</b>
Length of time lived in nbhd <ul style="list-style-type: none"> <li>• Less than 5 years</li> <li>• 6 or more</li> </ul>	67.3 32.7	75 25	0.642

## Appendix 7: Categorical Principal Component Analysis (CATPCA) Results

Table 7.1: Correlations of 4 variables used.

### Correlations

			neigh_kind	neigh_feel	neigh_help	neigh_proj
Spearman's rho	neigh_kind	Correlation Coefficient	1.000	-.281**	-.224**	-.155
		Sig. (2-tailed)	.	.001	.006	.057
		N	152	150	152	151
	neigh_feel	Correlation Coefficient	-.281**	1.000	.324**	.379**
		Sig. (2-tailed)	.001	.	.000	.000
		N	150	150	150	149
	neigh_help	Correlation Coefficient	-.224**	.324**	1.000	.495**
		Sig. (2-tailed)	.006	.000	.	.000
		N	152	150	153	152
	neigh_proj	Correlation Coefficient	-.155	.379**	.495**	1.000
		Sig. (2-tailed)	.057	.000	.000	.
		N	151	149	152	152

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Table 7.2: Scree plot and relevant results table used to determine the number of principal components required.

### Model Summary

Dimension	Cronbach's Alpha	Variance Accounted For		
		Multiple Nominal Variables	Non Multiple Variables	Total (Eigenvalue)
1	.696	.993	1.100	2.093
2	.029	.974	.048	1.022
3	-.222	.545	.312	.858
4	-.863	.324	.283	.607
5	-1.683	.178	.264	.442
6	-120.760	.011	.000	.011
7	-2248.259	.001	.000	.001
Total	.787 <sup>a</sup>	.432 <sup>b</sup>	2.008	2.440 <sup>c</sup>

a. Total Cronbach's Alpha is based on the total Eigenvalue.

b. Mean over dimensions.

c. Because there are Multiple Nominal variables, total Eigenvalue is not the sum over dimensions.

Figure 7.1: Scree plot

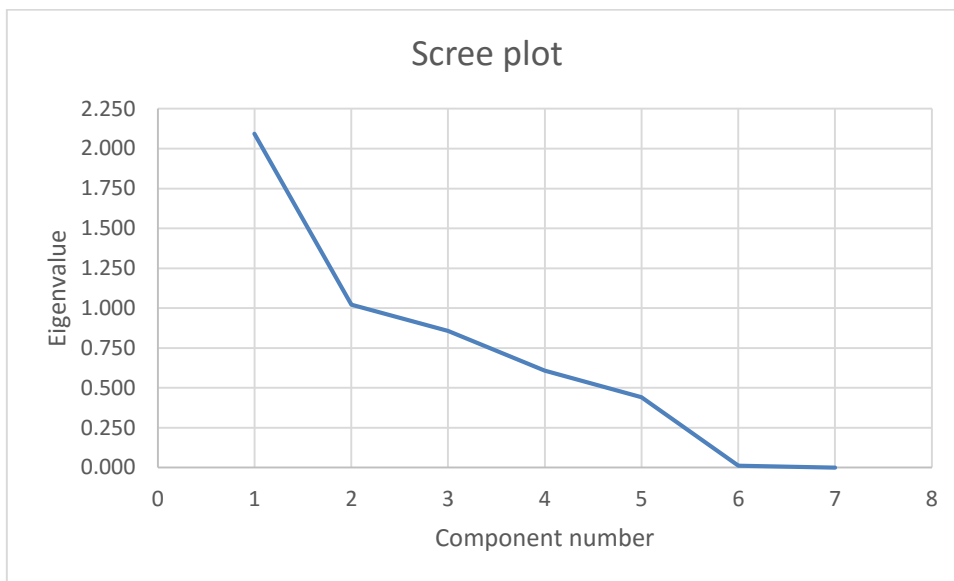


Table 7.3: Analysis levels of the four variables used.

Variable	Analysis level	Indication of 'fit' of variable in the principal component
Neigh_kind	Multiple nominal	Do not obtain component loadings. Variance of the category quantifications/ category points in the principal component space are used to indicate the 'fit'
Neigh_help		
Neigh_feel	Ordinal	Obtain component loadings so can be represented as a vector.
Neigh_proj		

Table 7.4: The results of the CATPCA tables from three rounds (in order) separately.

**Variance Accounted For**

	Centroid Coordinates		Vector Coordinates		Total	
	Dimension	Mean	Dimension	Total	Dimension	Total
	1		1		1	
neigh_kind	.467	.467	.558	.558	.467	.467
neigh_feel	.558	.558	.558	.558	.558	.558
neigh_help	.544	.544	.550	.550	.544	.544
neigh_proj	.550	.550	.550	.550	.550	.550
Active Total	2.120	2.120	1.109	1.109	2.120	2.120

**Variance Accounted For**

	Centroid Coordinates		Vector Coordinates		Total	
	Dimension	Mean	Dimension	Total	Dimension	Total
	1		1		1	
neigh_kind	.533	.533	.581	.581	.533	.533
neigh_feel	.581	.581	.581	.581	.581	.581
neigh_help	.566	.566	.528	.528	.566	.566
neigh_proj	.528	.528	.528	.528	.528	.528
Active Total	2.208	2.208	1.109	1.109	2.208	2.208

**Variance Accounted For**

	Centroid Coordinates		Vector Coordinates		Total	
	Dimension	Mean	Dimension	Total	Dimension	Total
	1		1		1	
neigh_kind	.551	.551			.551	.551
neigh_feel	.623	.623	.623	.623	.623	.623
neigh_help	.574	.574			.574	.574
neigh_proj	.559	.559	.559	.559	.559	.559
Active Total	2.306	2.306	1.181	1.181	2.306	2.306

Table 7.5: The Chronbach's alpha and eigenvalues of three rounds separately (in order).

**Model Summary**

Dimension	Cronbach's Alpha	Variance Accounted For		
		Multiple Nominal Variables	Non Multiple Variables	Total (Eigenvalue)
1	.704	1.011	1.109	2.120
Total	.704	1.011	1.109	2.120

**Model Summary**

Dimension	Cronbach's Alpha	Variance Accounted For		
		Multiple Nominal Variables	Non Multiple Variables	Total (Eigenvalue)
1	.729	1.099	1.109	2.208
Total	.729	1.099	1.109	2.208

**Model Summary**

Dimension	Cronbach's Alpha	Variance Accounted For		
		Multiple Nominal Variables	Non Multiple Variables	Total (Eigenvalue)
1	.755	1.125	1.181	2.306
Total	.755	1.125	1.181	2.306

Figure 7.2: Component loadings of ordinal variables and category points of multiple nominal variables of three rounds separately (in order) in the principal component space.

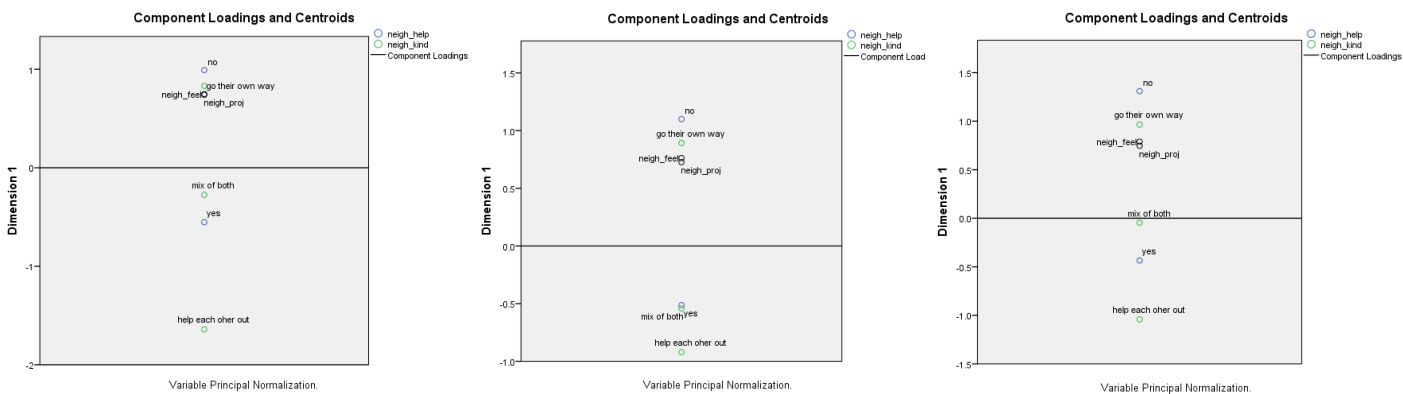




Table 7.6: Descriptive statistics of the derived object score for three rounds separately (in order)

**Statistics**

object\_score\_social\_conectednes

N	Valid	156
	Missing	0
Mean		.00093
Median		-.18100
Mode		-.712
Std. Deviation		1.000243
Variance		1.000
Range		3.933
Minimum		-1.730
Maximum		2.203
Percentiles	25	-.71200
	50	-.18100
	75	.62375

**Statistics**

object\_score\_social\_conectednes

N	Valid	153
	Missing	0
Mean		.00376
Median		-.26600
Mode		-.915
Std. Deviation		1.009327
Variance		1.019
Range		3.381
Minimum		-1.402
Maximum		1.979
Percentiles	25	-.91500
	50	-.26600
	75	.83200

**Statistics**

object\_score\_social\_conectednes

N	Valid	115
	Missing	0
Mean		.00492
Median		-.18200

Mode		-1.216
Std. Deviation		1.009843
Variance		1.020
Range		3.471
Minimum		-1.216
Maximum		2.255
Percentiles	25	-.78400
	50	-.18200
	75	.65700

## Appendix 8: Model building results for research question 1

### 1. Household food insecurity

#### *Univariate results summary*

Household food security status: 2 categories; 1=food secure   indicator & 0= moderate& severe food insecure   reference					
Variable	Reference category	Odds ratio/ Exp( $\beta$ )	95% CI for OR		p-value
			Lower	Upper	
Level of GFJ exposure	low				
• High		1.653	0.980	2.790	0.060
• Moderate		1.740	0.970	3.120	0.063
Senior	Not senior	2.442	1.325	4.500	0.004
Low income	High	0.180	0.094	0.344	0.000
Education	university				
• Less than high sch		0.161	0.074	0.349	0.000
• High sch & some post second		0.220	0.114	0.423	0.000
Male	Female	1.974	1.087	3.586	0.026
Aboriginal identity	Non-Aboriginal				
		0.346	0.208	0.577	0.000
Daily stress	Not stressful				
		0.881	0.650	1.194	0.414
Physical activity	Low	0.891	0.641	1.239	0.493
Pre-existing conditions	Never	1.247	0.787	1.977	0.347
Believe in changing health behaviour	Low	0.925	0.680	1.259	0.621
How long lived in the neighbourhood	<5 years	1.164	0.800	1.694	0.427
Social connectedness	Low				
• High		1.789	1.116	2.841	0.016
• Moderate		1.154	0.761	1.750	0.500
GFJ primary grocery store	No	0.980	0.675	1.424	0.917
Other food programs	None				
• 1-2		0.437	0.223	0.857	
• 3<		0.539	0.271	1.073	

The final model for household food security;

#### Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
			(Intercept)	3.013	.7846	1.475	4.551		14.745	1
[High exposure=3.00]	-.228	.4782	-1.165	.710	.226	1	.634	.797	.312	2.034

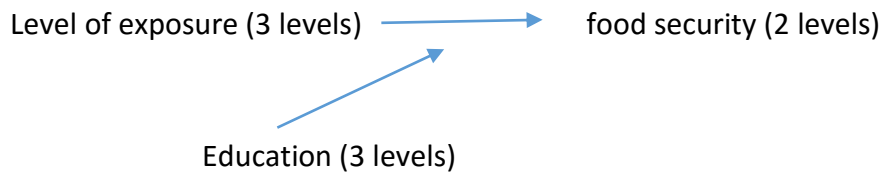
[Moderate exposure=2.00]	-.297	.4622	-1.203	.608	.414	1	.520	.743	.300	1.838
[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[>3 other food programs=3.00]	-1.060	.5191	-2.078	-.043	4.170	1	.041	.346	.125	.958
[1-2other food programs=2.00]	-1.301	.5430	-2.365	-.236	5.737	1	.017	.272	.094	.790
[no other food programs=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Low income=1.00]	-1.417	.3677	-2.137	-.696	14.840	1	.000	.243	.118	.499
[High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[less than high school=3.00]	-2.067	.8699	-3.772	-.362	5.646	1	.017	.127	.023	.696
[high sch&post second=2.00]	-3.348	.8544	-5.022	-1.673	15.351	1	.000	.035	.007	.188
[university=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[High neighbourhood connectedness=3.00]	.712	.3217	.081	1.342	4.896	1	.027	2.037	1.085	3.827
[Moderate neighbourhood connectedness=2.00]	.286	.2946	-.291	.864	.945	1	.331	1.332	.747	2.372
[Low neighbourhood connectedness=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Male=1]	.843	.3552	.146	1.539	5.628	1	.018	2.322	1.158	4.659
[Female=0]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[High exposure=3.00] * [less than high school=3.00]	.819	.8579	-.863	2.500	.911	1	.340	2.268	.422	12.188
[High exposure=3.00] * [high sch&post second=2.00]	2.232	.8490	.568	3.896	6.913	1	.009	9.322	1.765	49.230
[High exposure=3.00] * [university=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Moderate exposure=2.00] * [less than high school=3.00]	.357	1.0198	-1.642	2.356	.123	1	.726	1.429	.194	10.549
[Moderate exposure=2.00] * [high sch&post second=2.00]	2.227	.8765	.509	3.945	6.457	1	.011	9.275	1.664	51.688
[Moderate exposure=2.00] * [university=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [less than high school=3.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [high sch&post second=2.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [university=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: fs status binary

Model: (Intercept), level\_of\_exposure, other\_food\_programs, income, education, neighbourhood\_connectedness, gender, level\_of\_exposure \* education

a. Set to zero because this parameter is redundant.

## Hand calculation of estimates of ORs & 95% CIs of interacting variables in food security model



Predicted logit form of model

Logit =  $\beta_0 + \beta_{\text{high exp}} \text{high exp} + \beta_{\text{moderate exp}} \text{moderate exp} + \beta_{>3\text{food-based programs}} >3\text{food-based programs} + \beta_{1-2 \text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} <\text{high sch} + \beta_{\text{high sch \& post sec}} \text{high sch \& post sec} + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd cond} + \beta_{\text{male}} \text{male} + \beta_{\text{high exp} * <\text{high sch}} \text{high exp} * <\text{high sch} + \beta_{\text{high exp} * \text{high sch \& some post sec}} \text{high exp} * \text{high sch \& some post sec} + \beta_{\text{moderate exp} * <\text{high sch}} \text{moderate exp} * <\text{high sch} + \beta_{\text{moderate exp} * \text{high sch \& some post sec}} \text{moderate exp} * \text{high sch \& some post sec}$

1.

Compute logit for < high sch education and high GFJ exposure

Logit (< high sch edu=1, high sch & some post sec=0, high exposure=1, moderate exposure=0) =  $\beta_0 + \beta_{\text{high exp}} * 1 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} >3\text{food-based programs} + \beta_{1-2 \text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} * 1 + \beta_{\text{high sch \& post sec}} * 0 + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd cond} + \beta_{\text{male}} \text{male} + \beta_{\text{high exp} * <\text{high sch}} * 1 + \beta_{\text{high exp} * \text{high sch \& some post sec}} * 1 + \beta_{\text{moderate exp} * <\text{high sch}} * 0 + \beta_{\text{moderate exp} * \text{high sch \& some post sec}} * 0$ ----- (a)

Compute logit for < high sch education and low GFJ exposure

Logit (< high sch edu=1, high sch & some post sec=0, high exposure=0, moderate exposure=0) =  $\beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} >3\text{food-based programs} + \beta_{1-2 \text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} * 1 + \beta_{\text{high sch \& post sec}} * 0 + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd cond} + \beta_{\text{male}} \text{male} + \beta_{\text{high exp} * <\text{high sch}} * 0 + \beta_{\text{high exp} * \text{high sch \& some post sec}} * 0 + \beta_{\text{moderate exp} * <\text{high sch}} * 0 + \beta_{\text{moderate exp} * \text{high sch \& some post sec}} * 0$ ----- (b)

Logit difference = (a) - (b) =  $\beta_{\text{high exp}} + \beta_{\text{high exp} * <\text{high sch}} = -.228 + .819 = 0.591$

OR for <high sch education and high GFJ exp =  $e^{0.591} = 1.81$

Calculation of the 95% CI of the OR

$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp} * <\text{high sch}}) = \text{var} (\beta_{\text{high exp}}) + \text{var} (\beta_{\text{high exp} * <\text{high sch}}) + 2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp} * <\text{high sch}})$

$\text{var} (\beta_{\text{high exp}}) = \{\text{SE} (\beta_{\text{high exp}})\}^2 = (.4782)^2 = 0.2286$

$\text{var} (\beta_{\text{high exp} * <\text{high sch}}) = \{\text{SE} (\beta_{\text{high exp} * <\text{high sch}})\}^2 = (.8579)^2 = 0.7359$

$2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp} * <\text{high sch}}) = 2(-0.20656) = -0.4131$

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch}}) = 0.2286 + 0.7359 - 0.4131 = 0.5514$$

$$\text{SE} (\beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch}}) = \sqrt{0.5514} = 0.743$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE}(\beta)} = e^{0.591 \pm 1.96 * (0.743)}$$

$$\text{Upper limit} = e^{0.591 + 1.456} = e^{2.047} = 7.74$$

$$\text{Lower limit} = e^{0.591 - 1.456} = e^{-0.865} = 0.42$$

2.

Compute logit for high sch & some post sec education among high GFJ exposure

$$\begin{aligned} \text{Logit} (< \text{high sch edu}=0, \text{high sch \& some post sec}=1, \text{high exposure}=1, \text{moderate} \\ \text{exposure}=0) = & \beta_0 + \beta_{\text{high exp}} * 1 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} >3\text{food-based} \\ & \text{programs} + \beta_{1-2 \text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} \\ & * 0 + \beta_{\text{high sch \& post sec}} * 1 + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd} \\ & \text{cond} + \beta_{\text{male}} \text{male} + \beta_{\text{high exp}^* \text{high sch}} 1 * 0 + \beta_{\text{high exp}^* \text{high sch \& some post sec}} 1 * 1 + \beta_{\text{moderate exp}^* \text{high}} \\ & \text{sch} 0 * 0 + \beta_{\text{moderate exp}^* \text{high sch \& some post sec}} 0 * 1 \text{-----} (a) \end{aligned}$$

Compute logit for high sch & some post sec education among low GFJ exposure

$$\begin{aligned} \text{Logit} (< \text{high sch edu}=0, \text{high sch \& some post sec}=1, \text{high exposure}=0, \text{moderate} \\ \text{exposure}=0) = & \beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} >3\text{food-based} \\ & \text{programs} + \beta_{1-2 \text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} \\ & * 0 + \beta_{\text{high sch \& post sec}} * 1 + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd} \\ & \text{cond} + \beta_{\text{male}} \text{male} + \beta_{\text{high exp}^* \text{high sch}} 0 * 0 + \beta_{\text{high exp}^* \text{high sch \& some post sec}} 0 * 1 + \beta_{\text{moderate exp}^* \text{high}} \\ & \text{sch} 0 * 0 + \beta_{\text{moderate exp}^* \text{high sch \& some post sec}} 0 * 1 \text{-----} (b) \end{aligned}$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch \& some post sec}} = -.228 + 2.232 = 2.004$$

$$\text{OR for high sch \& some post sec education and high GFJ exp} = e^{2.004} = 7.42$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch \& some post sec}}) = \text{var} (\beta_{\text{high exp}}) + \text{var} (\beta_{\text{high exp}^* \text{high sch \& some post sec}}) \\ + 2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp}^* \text{high sch \& some post sec}})$$

$$\text{var} (\beta_{\text{high exp}}) = \{\text{SE} (\beta_{\text{high exp}})\}^2 = (.4782)^2 = 0.2286$$

$$\text{var} (\beta_{\text{high exp}^* \text{high sch \& some post sec}}) = \{\text{SE} (\beta_{\text{high exp}^* \text{high sch \& some post sec}})\}^2 = (.8490)^2 = 0.7208$$

$$2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp}^* \text{high sch \& some post sec}}) = 2 (-0.21566) = -0.4313$$

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch \& some post sec}}) = 0.2286 + 0.7208 - 0.4313 = 0.518$$

$$\text{SE} (\beta_{\text{high exp}} + \beta_{\text{high exp}^* \text{high sch \& some post sec}}) = \sqrt{0.518} = 0.7197$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE}(\beta)} = e^{2.004 \pm 1.96 * (0.7197)}$$

$$\text{Upper limit} = e^{2.004 + 1.41} = e^{3.414} = 30.39$$

$$\text{Lower limit} = e^{2.004 - 1.41} = e^{0.594} = 1.81$$

3.

Compute logit for < high sch education and moderate GFJ exposure

$$\text{Logit (< high sch edu}=1, \text{ high sch \& some post sec}=0, \text{ high exposure}=0, \text{ moderate exposure}=1) = \beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 1 + \beta_{>3\text{food-based programs}} * 3 + \beta_{1-2\text{food-based programs}} * 2 + \beta_{\text{low income}} * 1 + \beta_{<\text{high sch}} * 1 + \beta_{\text{high sch \& post sec}} * 0 + \beta_{\text{high nbhd cond}} * 1 + \beta_{\text{moderate nbhd cond}} * 0 + \beta_{\text{male}} * 1 + \beta_{\text{high exp} * <\text{high sch}} * 0 + \beta_{\text{high exp} * \text{high sch \& some post sec}} * 0 + \beta_{\text{moderate exp} * <\text{high sch}} * 1 + \beta_{\text{moderate exp} * \text{high sch \& some post sec}} * 0 \text{-----}(a)$$

Compute logit for < high sch education and low GFJ exposure

$$\text{Logit (< high sch edu}=1, \text{ high sch \& some post sec}=0, \text{ high exposure}=0, \text{ moderate exposure}=0) = \beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} * 3 + \beta_{1-2\text{food-based programs}} * 2 + \beta_{\text{low income}} * 1 + \beta_{<\text{high sch}} * 1 + \beta_{\text{high sch \& post sec}} * 0 + \beta_{\text{high nbhd cond}} * 1 + \beta_{\text{moderate nbhd cond}} * 0 + \beta_{\text{male}} * 1 + \beta_{\text{high exp} * <\text{high sch}} * 0 + \beta_{\text{high exp} * \text{high sch \& some post sec}} * 0 + \beta_{\text{moderate exp} * <\text{high sch}} * 0 + \beta_{\text{moderate exp} * \text{high sch \& some post sec}} * 0 \text{-----}(b)$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * <\text{high sch}} = -.297 + .357 = 0.06$$

$$\text{OR for <high sch education and moderate GFJ exp} = e^{0.06} = 1.06$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * <\text{high sch}}) = \text{var} (\beta_{\text{moderate exp}}) + \text{var} (\beta_{\text{moderate exp} * <\text{high sch}}) + 2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * <\text{high sch}})$$

$$\text{var} (\beta_{\text{moderate exp}}) = \{SE (\beta_{\text{moderate exp}})\}^2 = (.4622)^2 = 0.2136$$

$$\text{var} (\beta_{\text{moderate exp} * <\text{high sch}}) = \{SE (\beta_{\text{moderate exp} * <\text{high sch}})\}^2 = (1.0198)^2 = 1.0399$$

$$2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * <\text{high sch}}) = 2(-0.20102) = -0.402$$

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * <\text{high sch}}) = 0.2136 + 1.0399 - 0.402 = 0.852$$

$$SE (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * <\text{high sch}}) = \sqrt{0.852} = 0.923$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * SE (\beta)} = e^{0.06 \pm 1.96 * (0.923)}$$

$$\text{Upper limit} = e^{0.06 + 1.809} = e^{1.869} = 6.48$$

$$\text{Lower limit} = e^{0.06 - 1.809} = e^{-1.749} = 0.17$$

4.

Compute logit for high sch& some post sec education among moderate GFJ exposure

$$\text{Logit (< high sch edu}=0, \text{ high sch \& some post sec}=1, \text{ high exposure}=0, \text{ moderate exposure}=1) = \beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 1 + \beta_{>3\text{food-based programs}} * 3 + \beta_{1-2\text{food-based programs}} * 2 + \beta_{\text{low income}} * 1 + \beta_{<\text{high sch}} * 0 + \beta_{\text{high sch \& post sec}} * 1 + \beta_{\text{high nbhd cond}} * 1 + \beta_{\text{moderate nbhd cond}} * 0$$

$$\text{cond} + \beta_{\text{male}} \text{ male} + \beta_{\text{high exp} < \text{high sch}} 0 * 0 + \beta_{\text{high exp} * \text{high sch} \& \text{ some post sec}} 0 * 1 + \beta_{\text{moderate exp} < \text{high sch}} 1 * 0 + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}} 1 * 1 \text{-----} (a)$$

Compute logit for high sch& some post sec education among low GFJ exposure

$$\text{Logit} (< \text{high sch edu}=0, \text{high sch} \& \text{ some post sec}=1, \text{high exposure}=0, \text{moderate exposure}=0) = \beta_0 + \beta_{\text{high exp}} * 0 + \beta_{\text{moderate exp}} * 0 + \beta_{>3\text{food-based programs}} >3\text{food-based programs} + \beta_{1-2\text{ food-based programs}} 1-2\text{food-based programs} + \beta_{\text{low income}} \text{low income} + \beta_{<\text{high sch}} * 0 + \beta_{\text{high sch} \& \text{ post sec}} * 1 + \beta_{\text{high nbhd cond}} \text{high nbhd cond} + \beta_{\text{moderate nbhd cond}} \text{moderate nbhd cond} + \beta_{\text{male}} \text{ male} + \beta_{\text{high exp} < \text{high sch}} 0 * 0 + \beta_{\text{high exp} * \text{high sch} \& \text{ some post sec}} 0 * 1 + \beta_{\text{moderate exp} < \text{high sch}} 0 * 0 + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}} 0 * 1 \text{-----} (b)$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}} = -.297 + 2.227 = 1.93$$

$$\text{OR for high sch} \& \text{ some post sec education and moderate GFJ exp} = e^{1.93} = 6.89$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) = \text{var} (\beta_{\text{moderate exp}}) + \text{var} (\beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) + 2\text{COV} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}})$$

$$\text{var} (\beta_{\text{moderate exp}}) = \{SE (\beta_{\text{moderate exp}})\}^2 = (.4622)^2 = 0.2136$$

$$\text{var} (\beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) = \{SE (\beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}})\}^2 = (.8765)^2 = 0.768$$

$$2\text{COV} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) = 2(-0.20668) = -0.4133$$

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) = 0.2136 + 0.768 - 0.4133 = 0.568$$

$$SE (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * \text{high sch} \& \text{ some post sec}}) = \sqrt{0.568} = 0.754$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * SE (\beta)} = e^{1.93 \pm 1.96 * (0.754)}$$

$$\text{Upper limit} = e^{1.93 + 1.477} = e^{3.407} = 30.17$$

$$\text{Lower limit} = e^{1.93 - 1.477} = e^{0.453} = 1.57$$

5.

OR for high GFJ exposure among university level educated = 0.8

CI of OR = 0.31, 2.03

6.

OR for moderate GFJ exposure among university level educated = 0.74

CI of OR = 0.30, 1.83

Effect	Among	OR	95% CI of OR
High exposure	< high sch	1.81	0.42, 7.74



High exposure	High scl &some post sec	7.42	1.81, 30.39
High exposure	university	0.8	0.31, 2.0
Moderate exposure	< high sch	1.06	0.17, 6.48
Moderate exposure	High scl &some post sec	6.89	1.57, 30.17
Moderate exposure	university	0.74	0.30, 1.83

SAS output for the food security final model showing the ORs and their 95% CI of interaction terms involved in GFJ exposure\* education interaction

Differences of GFJ_exposure*edu Least Squares Means											
GFJ_expo:edu	GFJ_expo:edu	GFJ_expo:edu	GFJ_expo:edu	Estimate	exp(estim	Pr >  z	Alpha	Lower	exp(lower	Upper	exp(upper
1	1	1	2	-0.1326	0.875815	0.7594	0.05	-0.9812	0.374861	0.716	2.046232
1	1	1	3	-1.2479	0.287107	0.0177	0.05	-2.2793	0.102356	-0.2165	0.805333
1	1	2	1	0.5316	1.701653	0.5278	0.05	-1.1186	0.326737	2.1817	8.861358
1	1	2	2	-0.05769	0.943943	0.9004	0.05	-0.9609	0.382548	0.8455	2.329142
1	1	2	3	-1.1781	0.307863	0.022	0.05	-2.1859	0.112377	-0.1702	0.843496
1	1	3	1	0.5915	1.806696	0.4258	0.05	-0.8642	0.421389	2.0471	7.745407
1	1	3	2	1.8723	6.503237	0.0196	0.05	0.2995	1.349184	3.4451	31.34642
1	1	3	3	-1.4754	0.228687	0.0209	0.05	-2.7279	0.065356	-0.223	0.800115
1	2	1	3	-1.1153	0.327817	0.0045	0.05	-1.885	0.151829	-0.3456	0.707796
1	2	2	1	0.6642	1.942936	0.3996	0.05	-0.8813	0.414244	2.2097	9.112982
1	2	2	2	0.07494	1.077819	0.799	0.05	-0.502	0.605319	0.6519	1.919184
1	2	2	3	-1.0454	0.351551	0.0036	0.05	-1.7484	0.174052	-0.3425	0.709993
1	2	3	1	0.7241	2.062874	0.3314	0.05	-0.7371	0.4785	2.1853	8.893316
1	2	3	2	2.0049	7.425351	0.0054	0.05	0.5939	1.811038	3.4158	30.44129
1	2	3	3	-1.3428	0.261114	0.0111	0.05	-2.3786	0.09268	-0.307	0.735651
1	3	2	1	1.7795	5.926892	0.0363	0.05	0.1131	1.119744	3.4459	31.37151
1	3	2	2	1.1902	3.287739	0.006	0.05	0.3418	1.407479	2.0387	7.680618
1	3	2	3	0.06986	1.072358	0.8011	0.05	-0.4737	0.622694	0.6135	1.846884
1	3	3	1	1.8394	6.292761	0.0246	0.05	0.2356	1.265668	3.4432	31.28692
1	3	3	2	3.1202	22.65091	<.0001	0.05	1.5633	4.774551	4.6771	107.458
1	3	3	3	-0.2275	0.796522	0.6342	0.05	-1.1648	0.311985	0.7098	2.033585
2	1	2	2	-0.5892	0.554771	0.4662	0.05	-2.1742	0.113699	0.9957	2.706618
2	1	2	3	-1.7096	0.180938	0.0414	0.05	-3.3525	0.034997	-0.06681	0.935373
2	1	3	1	0.05991	1.061741	0.9482	0.05	-1.7487	0.174	1.8686	6.479219
2	1	3	2	1.3407	3.821718	0.2024	0.05	-0.7207	0.486412	3.4021	30.02709
2	1	3	3	-2.007	0.134391	0.0277	0.05	-3.7943	0.022499	-0.2197	0.80276
2	2	2	3	-1.1204	0.326149	0.0056	0.05	-1.9134	0.147578	-0.3274	0.720795
2	2	3	1	0.6492	1.914009	0.4039	0.05	-0.8753	0.416737	2.1736	8.789871
2	2	3	2	1.93	6.88951	0.0105	0.05	0.4522	1.571766	3.4077	30.19571
2	2	3	3	-1.4178	0.242246	0.0091	0.05	-2.4832	0.083476	-0.3523	0.703069
2	3	3	1	1.7695	5.867919	0.0285	0.05	0.1859	1.204302	3.3531	28.59123
2	3	3	2	3.0503	21.12168	<.0001	0.05	1.517	4.558529	4.5837	97.87587
2	3	3	3	-0.2974	0.742747	0.5199	0.05	-1.2032	0.300232	0.6084	1.837489
3	1	3	2	1.2808	3.599518	0.1984	0.05	-0.6711	0.511146	3.2327	25.348
3	1	3	3	-2.0669	0.126578	0.0175	0.05	-3.7719	0.023008	-0.3619	0.696352
3	2	3	3	-3.3477	0.035165	<.0001	0.05	-5.0223	0.006589	-1.6731	0.187664

## 2. General health

### Univariate results summary

<b>General health: 2 categories; 1=good to excellent  indicator &amp; 0=fair to poor  reference</b>					
Variable	Reference category	Odds ratio/ Exp( $\beta$ )	95% CI for OR		p-value
			Lower	Upper	
Exposure level to GFJ (3 levels)	low				
• High		0.920	0.550	1.536	0.749
• Moderate		0.993	0.573	1.721	0.980
Senior	Not senior	0.634	0.297	1.354	0.239
Low income	High	0.317	0.168	0.598	0.000
Education	University				
• Less than high sch		0.005	0.107	0.670	0.005
• High sch & some post second		0.047	0.206	0.990	0.047
Male	Female	1.284	0.714	2.312	0.404
Aboriginal identity	Non-Aboriginal	0.689	0.367	1.293	0.246
Daily stress	Not stressful	0.753	0.502	1.129	0.170
Physical activity	Low	1.028	0.685	1.543	0.895
Pre-existing chronic conditions	Never	0.398	0.229	0.693	0.001
Believe in changing health behaviour	Low	1.084	0.768	1.530	0.646
How long lived in the neighbourhood	<5 years	0.848	0.550	1.307	0.455
Social connectedness (tertiles)	Low				
• High		1.560	0.930	2.615	0.092
• Moderate		1.268	0.815	1.973	0.293
GFJ primary grocery store	No	0.713	0.460	1.104	0.130
Other food programs	None				
• >3		1.127	0.494	2.574	0.776
• 1-2		1.015	0.498	2.071	0.967

The final model for general health;

#### Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	3.274	.4951	2.304	4.245	43.746	1	.000	26.430	10.016	69.743
[High exposure=3.00]	-.196	.3313	-.846	.453	.351	1	.553	.822	.429	1.573
[Moderate exposure=2.00]	-.156	.3238	-.791	.479	.232	1	.630	.856	.454	1.614

[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[less than high school=3.00]	-1.149	.4961	-2.122	-.177	5.369	1	.021	.317	.120	.838
[high sch& post second=2.00]	-.379	.4258	-1.213	.456	.792	1	.373	.685	.297	1.577
[university=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Low income=1.00]	-1.213	.3311	-1.862	-.564	13.428	1	.000	.297	.155	.569
[High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[pre-existing conditions=1.00]	-1.009	.3252	-1.647	-.372	9.627	1	.002	.365	.193	.690
[No pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[stressful=2.00]	-.520	.2691	-1.047	.008	3.733	1	.053	.595	.351	1.008
[Not stressful=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[senior=1.00]	-.797	.4641	-1.707	.112	2.950	1	.086	.451	.181	1.119
[Not senior=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: general\_health

Model: (Intercept), level\_of\_exposure, education, income, pre-existing\_conditions, daily\_stress, senior

a. Set to zero because this parameter is redundant.

### 3. Mental health

#### *Univariate results summary*

<b>Mental health: 2 categories; 1=good to excellent   indicator &amp; 0=fair to poor   reference</b>					
Variable	Reference category	Odds ratio/ Exp( $\beta$ )	95% CI for OR		p-value
			Lower	Upper	
Exposure level to GFJ (3 levels)	low	0.645	0.272	1.528	0.319
• High comp		0.680	0.315	1.465	0.325
• Moderate					
Senior	Not senior	0.756	0.275	2.080	0.589
Low income	High	0.375	0.135	1.044	0.060
Education	University				
• Less than high sch		0.621	0.206	1.874	0.398
• High sch & some post second		1.059	0.397	2.825	0.909
Male	Female	1.382	0.526	3.629	0.511
Aboriginal identity	Non-Aboriginal	1.079	0.525	2.218	0.835
Daily stress	Not stressful	0.397	0.208	0.756	0.005
Physical activity	Low	1.122	0.617	2.042	0.705
Pre-existing chronic conditions	Never	0.660	0.343	1.269	0.212
Believe in changing health behaviour	Low	0.986	0.541	1.797	0.963

How long lived in the neighbourhood	<5 years	1.303	0.579	2.930	0.522
Social connectedness (tertiles)	Low	1.234	0.615	2.478	0.554
		• High 1.399	• Moderate 0.768	2.548	0.273
GFJ primary grocery store	No	1.101	0.482	2.515	0.819
Other food programs	None	• >3 0.827	• 1-2 0.308	2.219	0.706
		0.714	0.282	1.810	0.478

The final model for mental health;

**Parameter Estimates**

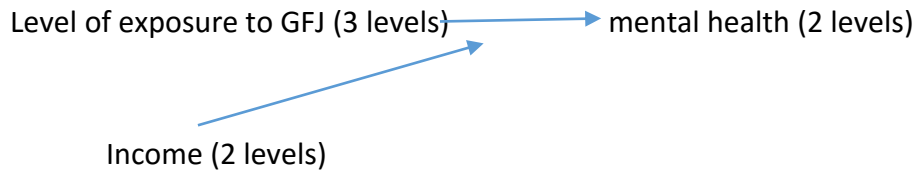
Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	2.833	.8925	1.083	4.582	10.074	1	.002	16.991	2.955	97.705
[High exposure=3.00]	1.039	.9703	-.863	2.940	1.146	1	.284	2.825	.422	18.924
[Moderate exposure=2.00]	-.144	.6273	-1.373	1.086	.052	1	.819	.866	.253	2.962
[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Low income=1.00]	.626	1.0371	-1.406	2.659	.365	1	.546	1.871	.245	14.281
[High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Stressful=2.00]	-1.128	.3456	-1.805	-.451	10.657	1	.001	.324	.164	.637
[Not stressful=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[high exposure=3.00] * [Low income=1.00]	-2.483	1.1689	-4.774	-.192	4.512	1	.034	.083	.008	.825
[high exposure=3.00] * [High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[moderate exposure=2.00] * [Low income=1.00]	-1.071	.9429	-2.919	.777	1.289	1	.256	.343	.054	2.176
[moderate exposure=2.00] * [High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [Low income=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: mental\_health

Model: (Intercept), level\_of\_exposure, income, daily\_stress, level\_of\_exposure \* income

a. Set to zero because this parameter is redundant.

## Hand calculation of estimates of ORs & 95% CIs of interacting variables in mental health model



Predicted logit form of model

Logit =  $\beta_0 + \beta_{\text{high exp}} \text{high exp} + \beta_{\text{moderate exp}} \text{moderate exp} + \beta_{\text{low income}} \text{low income} + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} \text{high exp*low income} + \beta_{\text{moderate exp*low income}} \text{moderate exp*low income}$

1.

OR for moderate GFJ exposure in low income group

Logit (high exp=0, moderate exp=1, low income=1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{low income}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0*1 + \beta_{\text{moderate exp*low income}} 1*1$ ----- (a)

Logit (high exp=0, moderate exp=0, low income=1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0*1 + \beta_{\text{moderate exp*low income}} 0*0$ ----- (b)

Logit difference = (a) - (b) =  $\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*low income}} = -.144 - 1.071 = -1.215$

OR for moderate exposure in low income =  $e^{-1.215} = 0.297$

Calculation of the 95% CI of the OR

$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*low income}}) = \text{var} (\beta_{\text{moderate exp}}) + \text{var} (\beta_{\text{moderate exp*low income}}) + 2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp*low income}})$

$\text{var} (\beta_{\text{moderate exp}}) = \{SE (\beta_{\text{moderate exp}})\}^2 = (.6273)^2 = 0.394$

$\text{var} (\beta_{\text{moderate exp*low income}}) = \{SE (\beta_{\text{moderate exp*low income}})\}^2 = \{.9429\}^2 = 0.889$

$2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp*low income}}) = 2(-0.37083) = -0.742$

$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{Moderate exp*low income}}) = 0.394 + 0.889 - 0.742 = 0.541$

$SE (\beta_{\text{low income}} + \beta_{\text{high exp*low income}}) = \sqrt{0.541} = 0.736$

95% CI of OR =  $e^{\beta \pm 1.96 * SE (\beta)} = e^{-1.215 \pm 1.96 * (0.736)}$

Upper limit =  $e^{-1.215 + 1.443} = e^{0.228} = 1.26$

Lower limit =  $e^{-1.215 - 1.443} = e^{-2.658} = 0.07$

2.

OR for high GFJ exposure in low income group

$$\text{Logit (high exp=1, moderate exp=0, low income=1)} = \beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 1*1 + \beta_{\text{moderate exp*low income}} 0*1 \text{----- (a)}$$

$$\text{Logit (high exp=0, moderate exp=0, low income=1)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0*1 + \beta_{\text{moderate exp*low income}} 0*0 \text{----- (b)}$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{high exp}} + \beta_{\text{high exp*low income}} = 1.039 + -2.483 = -1.444$$

$$\text{OR for high exposure in low income} = e^{-1.444} = 0.236$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*low income}}) = \text{var} (\beta_{\text{high exp}}) + \text{var} (\beta_{\text{high exp*low income}}) + 2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*low income}})$$

$$\text{var} (\beta_{\text{high exp}}) = \{SE (\beta_{\text{high exp}})\}^2 = (.9703)^2 = 0.941$$

$$\text{var} (\beta_{\text{high exp*low income}}) = \{SE (\beta_{\text{high exp*low income}})\}^2 = \{1.1689\}^2 = 1.366$$

$$2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*low income}}) = 2(-0.93839) = -1.876$$

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*low income}}) = 0.941 + 1.366 - 1.876 = 0.431$$

$$SE (\beta_{\text{high exp}} + \beta_{\text{high exp*low income}}) = \sqrt{0.431} = 0.656$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * SE (\beta)} = e^{-1.444 \pm 1.96 * (0.656)}$$

$$\text{Upper limit} = e^{-1.444 + 1.285} = e^{-0.158} = 0.85$$

$$\text{Lower limit} = e^{-1.444 - 1.285} = e^{-2.729} = 0.07$$

3.

OR for moderate GFJ exposure in high income group

$$\text{Logit (high exp=0, moderate exp=1, low income=0)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{low income}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0*0 + \beta_{\text{moderate exp*low income}} 1*0 \text{----- (a)}$$

$$\text{Logit (high exp=0, moderate exp=0, low income=0)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0*0 + \beta_{\text{moderate exp*low income}} 0*0 \text{----- (b)}$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{moderate exp}} = -.144$$

$$\text{OR for moderate exposure in high income} = e^{-0.144} = 0.87$$

Calculation of the 95% CI of the OR

$$SE (\beta_{\text{moderate exp}}) = .6273$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * SE (\beta)} = e^{-0.144 \pm 1.96 * (0.6273)}$$

$$\text{Upper limit} = e^{-0.144 + 1.229} = e^{1.085} = 2.96$$

$$\text{Lower limit} = e^{-0.144 - 1.229} = e^{-1.373} = 0.25$$

4.

OR for high GFJ exposure in high income group

$$\text{Logit (high exp=1, moderate exp=0, low income=0)} = \beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 1 * 0 + \beta_{\text{moderate exp*low income}} 0 * 0 \text{----- (a)}$$

$$\text{Logit (high exp=0, moderate exp=0, low income=0)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{low income}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{high exp*low income}} 0 * 0 + \beta_{\text{moderate exp*low income}} 0 * 0 \text{----- (b)}$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{high exp}} = 1.039$$

$$\text{OR for high exposure in high income} = e^{1.039} = 2.83$$

Calculation of the 95% CI of the OR

$$\text{SE } (\beta_{\text{high exp}}) = 0.9703$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE } (\beta)} = e^{1.039 \pm 1.96 * (0.9703)}$$

$$\text{Upper limit} = e^{1.039 + 1.902} = e^{2.941} = 18.93$$

$$\text{Lower limit} = e^{1.039 - 1.902} = e^{-0.863} = 0.42$$

Effect	Among	OR	95% CI
High exposure	High income	2.83	0.42, 18.93
Moderate exposure	High income	0.87	0.25, 2.96
High exposure	Low income	0.24	0.07, 0.85
Moderate exposure	Low income	0.3	0.07, 1.26

SAS output for mental health final model showing the ORs and their 95% CI of interaction terms involved in GFJ exposure\*income interaction

Differences of GFJ_exposure*income Least Squares Means													
GFJ_expo:	income	GFJ_expo:	income	Estimate	exp(estim	Standard	tz Value	Pr >  z	Alpha	Lower	exp(low)	Upper	exp(upper
1	0	1	1	-1.8566	0.156203	0.6736	-2.76	0.0058	0.05	-3.1769	0.041715	-0.5363	0.584908
1	0	2	0	-0.2301	0.794454	0.474	-0.49	0.6273	0.05	-1.1591	0.313768	0.6989	2.011539
1	0	2	1	-0.6743	0.509513	0.6602	-1.02	0.307	0.05	-1.9682	0.139708	0.6196	1.858185
1	0	3	0	-1.4443	0.235911	0.6566	-2.2	0.0278	0.05	-2.7311	0.065148	-0.1575	0.854277
1	0	3	1	-0.818	0.441313	0.8867	-0.92	0.3563	0.05	-2.5558	0.07763	0.9199	2.509039
1	1	2	0	1.6265	5.086042	0.757	2.15	0.0317	0.05	0.1429	1.153614	3.1102	22.42553
1	1	2	1	1.1823	3.261868	0.797	1.48	0.138	0.05	-0.3798	0.683998	2.7444	15.55528
1	1	3	0	0.4123	1.510287	0.8657	0.48	0.6338	0.05	-1.2843	0.276844	2.109	8.239997
1	1	3	1	1.0387	2.825541	0.9703	1.07	0.2844	0.05	-0.8631	0.421852	2.9405	18.92531
2	0	2	1	-0.4442	0.641337	0.7455	-0.6	0.5513	0.05	-1.9054	0.148763	1.017	2.764888
2	0	3	0	-1.2142	0.296947	0.7354	-1.65	0.0987	0.05	-2.6556	0.070257	0.2272	1.255081
2	0	3	1	-0.5879	0.555493	0.9426	-0.62	0.5329	0.05	-2.4354	0.087563	1.2596	3.524012
2	1	3	0	-0.77	0.463013	0.8878	-0.87	0.3858	0.05	-2.5099	0.081276	0.97	2.637944
2	1	3	1	-0.1436	0.866234	0.6273	-0.23	0.8189	0.05	-1.3731	0.25332	1.0858	2.961808
3	0	3	1	0.6263	1.870676	1.0371	0.6	0.5459	0.05	-1.4063	0.245048	2.659	14.282

4. Health compared to 1 year ago

*Univariate results summary*

<b>Health compared to 1 year ago 2 categories; 1=good to excellent  indicator &amp; 0=fair to poor  reference</b>					
Variable	Reference category	Odds ratio/ Exp( $\beta$ )	95% CI for OR		p-value
			Lower	Upper	
Exposure level to GFJ	low				
• High		1.349	0.640	2.844	0.432
• Moderate		1.711	0.668	4.380	0.263
Senior	Not senior	0.556	0.237	1.304	0.177
Low income	High	0.325	0.147	0.719	0.005
Education	University				
• Less than high sch		0.615	0.229	1.653	0.335
• High sch & some post second		0.503	0.210	1.207	0.124
Male	Female	2.365	1.031	5.426	0.042
Aboriginal identity	Non-Aboriginal	0.617	0.335	1.137	0.122
Daily stress	Not stressful	0.448	0.250	0.805	0.007
Physical activity	Low	0.928	0.543	1.586	0.784
Pre-existing chronic conditions	Never	0.513	0.275	0.959	0.037
Believe in changing health behaviour	Low	0.977	0.564	1.693	0.933
How long lived in the neighbourhood	<5 years	1.011	0.551	1.855	0.972
Social connectedness	Low				
• High		2.178	1.022	4.643	0.044
• Moderate		1.412	0.688	2.898	0.348
GFJ primary grocery store	No	1.281	0.632	2.595	0.492
Other food programs	None				
• >3		0.682	0.216	2.155	0.514
• 1-2		0.918	0.320	2.639	0.874

The final model for health compared to one year ago;

**Parameter Estimates**

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper



(Intercept)	3.172	.5027	2.187	4.157	39.820	1	.000	23.859	8.908	63.906
[High exposure=3.00]	.206	.4023	-.583	.994	.262	1	.609	1.229	.558	2.703
[Moderate exposure=2.00]	.339	.5423	-.724	1.401	.390	1	.533	1.403	.485	4.061
[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Low income=1.00]	-1.132	.3977	-1.912	-.353	8.102	1	.004	.322	.148	.703
[High income=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Stressful=2.00]	-.875	.3552	-1.572	-.179	6.076	1	.014	.417	.208	.836
[Not stressful=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[pre-existing conditions=1.00]	-.922	.3392	-1.587	-.257	7.384	1	.007	.398	.205	.773
[No pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: comp\_health

Model: (Intercept), level\_of\_exposure, income, daily\_stress, preexisting\_conditions

a. Set to zero because this parameter is redundant.

## 5. BMI

### *Univariate results summary*

<b>BMI: 2 categories;</b>					
<b>1=underweight/ normal weight   indicator &amp;</b>					
<b>0=overweight/ obese   reference</b>					
Variable	Reference category	Odds ratio/ Exp( $\beta$ )	95% CI for OR		p-value
			Lower	Upper	
Exposure level to GFJ	low				
• High		0.838	0.549	1.280	0.414
• Moderate		0.736	0.451	1.200	0.219
Senior	Not senior	0.840	0.463	1.525	0.567
Low income	High	0.878	0.642	1.199	0.412
Education	University				
• Less than high sch		0.876	0.445	1.724	0.701
• High sch & some post second		0.934	0.679	1.285	0.675
Male	Female	0.879	0.565	1.368	0.569
Aboriginal identity	Non-Aboriginal	0.939	0.580	1.520	0.797
Daily stress	Not stressful	0.852	0.607	1.197	0.357
Physical activity	Low	1.095	0.877	1.368	0.421
Pre-existing chronic conditions	Never	0.642	0.452	0.910	0.013
Believe in changing health behaviour	Low	0.756	0.591	0.968	0.027
How long lived in the neighbourhood	<5 years	0.846	0.674	1.062	0.149
Social connectedness	Low				
• High		1.004	0.753	1.339	0.980

• Moderate		0.913	0.707	1.179	0.486
GFJ primary grocery store	No	1.110	0.897	1.374	0.337
Other food programs	None				
• >3		1.089	0.615	1.927	0.770
• 1-2		1.065	0.584	1.942	0.837

The final model for BMI;

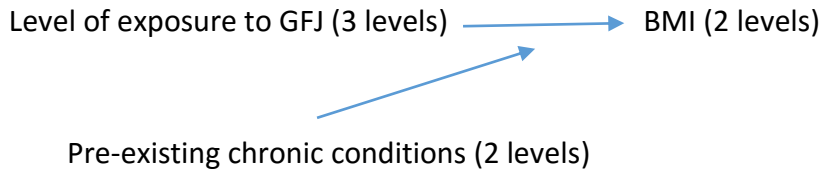
Parameter Estimates										
Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
			(Intercept)	.236	.3023	-.356	.829		.610	1
[High exposure=3.00]	-.438	.2977	-1.022	.145	2.167	1	.141	.645	.360	1.156
[Moderate exposure=2.00]	-.531	.3620	-1.240	.179	2.150	1	.143	.588	.289	1.196
[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[pre-existing conditions=1.00]	-.927	.3282	-1.571	-.284	7.982	1	.005	.396	.208	.753
[No pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[high believes in changing health behaviour=2.00]	-.258	.1249	-.503	-.014	4.278	1	.039	.772	.605	.987
[low believes changing health behaviour=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[lived in neighbourhood 6 years or more=2.00]	-.254	.1309	-.510	.003	3.758	1	.053	.776	.600	1.003
[lived in neighbourhood 5 years or less=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[high exposure=3.00] * [pre-existing conditions=1.00]	.741	.3354	.083	1.398	4.876	1	.027	2.097	1.087	4.047
[high exposure=3.00] * [no pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[moderate exposure=2.00] * [pre-existing conditions=1.00]	.610	.3862	-.147	1.366	2.492	1	.114	1.840	.863	3.921
[moderate exposure=2.00] * [no pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [pre-existing conditions=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low exposure=1.00] * [no pre-existing conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: bmi

Model: (Intercept), level\_of\_exposure, preexisting\_conditions, believes\_changing\_health\_behaviour, neighbourhood\_long\_lived, level\_of\_exposure \* preexisting\_conditions

a. Set to zero because this parameter is redundant.

### Hand calculation of estimates of ORs & 95% CIs of interacting variables in BMI model



Predicted logit form of model

Logit =  $\beta_0 + \beta_{\text{high exp}} \text{high exp} + \beta_{\text{moderate exp}} \text{moderate exp} + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{pre-existing conditions}} \text{pre-existing conditions} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{high exp*pre-existing conditions}} \text{high exp*pre-existing conditions} + \beta_{\text{moderate exp*pre-existing conditions}} \text{moderate exp*pre-existing conditions}$

1.

OR for moderate GFJ exposure in ever having pre-existing conditions group

Logit (high exp=0, moderate exp=1, pre-existing conditions=1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{pre-existing conditions}} 1 + \beta_{\text{high exp*pre-existing conditions}} 0 + \beta_{\text{moderate exp*pre-existing conditions}} 1$ -----  
(a)

Logit (high exp=0, moderate exp=0, pre-existing conditions =1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{pre-existing conditions}} 1 + \beta_{\text{high exp*pre-existing conditions}} 0 + \beta_{\text{moderate exp*pre-existing conditions}} 0$ -----  
(a)

Logit difference= (a) - (b) =  $\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*pre-existing conditions}} = -.531 + .610 = 0.079$

OR for moderate exposure in ever having pre-existing conditions =  $e^{0.079} = 1.08$

Calculation of the 95% CI of the OR

$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*pre-existing conditions}}) = \text{var} (\beta_{\text{moderate exp}}) + \text{var} (\beta_{\text{moderate exp*pre-existing conditions}}) + 2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp*pre-existing conditions}})$

$\text{var} (\beta_{\text{moderate exp}}) = \{SE (\beta_{\text{moderate exp}})\}^2 = (.3620)^2 = 0.131$

$\text{var} (\beta_{\text{moderate exp*pre-existing conditions}}) = \{SE (\beta_{\text{moderate exp*pre-existing conditions}})\}^2 = \{.3862\}^2 = 0.149$

$2\text{cov} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp*pre-existing conditions}}) = 2(-0.13093) = -0.262$

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*pre-existing conditions}}) = 0.131 + 0.149 - 0.262 = 0.018$$

$$\text{SE} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp*pre-existing conditions}}) = \sqrt{0.018} = 0.134$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE} (\beta)} = e^{0.079 \pm 1.96 * (0.134)}$$

$$\text{Upper limit} = e^{0.079 + 0.2626} = e^{0.3416} = 1.41$$

$$\text{Lower limit} = e^{0.079 - 0.2626} = e^{-0.1836} = 0.83$$

2.

OR for high GFJ exposure in ever having pre-existing conditions group

$$\text{Logit (high exp=1, moderate exp=0, pre-existing conditions=1)} = \beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{pre-existing conditions}} * 1 + \beta_{\text{high exp*pre-existing conditions}} 1 * 1 + \beta_{\text{moderate exp*pre-existing conditions}} 0 * 1 \text{-----}$$

(a)

$$\text{Logit (high exp=0, moderate exp=0, pre-existing conditions =1)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{pre-existing conditions}} * 1 + \beta_{\text{high exp*pre-existing conditions}} 0 * 1 + \beta_{\text{moderate exp*pre-existing conditions}} 0 * 1 \text{-----}$$

(a)

$$\text{Logit difference} = (a) - (b) = \beta_{\text{high exp}} + \beta_{\text{high exp*pre-existing conditions}} = -.438 + .741 = 0.303$$

$$\text{OR for high exposure in ever having pre-existing conditions} = e^{0.303} = 1.35$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*pre-existing conditions}}) = \text{var} (\beta_{\text{high exp}}) + \text{var} (\beta_{\text{high exp*pre-existing conditions}}) + 2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*pre-existing conditions}})$$

$$\text{var} (\beta_{\text{high exp}}) = \{\text{SE} (\beta_{\text{high exp}})\}^2 = (.2977)^2 = 0.088$$

$$\text{var} (\beta_{\text{high exp*pre-existing conditions}}) = \{\text{SE} (\beta_{\text{high exp*pre-existing conditions}})\}^2 = \{.3354\}^2 = 0.112$$

$$2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*pre-existing conditions}}) = 2(-0.08634) = -0.172$$

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*pre-existing conditions}}) = 0.088 + 0.112 - 0.172 = 0.028$$

$$\text{SE} (\beta_{\text{high exp}} + \beta_{\text{high exp*pre-existing conditions}}) = \sqrt{0.028} = 0.167$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE} (\beta)} = e^{0.303 \pm 1.96 * (0.167)}$$

$$\text{Upper limit} = e^{0.303 + 0.327} = e^{0.63} = 1.87$$

$$\text{Lower limit} = e^{0.303 - 0.327} = e^{-0.024} = 0.98$$

3.

OR for moderate GFJ exposure in never having pre-existing conditions group

$$\text{Logit (high exp=0, moderate exp=1, pre-existing conditions=0)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{higher health believe}} \text{higher health believe} + \beta_{\text{nbhd long lived}} \text{nbhd long lived} + \beta_{\text{pre-existing conditions}} * 0$$

Logit (high exp=0, moderate exp=0, pre-existing conditions =0)  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{pre-existing conditions}}$  (a)

Logit (high exp=1, moderate exp=0, pre-existing conditions =0)  $\beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{pre-existing conditions}}$  (b)

Logit difference = (a) - (b) =  $\beta_{\text{moderate exp}} = -.531$

OR for moderate exposure in never having pre-existing conditions =  $e^{-0.531} = 0.59$

Calculation of the 95% CI of the OR

SE ( $\beta_{\text{moderate exp}}$ ) = .3620

95% CI of OR =  $e^{\beta \pm 1.96 \cdot SE(\beta)} = e^{-0.531 \pm 1.96 \cdot (0.3620)}$

Upper limit =  $e^{-0.531 + 0.709} = e^{0.178} = 1.19$

Lower limit =  $e^{-0.531 - 0.709} = e^{-1.24} = 0.29$

#### 4.

OR for high GFJ exposure in never having pre-existing conditions group

Logit (high exp=1, moderate exp=0, pre-existing conditions=0)  $\beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{pre-existing conditions}}$  (a)

Logit (high exp=0, moderate exp=0, pre-existing conditions =0)  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{pre-existing conditions}}$  (b)

Logit difference = (a) - (b) =  $\beta_{\text{high exp}} = -.438$

OR for high exposure in never having pre-existing conditions =  $e^{-0.438} = 0.65$

Calculation of the 95% CI of the OR

SE ( $\beta_{\text{high exp}}$ ) = .2977

95% CI of OR =  $e^{\beta \pm 1.96 \cdot SE(\beta)} = e^{-0.438 \pm 1.96 \cdot (0.298)}$

Upper limit =  $e^{-0.438 + 0.584} = e^{0.146} = 1.16$

Lower limit =  $e^{-0.438 - 0.584} = e^{-0.978} = 0.38$

Effect	Among	OR	95% CI
High exposure	Never had pre-existing conditions	0.65	0.38, 1.16

Moderate exposure	Never had pre-existing conditions	0.59	0.29, 1.19
High exposure	Ever had pre-existing conditions	1.35	0.98, 1.87
Moderate exposure	Ever had pre-existing conditions	1.08	0.83, 1.41

SAS output for BMI final model showing the ORs and their 95% CI of interaction terms involved in GFJ exposure\*pre-existing conditions interaction

Differences of GFJ_expos*chronic_co Least Squares Means													
GFJ_exp	chronic	GFJ_ex	chronic	Estimate	exp(estim	Standard	z Value	Pr >  z	Alpha	Lower	exp(low)	Upper	exp(upper
1	0	1	1	-0.1867	0.829693	0.1527	-1.22	0.2213	0.05	-0.486	0.615082	0.1125	1.119072
1	0	2	0	0.2237	1.250696	0.1141	1.96	0.0499	0.05	0.000146	1.000146	0.4472	1.563927
1	0	2	1	-0.09407	0.910219	0.2343	-0.4	0.688	0.05	-0.5532	0.575107	0.3651	1.440658
1	0	3	0	0.3024	1.353102	0.1686	1.79	0.0729	0.05	-0.0281	0.972291	0.633	1.883252
1	0	3	1	-0.6249	0.535315	0.3045	-2.05	0.0401	0.05	-1.2217	0.294729	-0.02819	0.972204
1	1	2	0	0.4104	1.507421	0.1743	2.35	0.0185	0.05	0.06884	1.071265	0.752	2.121238
1	1	2	1	0.09266	1.097089	0.2117	0.44	0.6616	0.05	-0.3223	0.724481	0.5076	1.661299
1	1	3	0	0.4892	1.631011	0.2071	2.36	0.0182	0.05	0.08326	1.086824	0.8951	2.447581
1	1	3	1	-0.4382	0.645197	0.2977	-1.47	0.141	0.05	-1.0216	0.360018	0.1452	1.156271
2	0	2	1	-0.3178	0.727748	0.2418	-1.31	0.1888	0.05	-0.7917	0.453074	0.1562	1.16906
2	0	3	0	0.07874	1.081923	0.1353	0.58	0.5607	0.05	-0.1865	0.829859	0.344	1.410579
2	0	3	1	-0.8486	0.428014	0.3085	-2.75	0.0059	0.05	-1.4533	0.233797	-0.2439	0.783566
2	1	3	0	0.3965	1.486612	0.267	1.48	0.1376	0.05	-0.1269	0.880822	0.9199	2.509039
2	1	3	1	-0.5309	0.588075	0.362	-1.47	0.1426	0.05	-1.2405	0.28924	0.1787	1.195662
3	0	3	1	-0.9274	0.395581	0.3282	-2.83	0.0047	0.05	-1.5707	0.2079	-0.284	0.752767

## Appendix 9: Model building results for research question 2

### 1. Household food security

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	.251	.5411	-.810	1.311	.214	1	.643	1.285	.445	3.711
[High exposure=3.00]	.555	.2813	.004	1.106	3.891	1	.049	1.742	1.004	3.023
[Moderate exposure=2.00]	.765	.3129	.152	1.378	5.979	1	.014	2.149	1.164	3.968
[Low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[>3 other food programs=3.00]	-.543	.4048	-1.336	.250	1.799	1	.180	.581	.263	1.285
[1-2 other food programs=2.00]	-.841	.4082	-1.641	-.041	4.244	1	.039	.431	.194	.960
[no other food programs=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[High neighbourhood connectedness=3.00]	.507	.2657	-.014	1.028	3.642	1	.056	1.660	.986	2.795
[Moderate neighbourhood connectedness=2.00]	.077	.2461	-.405	.560	.099	1	.753	1.080	.667	1.750
[Low neighbourhood connectedness=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Male=1]	.742	.3111	.132	1.351	5.684	1	.017	2.100	1.141	3.863
[Female=0]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[2-4 disadv conditions=1.00]	-.960	.2560	-1.461	-.458	14.055	1	.000	.383	.232	.633
[0-1 disadv conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: fs status binary

Model: (Intercept), level\_of\_exposure, other\_food\_programs, neighbourhood\_connectedness, gender, disadvantage\_category

a. Set to zero because this parameter is redundant.

### 2. General health

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	1.784	.3124	1.171	2.396	32.603	1	.000	5.952	3.227	10.979

[level_of_exposure=3.00]	-.060	.2817	-.612	.492	.046	1	.831	.942	.542	1.636
[level_of_exposure=2.00]	-.061	.3012	-.651	.529	.041	1	.840	.941	.521	1.698
[level_of_exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[daily_stress=2.00]	-.367	.2223	-.803	.068	2.732	1	.098	.693	.448	1.071
[daily_stress=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[preexisting_conditions=1.00]	-.947	.2843	-1.504	-.390	11.100	1	.001	.388	.222	.677
[preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[disadvantage_category=1.00]	-.445	.2761	-.986	.096	2.596	1	.107	.641	.373	1.101
[disadvantage_category=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: general\_health

Model: (Intercept), level\_of\_exposure, daily\_stress, preexisting\_conditions, disadvantage\_category

a. Set to zero because this parameter is redundant.

### 3. Mental health

#### Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			95% Wald Confidence Interval for Exp(B)		
			Lower	Upper	Wald Chi-Square	df	Sig.	Exp(B)	Lower	Upper
(Intercept)	2.359	.5372	1.306	3.412	19.286	1	.000	10.581	3.692	30.323
[high exposure=3.00]	.145	.5579	-.948	1.239	.068	1	.795	1.156	.387	3.451
[moderate exposure=2.00]	.121	.4482	-.757	1.000	.073	1	.787	1.129	.469	2.717
[low exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Stressful=2.00]	-.947	.3296	-1.593	-.301	8.255	1	.004	.388	.203	.740
[Not stressful=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[2-4 disadv conditions =1.00]	.960	.7854	-.579	2.499	1.495	1	.221	2.612	.560	12.176
[0-1 disadv categories =.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[high exposure=3.00] * [2-4 disadv conditions =1.00]	-1.303	.8667	-3.001	.396	2.259	1	.133	.272	.050	1.486
[high exposure=3.00] * [0-1 disadv categories =.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[Moderate exposure=2.00] * [2-4 disadv conditions=1.00]	-1.390	.8024	-2.963	.183	3.001	1	.083	.249	.052	1.200
[Moderate exposure=2.00] * [0-1 disadv categories =.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[low_exposure=1.00] * [2-4 disadv conditions =1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.



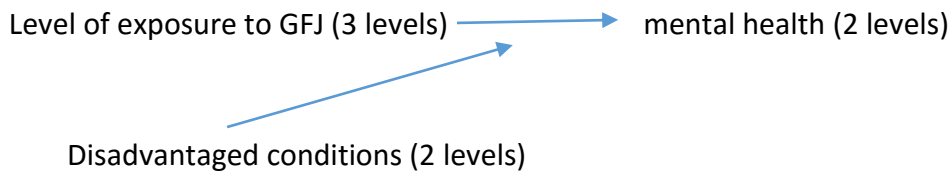
[Low exposure=1.00] * [0-1 disadv categories =.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: mental\_health

Model: (Intercept), level\_of\_exposure, daily\_stress, disadvantage\_category, level\_of\_exposure \* disadvantage\_category

a. Set to zero because this parameter is redundant.

### Hand calculation of estimates of ORs & 95% CIs of interacting variables in mental health model



#### Predicted logit form of model

Logit =  $\beta_0 + \beta_{\text{high exp}} \text{high exp} + \beta_{\text{moderate exp}} \text{moderate exp} + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} \text{2-4 disadv conditions} + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} \text{high exp} * 2-4 \text{ disadv conditions} + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} \text{moderate exp} * 2-4 \text{ disadv conditions}$

1.

#### OR for moderate GFJ exposure in 2-4 disadv group

Logit (high exp=0, moderate exp=1, 2-4 disadv conditions =1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} * 1 + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} 0 * 1 + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} 1 * 1$ ----- (a)

Logit (high exp=0, moderate exp=0, 2-4 disadv conditions =1) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} * 1 + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} 0 * 1 + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} 0 * 1$ ----- (a)

Logit difference= (a) - (b) =  $\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} = -0.121 - 1.390 = -1.511$

OR for moderate exposure in 2-4 disadv conditions =  $e^{-1.511} = 0.28$

#### Calculation of the 95% CI of the OR

$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}}) = \text{var} (\beta_{\text{moderate exp}}) + \text{var} (\beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}}) + 2\text{COV} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}})$

$\text{var} (\beta_{\text{moderate exp}}) = \{SE (\beta_{\text{moderate exp}})\}^2 = (.6273)^2 = 0.394$

$\text{var} (\beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}}) = \{SE (\beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}})\}^2 = \{.8024\}^2 = 0.644$

$2\text{COV} (\beta_{\text{moderate exp}}, \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}}) = 2(-0.22156) = -0.4431$

$$\text{Var} (\beta_{\text{moderate exp}} + \beta_{\text{Moderate exp*2-4 disadv conditions}}) = 0.394 + 0.644 - 0.443 = 0.595$$

$$\text{SE} (\beta_{\text{low income}} + \beta_{\text{high exp*2-4 disadv conditions}}) = \sqrt{0.595} = 0.771$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE}(\beta)} = e^{-1.534 \pm 1.96 * (0.771)}$$

$$\text{Upper limit} = e^{-1.511 + 1.511} = e^0 = 1$$

$$\text{Lower limit} = e^{-1.511 - 1.511} = e^{-3.022} = 0.05$$

2.

OR for high GFJ exposure in 2-4 disadv group

$$\text{Logit (high exp=1, moderate exp=0, 2-4 disadv conditions =1)} = \beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{2-4 disadv conditions}} * 1 + \beta_{\text{high exp*2-4 disadv conditions}} 1 * 1 + \beta_{\text{moderate exp*2-4 disadv conditions}} 0 * 1 \text{----- (a)}$$

$$\text{Logit (high exp=0, moderate exp=0, 2-4 disadv conditions =1)} = \beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{2-4 disadv conditions}} * 1 + \beta_{\text{high exp*2-4 disadv conditions}} 0 * 1 + \beta_{\text{moderate exp*2-4 disadv conditions}} 0 * 1 \text{----- (a)}$$

$$\text{Logit difference} = (a) - (b) = \beta_{\text{high exp}} + \beta_{\text{high exp*2-4 disadv conditions}} = .145 - 1.303 = -1.158$$

$$\text{OR for high exposure in 2-4 disadv conditions} = e^{-1.158} = 0.31$$

Calculation of the 95% CI of the OR

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*2-4 disadv conditions}}) = \text{var} (\beta_{\text{high exp}}) + \text{var} (\beta_{\text{high exp*2-4 disadv conditions}}) + 2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*2-4 disadv conditions}})$$

$$\text{var} (\beta_{\text{high exp}}) = \{\text{SE} (\beta_{\text{high exp}})\}^2 = (.5579)^2 = 0.311$$

$$\text{var} (\beta_{\text{high exp*2-4 disadv conditions}}) = \{\text{SE} (\beta_{\text{high exp*2-4 disadv conditions}})\}^2 = \{.8667\}^2 = 0.751$$

$$2\text{cov} (\beta_{\text{high exp}}, \beta_{\text{high exp*2-4 disadv conditions}}) = 2(-0.31974) = -0.639$$

$$\text{Var} (\beta_{\text{high exp}} + \beta_{\text{high exp*2-4 disadv conditions}}) = 0.311 + 0.751 - 0.639 = 0.423$$

$$\text{SE} (\beta_{\text{low income}} + \beta_{\text{high exp*2-4 disadv conditions}}) = \sqrt{0.423} = 0.65$$

$$95\% \text{ CI of OR} = e^{\beta \pm 1.96 * \text{SE}(\beta)} = e^{-1.158 \pm 1.96 * (0.65)}$$

$$\text{Upper limit} = e^{-1.158 + 1.274} = e^{0.116} = 1.12$$

$$\text{Lower limit} = e^{-1.158 - 1.274} = e^{-2.432} = 0.09$$

3.

OR for high GFJ exposure in 0-1 disadv group

$$\text{Logit (high exp=1, moderate exp=0, 2-4 disadv conditions =0)} = \beta_0 + \beta_{\text{high exp}} 1 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{\text{2-4 disadv conditions}} * 0 + \beta_{\text{high exp*2-4 disadv conditions}} 1 * 0 + \beta_{\text{moderate exp*2-4 disadv conditions}} 0 * 0 \text{----- (a)}$$

Logit (high exp=0, moderate exp=0, 2-4 disadv conditions =0) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} * 0 + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} 0 * 0 + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} 0 * 0$ ----- (a)

Logit difference= (a) - (b) =  $\beta_{\text{high exp}} = .145$

OR for high exposure in 0-1 disadv conditions =  $e^{0.145} = 1.15$

Calculation of the 95% CI of the OR

SE ( $\beta_{\text{high exp}}$ ) = .5579

95% CI of OR =  $e^{\beta \pm 1.96 * SE(\beta)} = e^{0.145 \pm 1.96 * (0.5579)}$

Upper limit =  $e^{0.145 + 1.093} = e^{1.238} = 3.45$

Lower limit =  $e^{0.145 - 1.093} = e^{-0.948} = 0.39$

4.

OR for moderate GFJ exposure in 0-1 disadv group

Logit (high exp=0, moderate exp=1, 2-4 disadv conditions =0) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 1 + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} * 0 + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} 0 * 0 + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} 1 * 0$ ----- (a)

Logit (high exp=0, moderate exp=0, 2-4 disadv conditions =0) =  $\beta_0 + \beta_{\text{high exp}} 0 + \beta_{\text{moderate exp}} 0 + \beta_{\text{stressful}} \text{stressful} + \beta_{2-4 \text{ disadv conditions}} * 0 + \beta_{\text{high exp} * 2-4 \text{ disadv conditions}} 0 * 0 + \beta_{\text{moderate exp} * 2-4 \text{ disadv conditions}} 0 * 0$ ----- (a)

Logit difference= (a) - (b) =  $\beta_{\text{moderate exp}} = .121$

OR for moderate exposure in 0-1 disadv conditions =  $e^{0.121} = 1.13$

Calculation of the 95% CI of the OR

SE ( $\beta_{\text{moderate exp}}$ ) = .4482

95% CI of OR =  $e^{\beta \pm 1.96 * SE(\beta)} = e^{0.121 \pm 1.96 * (0.4482)}$

Upper limit =  $e^{0.121 + 0.878} = e^{0.999} = 2.72$

Lower limit =  $e^{0.121 - 0.878} = e^{-0.757} = 0.47$

Effect	Among	OR	95% CI
High exposure	0-1 disadv group	1.15	0.39, 3.45
Moderate exposure	0-1 disadv group	1.13	0.47, 2.72
High exposure	2-4 disadv group	0.31	0.09, 1.12
Moderate exposure	2-4 disadv group	0.28	0.05, 1.00

SAS output for mental health final model showing the ORs and their 95% CI of interaction terms involved in GFJ exposure\*disadvantaged category interaction

Differences of GFJ_expos*multiple_d Least Squares Means													
GFJ_expos	multiple_d	GFJ_expos	multiple_d	Estimate	exp(estim)	Standard	z Value	Pr >  z	Alpha	Lower	exp(low)	Upper	exp(upper)
1	0	1	1	-0.3425	0.709993	0.4372	-0.78	0.4334	0.05	-1.1993	0.301405	0.5143	1.672467
1	0	2	0	0.1115	1.117954	0.5119	0.22	0.8276	0.05	-0.8919	0.409876	1.1148	3.048958
1	0	2	1	-0.3184	0.727312	0.4912	-0.65	0.5169	0.05	-1.2812	0.277704	0.6444	1.904844
1	0	3	0	-1.1574	0.314302	0.6503	-1.78	0.0751	0.05	-2.4319	0.08787	0.1172	1.124344
1	0	3	1	-0.1972	0.821026	0.581	-0.34	0.7344	0.05	-1.3359	0.262921	0.9416	2.564081
1	1	2	0	0.4539	1.574441	0.5077	0.89	0.3713	0.05	-0.5412	0.582049	1.4491	4.259279
1	1	2	1	0.02407	1.024362	0.3941	0.06	0.9513	0.05	-0.7483	0.47317	0.7965	2.217765
1	1	3	0	-0.8149	0.442684	0.6732	-1.21	0.2261	0.05	-2.1344	0.118316	0.5046	1.656323
1	1	3	1	0.1453	1.156386	0.5579	0.26	0.7945	0.05	-0.9481	0.387477	1.2387	3.451124
2	0	2	1	-0.4299	0.650574	0.5621	-0.76	0.4444	0.05	-1.5316	0.216189	0.6718	1.957758
2	0	3	0	-1.2688	0.281169	0.6337	-2	0.0453	0.05	-2.5109	0.081195	-0.02674	0.973614
2	0	3	1	-0.3086	0.734475	0.5931	-0.52	0.6028	0.05	-1.471	0.229696	0.8537	2.34832
2	1	3	0	-0.839	0.432142	0.7346	-1.14	0.2534	0.05	-2.2788	0.102407	0.6009	1.823759
2	1	3	1	0.1212	1.128851	0.4482	0.27	0.7868	0.05	-0.7572	0.468978	0.9997	2.717466
3	0	3	1	0.9602	2.612219	0.7854	1.22	0.2215	0.05	-0.5791	0.560403	2.4995	12.1764

#### 4. Health compared to one year ago

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	2.381	.4431	1.512	3.249	28.871	1	.000	10.814	4.537	25.771
[level_of_exposure=3.00]	.282	.3795	-.462	1.025	.551	1	.458	1.325	.630	2.788
[level_of_exposure=2.00]	.448	.4959	-.524	1.420	.817	1	.366	1.565	.592	4.137
[level_of_exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[daily_stress=2.00]	-.827	.3172	-1.449	-.206	6.803	1	.009	.437	.235	.814
[daily_stress=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[preexisting_conditions=1.00]	-.758	.3218	-1.389	-.127	5.548	1	.018	.469	.249	.880
[preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[disadvantage_category=1.00]	-.517	.3280	-1.160	.126	2.485	1	.115	.596	.313	1.134
[disadvantage_category=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: comp\_health

Model: (Intercept), level\_of\_exposure, daily\_stress, preexisting\_conditions, disadvantage\_category

a. Set to zero because this parameter is redundant.

## 5. BMI

**Parameter Estimates**

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	.477	.3190	-.148	1.103	2.240	1	.134	1.612	.863	3.012
[level_of_exposure=3.00]	-.394	.2941	-.971	.182	1.799	1	.180	.674	.379	1.200
[level_of_exposure=2.00]	-.484	.3618	-1.193	.226	1.786	1	.181	.617	.303	1.253
[level_of_exposure=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[preexisting_conditions=1.00]	-.921	.3309	-1.569	-.272	7.740	1	.005	.398	.208	.762
[preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[believes_changing_health_behaviour=2.00]	-.287	.1278	-.537	-.036	5.026	1	.025	.751	.584	.965
[believes_changing_health_behaviour=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[neighbourhood_long_lived=2.00]	-.318	.1350	-.582	-.053	5.535	1	.019	.728	.559	.948
[neighbourhood_long_lived=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[disadvantage_category=1.00]	-.482	.1939	-.862	-.102	6.186	1	.013	.617	.422	.903
[disadvantage_category=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[level_of_exposure=3.00] * [preexisting_conditions=1.00]	.721	.3361	.062	1.380	4.603	1	.032	2.057	1.064	3.975
[level_of_exposure=3.00] * [preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[level_of_exposure=2.00] * [preexisting_conditions=1.00]	.576	.3895	-.187	1.340	2.190	1	.139	1.780	.829	3.818
[level_of_exposure=2.00] * [preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[level_of_exposure=1.00] * [preexisting_conditions=1.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
[level_of_exposure=1.00] * [preexisting_conditions=.00]	0 <sup>a</sup>	.	.	.	.	.	.	1	.	.
(Scale)	1									

Dependent Variable: bmi

Model: (Intercept), level\_of\_exposure, preexisting\_conditions, believes\_changing\_health\_behaviour, neighbourhood\_long\_lived, disadvantage\_category, level\_of\_exposure \* preexisting\_conditions

a. Set to zero because this parameter is redundant.