Food For Thought: An Analysis of the Relationship Between Food Deserts and Childhood Academic Performance in Halifax Regional Municipality, Nova Scotia

By

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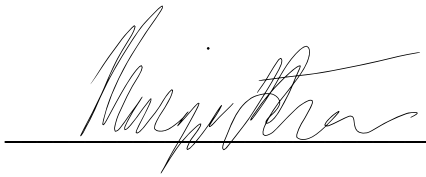

Signature of Author

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Abstract

This study explores the relationship between geographic food deserts and sixth grade academic performance in Halifax Regional Municipality (HRM), Nova Scotia. An ArcGIS Pro Network Analysis was used to map geocoded grocery stores and their service areas based on 1km, 8km, and 16 km driving distance from each store. Test scores representing the percentage of students who met or exceeded provincial learning expectations in both reading and math were gathered for each elementary school within HRM, and then assigned to each geocoded school location on a map. These scores were symbolized using ArcGIS Pro's quantile distribution, and then spatially overlaid with the results from the grocery Network Analysis. Results were calculated by using the "Select By Location " tool within ArcGIS Pro to observe which schools fell into a 1km, 8km, 16km, or greater than 16km driving distance from a grocery store. Schools greater than a 16 km driving distance from a grocery store consistently performed within the lowest academic score quantiles, with ~45% of observations falling within the lowest quantile and 0% within the highest quantile in both math and reading. The relationship differed between math and reading scores. Reading scores were correlated to generally decrease as the distance from a grocery store grew. Overall, math scores showed significantly less observations in the highest quantile as well as a significantly greater range of scores. This suggests that there is a correlation between how far a sixth-grade student is from a grocery store with their academic performance, but other variables must be observed to gain a better understanding.

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Chapter 1: Introduction

This study examines the geographic relationship of food desert areas and elementary level academic performance in Halifax Regional Municipality, Nova Scotia. This relationship is explored using a geographic information sciences (GIS) Network Analysis, and spatial layer overlay with ArcGIS Pro (Fulton, 2020).

1.1 Background

The impact of food accessibility can have a significant effect on childhood academic achievement, as exemplified by studies linking household food insecurity to lower academic performance. A 2019 study investigated the relationship between household food insecurity and academic performance among Nova Scotian elementary school students. Von Maltzahn (2019) states that in Nova Scotia, the proportion of children living with household food insecurity in 2012 was 21.2% and up to 22% in 2014. Food insecurity is linked to "food deserts", which are defined as areas where food is both disproportionately expensive and geographically difficult to access (McEntee and Agyeman, 2010). Rural areas are particularly at risk of being defined as a food desert, as resources are geographically farther apart and affordable and accessible transportation options are typically limited. Residents living within food deserts face insufficient availability of nutritious foods, which can put them at risk for negative health and well-being outcomes. Particularly, food insecurity among children holds an association with lower academic achievement in elementary school students. A 2017 provincial public health nutrition study by Faught et al. further investigated this relationship using a population-based health survey of 5th

grade students in Nova Scotia, ultimately finding that academic performance ranged significantly by level of food security. The authors also found that 84% of students who hold high food security met expectations in standardized testing; this was compared to students who were experiencing low food security, where 77% of students met expectations. This study aims to investigate whether this difference in academic performance between students with high and low food security provincially in Nova Scotia is consistent within HRM. This study will examine the relationship between where food deserts are located in Halifax Regional Municipality (HRM) and the academic performance of children in sixth grade.

1.2 Research Questions

The research questions of this study are twofold: 1) The first research question in this study is, where are food deserts in HRM located? 2) The second research question investigated is, what is the spatial relationship between the geographic location of food deserts and academic performance in HRM?

1.3 Definitions

Food Desert

A food desert is an area where food is both expensive, and inaccessible (McEntee and Agyeman, 2010). This creates a geographical area where residents cannot easily access grocery stores, and therefore have limited access to necessary food resources. In this study, distances of 1, 8, and 16 kilometre from a food resource are used. This encompasses a 1 kilometre accessible

distance from a grocery store in an urban area (Morton & Blanchard, 2007) and a 16 kilometre distance in a rural area (Illinois Department of Public Health, 2021). An additional distance of 8 kilometres was chosen to account for suburban areas.

Food Security

Food security is defined by the Food and Agriculture Organization of the United Nations (FAO) as follows:

> "Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002).

Food Insecurity

According to FAO (2023), food insecurity is defined as a state where a person or household lacks regular access to an adequate amount of safe and nutritious food for growth, development, and an active, healthy life. Food insecurity can occur due to food unavailability, or lack of resources to obtain food such as financial means or transportation (FAO, 2023).

1.4 Purpose of the Study

This study aims to fill the gap of locating food deserts in rural HRM, utilizing spatial analysis and geographic information science (GIS). This gap exists as previous studies have examined the relationship between food deserts and academic performance provincially, but prior to this study, it had not been studied at a more granular level within a specific school board. By using GIS, this study will use a Network Analysis to visualize the geographic network of food resources across HRM. By using a spatial overlay with provincial public school test data, areas of overlap between academic performance and food desert locations will be observed (Fulton, 2020). The research builds upon a similar study conducted on the Halifax peninsula, which seeks to understand food desert locations and significance (Fulton, 2020). The purpose of this study is to explore the geographic relationship between food insecurity and academic performance of sixth grade students within HRM.

1.5 Significance

The findings of this study will help visualize food deserts across HRM. This will improve understanding on how food insecurity can affect children, and how increased food security can result in elevated academic performance. HRM food deserts have been studied within the Halifax peninsula, showing that there is a relationship between food desert locations and academic performance. This research has yet to extrapolate into rural areas of HRM, where food resources

are scarce, and income levels are lower. As wage gaps and inflation increase, this relationship will likely only become more pronounced. Understanding relationships between childhood food insecurity and academic performance is pivotal to developing solutions towards food insecurity across Nova Scotia as it can inform decisions such as grocery store planning, and deciding where to allocate additional food resources supports such as food banks, mobile food markets, or breakfast programs. The results of this study can inform future geographic research that can add numerous other variables related to food insecurity and childhood academic performance such as income, parental education, or racial injustices. This study will serve as an exploration to enrich knowledge in both rural academic performance and childhood food insecurity in HRM.

1.6 Limitations

Given limitations of time and publicly available resources, only schools that are part of the Halifax Regional Centre for Education (HRCE) were included in this study, limiting this research to one school board out of 7 school boards across the province. This does not paint a complete picture of the province and will result in numerous town level analyses rather than an in-depth analysis of the entire province. Furthermore, five schools do not have publicly available exam data, causing uncertainty in numerous locations. A second limitation of this study is that HRCE community reports stating provincial test scores by school were only publicly released during the 2015-2016 school year, limiting the research to one year.

Chapter 2: Literature Review

2.1 A Glance at Food Insecurity and Food Deserts

Rates of food insecurity are increasing in Nova Scotia (Tarasuk et al., 2022). Food deserts in rural areas are a growing concern as residents are increasingly unable to access nutritious foods (Wilson et al., 2020). Inadequate nutrition, particularly during childhood, is shown to result in numerous physical and mental health challenges, and this can have significant impact(s) on children's academic performance (Kleinman et al., 2002). This study will explore this relationship further by using GIS to observe spatial overlap between food deserts and academic performance.

Food Insecurity in Canada

Food insecurity is defined as inadequate or insecure access to food due to financial constraints (Tarasuk et al., 2022). Health Canada (2020) defines a household as food secure when all members always have access to enough food for an active, healthy life. Inadequate food access across Canada has been steadily increasing since the first systemic monitoring in the Canadian Income Survey (CIS) of 2005 (Tarasuk et al., 2022). Food insecurity in Nova Scotia is increasing at a faster rate than other Canadian provinces. In 2021, the prevalence of household food insecurity at any level was found to be 17.7% in Nova Scotia, and 15.9% averaged across all Canadian provinces (Tarasuk et al., 2022). Nova Scotia held the highest rate of food insecurity in Canada with a percentage of persons by household food insecurity (moderate or severe) of 15.5% and 13.0% in 2018 and 2019 respectively (Caron et al., 2022). This is

significantly above Canada's federal food insecurity rate of 11.5% in 2018 and 10.6% in 2019 (Caron et al., 2022). Furthermore, the CIS shows that 44.2% of food-insecure households in 2021 had one or more children as a member (Tarasuk et al., 2022). In 2021, approximately 19.6% of Canadian children experienced food insecurity (Tarasuk et al., 2022). However, in Nova Scotia, this rate increases to 25.8% (Tarasuk et al., 2022).

Feed Nova Scotia (2021) states that Nova Scotia's elevated rates of food insecurity are linked to a variety of factors, including: "Systemic racism and oppression; precarious work and low wages; lack of affordable housing; lack of affordable childcare; inadequate income assistance levels; inadequate disability support; mental and physical health challenges; [and] the increasing cost of living". Inadequate access to healthy foods is detrimental in childhood development, resulting in close ties to chronic illness, lowered life expectancies, and other comorbidities (Lebel et al., 2016). This is particularly important in childhood as cognition develops. Roberts et al. (2022) exemplified this relationship further by examining 12 trials of undernourished children from the ages of 2-6. Out of all studies analyzed, eight found significant positive effects on cognitive abilities when micronutrient supplementation is introduced. Omega-3 fatty acids and iron were both shown to have a positive correlation with increased learning abilities, verbal reasoning, intellectual functioning, information processing speeds, memory, and motor skills. This shows how a lack of micronutrient consumption can be multifaceted in learning and development, and the importance of childhood nutrition.

Rural Food Access

In rural communities, rates of food insecurity increase as a result of challenges related to distance to adequate food resources and affordability (Lebel et al., 2016). Increased distance from densely populated areas results in difficulty accessing foods in rural areas~~,~~ due to lack of public transport and a requirement of a vehicle to access a food resource (Lebel et al., 2016). This creates a barrier as households cannot use alternative methods of transportation and will not be able to access healthy foods if they do not own or have access to motorized transport. Alongside distance, rural communities tend to have lower median household income rates compared to urban cities, resulting in another barrier to adequate food access (Statistics Canada, 2015). Average Canadian earnings are 27% higher in large urban areas compared to rural and remote areas (Statistics Canada, 2015). Due to transportation costs, increased distance from manufacturers, and lower store volumes in remote access, food is notably more expensive in rural areas (Hardin-Fanning & Rayens, 2015). Cumulatively, this can create areas where food is inaccessible to its community members, resulting in food desert.

Food Deserts

A food desert is an area where food is relatively unavailable, expensive, and/or inaccessible (McEntee & Agyeman, 2010). This term was first coined by The Scottish Nutrition Task Force in the 1990s and was used to represent a geographic area where healthy food was unaffordable (Beaulac et al., 2009). In rural areas, this is defined as an area where at least 50% of the area's population lives 16 or more kilometres from an adequate food source (Morton &

Blanchard, 2007). These areas typically hold an elevated level of small convenience stores but limited access to supermarkets, resulting in challenging access to nutritious foods (Morton & Blanchard, 2007).

Food Deserts in Nova Scotia

As a result of increased levels of food insecurity and food deserts in Nova Scotia, many individuals have documented the challenging experiences many Nova Scotians face. In *Deserted*, a film examining rural food access in Nova Scotia, Wilson et al. (2022) explores the food desert communities of Musquodoboit, Upper Big Tracadie, Millbrook, Dean Settlement, and Bridgewater. Wilson et al. investigate what it is like for rural Nova Scotians living in these communities through interviews. Community members state that they have no access to public transport in their areas, and a drive to a grocery store can take up to an hour. A Middle Musquodoboit community member notes that they have access to small convenience stores, but the nearest supermarket is over 20 kilometres away. This results in group shopping trips, where a community member will post when they are going to a grocery store so others can access food with them. Another option residents have is to taxi to the nearest store, costing upwards of $40, an inaccessible amount to towns experiencing high poverty rates. The inconvenient and time-consuming nature of this results in community members shopping for food at corner stores, which typically lack fresh foods and foods with higher nutritional levels.

Egbe et al. (2021) further investigated the availability and affordability of healthy food in Nova Scotia. They examined the availability of health foods in Nova Scotia, finding disparities in food availability, where healthy food options were substantially more available in chain stores

than in small, independent, or corner stores. Alongside the findings in *Deserted,* there is a clear relationship between food insecurity and proximity to only small food retailers. Although studies in Nova Scotia that analyze the difference between rural and urban food prices have not yet been conducted, the relationship between food accessibility and rural communities is shown in a 2015 Kentucky study. Researchers analysed four Kentucky Counties and found that more nutritious food items were sold at higher costs in rural areas (Hardin-Fanning & Rayens, 2015). This can hold negative physical and mental effects due to poor access to nutritious foods (Gómez-Pinilla, 2010).

2.2 Relationship Between Childhood Nutrition and Academic Performance

Academic Performance of Elementary Aged Children and Nutrition

A diet including access to nutritious food has been shown to affect cognitive processes and emotions. Gómez-Pinilla (2010) found that a diet that has abundant nutrients such as calcium and omega-3 fatty acids are essential for the maintenance of synaptic function, which plays a role in memory and learning. They also noted that diet affects energy production, with adequate consumption of vitamins B, D, and E having positive effects on memory, cognition, and delay in cognitive decline. Alongside this, they found that excess saturated fats can inhibit cognitive function. Furthermore, household food insecurity is noted as a social-determinant of health, linked to numerous other indicators such as physical and mental health disorders (Jessiman-Perreault et al., 2017).

Academic performance has been linked to diet and sufficient food access in elementary aged children. Kleinman et al. (2022) found that children who live in a food insecure household

were more likely to perform poorly in school, have lowered attendance rates, and must repeat a grade. In their study, they monitored children's academic performance and its relationship with nutrition while a free school breakfast program in Boston was active. They found that children with low nutritional intakes, prior to starting the breakfast program held a mean grade point average (GPA) of 2.1, whereas the students who had taken a full year of the breakfast program scored a mean GPA of 2.6 on a 4.0 scale. The scores were obtained using standardized testing in reading, mathematics, social studies, and science.

Florence et al. (2008) investigated the relationship between diet quality and academic performance of 5200 fifth grade children in Nova Scotia in 2008, using factors such as height, weight, and academic performance. The students' diet quality was assessed using the YAQ food frequency questionnaire, as well as the Diet Quality Index (DQI). This monitored intake of fruit, vegetables, grains, fiber, protein, iron, calcium, and vitamin C. The research further monitored less healthful components such as saturated fats. This was independently compared to academic performance, using the Children's Lifestyle and School Performance Study (CLASS), and standardized provincial test scores. This analysis showed the importance of fruit, vegetable, and dietary fat intake, showing a positive relationship with diet adequacy and variety with elevated provincial test scores.

HRM Food Deserts and Academic Performance

Examining the effects of a diet that is high in saturated fats, and low in vitamins, as shown by Gómez-Pinilla (2010) along with rural grocery trends, there is a relationship to be explored between food deserts and academic performance. Residents in more rural areas of HRM

are often limited to convenience stores within an accessible distance (16km) (Wilson et al., 2020). The diet of a rurally based resident would not have the same nutritional value as the diet of an individual who was able to access produce and a wider variety of nutrients (Egbe et al., 2021).

Faught et al. (2017) examine education as a social determinant of health. They examine food insecurity and how this influences children's academic achievement in Nova Scotia. They used Children's Lifestyle and School performance Study (CLASS) II conducted in Nova Scotia and Nova Scotia's Department of Early Education and Child Development as a data source. These involve investigating provincial standardized test scores and parent surveys on factors such as household income and socio-economic status. This relationship in a Halifax context has further been investigated by Kirk et al. (2014), showing students who lived in households that experienced food insecurity were more likely to have poor diet quality, and poorer psycho-social outcomes. Kirk et al. further found that even students who suffer from marginal food insecurity reported significantly higher levels of stress and impaired academic performance compared to students living in a food secure household. Kirk et al., as well as Faught et al., show that there is a clear relationship between households who experience food insecurity and children's academic performance.

Chapter 3: Methods

This study uses GIS methods to observe the correlation between food desert locations and sixth grade academic scores across HRM. This is completed using an ArcGIS Network Analysis to measure food resource accessibility, and provincial examination scores to measure academic performance. Then, scores are converted into ArcGIS Pro layers, and overlaid for analysis.

3.1 Food Resource Data Collection

This first step in data collection was to produce a Google Earth Pro dataset of adequate food resources in HRM. Adequate food resources are defined as a commercial destination where households are able to obtain all foods, they need to be considered food secure (FAO, 2002). Using this definition, food resources analysed in this research must provide all foods needed to fully sustain an individual's healthy and active life. As stated by Canada's Food Guide, this must include multiple fruits and vegetables, protein rich foods, and whole grains (Health Canada, 2022). For this reason, convenience stores and drug stores were excluded from this analysis due to their frequent unavailability of foods that meet these standards. Stores that require membership for access (i.e., Costco) were also excluded from this analysis as the additional cost adds inaccessibility. This study found 63 grocery stores located within HRM. Of these, 11 of the stores were located on the Halifax peninsula.

3.2 Refining Geographic Data

Grocery store addresses were determined using KML files that hold coordinates for each store from Google Earth Pro (Fulton, 2020). These addresses were obtained by searching HRM by each town, moving west to east, and creating a marker for each store. Stores that were not clearly defined as an adequate food resource were researched further utilizing storefront websites to view available products. Once a finalized KML file of all grocery stores was created, points were converted to a shapefile, and then a feature class using ArcGIS Pro (Fulton, 2020). Furthermore, the grocery points were used in a Kernel Density analysis in ArcGIS Pro. This analysis was completed to measure grocery density across HRM by the cell size of the study area.

3.3 Measuring Food Accessibility

To measure food resource accessibility, Halifax Regional Municipality's boundary was overlaid with the feature class of grocery stores to prepare for a network analysis. This study used a Network Analysis to calculate routes along street networks, and to measure the area reached by each food resource. This was performed using the methods employed by Larson & Gilliand (2008) in their London, Ontario study using ArcMap to map and analyze food deserts. This method is further supported by Mui et al. (2015) who conducted a Baltimore Network Analysis that used GIS to analyze low-income neighbourhoods, and their access to healthy food sources.

Using ESRI's proximity network, networks of 1, 8, and 16 kilometres from each grocery store were constructed. These distances were chosen as 1 kilometre is cited as an accessible distance from a grocery store in an urban area (Morton & Blanchard, 2007), and 16 kilometres is noted as an accessible distance from a grocery store in a rural area (Illinois Department of Public Health, 2021). An additional distance of 8 kilometres was chosen as a middle distance to get a better understanding of 'suburban' areas that may not clearly fall into the urban, or rural category. This method was chosen to account for road features like complex routes, natural features like bodies of water, and driving times. Doing so provides a more accurate analysis compared to using the radius distance from each store. The built network accounted for factors such as one-way streets to find the true distance each grocery store reaches. After each network was built, it was symbolized and converted to a layer using ArcGIS Pro.

3.4 Academic Performance

Academic scores were obtained from the 2015-2016 academic year provincial standardized testing for sixth grade students in reading and mathematics from Halifax Regional Centre for Education. The 2015-2016 school year was chosen as provincial test results were publicized as community reports for public viewing for the first and only time in Nova Scotia. These records were used for a standardized method of measuring performance province wide to observe differences. This numerical data was then spatially joined to a previously created layer of the HRM zonal boundary.

Academic data was then symbolized using ArcGIS Pro quantiles based on distributions of reading and math scores. 71 schools were studied, 58 were classified as elementary schools and

13 were classified as junior high or middle schools. This resulted in reading quantiles of 41-63%, 64-73%, 74-80%, 81-86%, and 87-100% to represent the percent of sixth grade students who met or exceeded provincial reading expectations. Math quantiles based on distribution of scores were determined to be 12-57%, 58-67%, 68-76%, 77-84% and 85-98% to represent the percent of sixth grade students who met or exceeded provincial math expectations. For both subjects, points were then symbolized by quantile with red representing the 1st (lowest) quantile, orange representing the 2nd quantile, yellow representing the 3rd quantile, light green representing the 4th quantile and dark green representing the 5th quantile (highest).

3.5 Food Resource and Academic Data Overlay

Spatial layers from grocery store data as well as provincial examination scores results were then overlaid using ArcGIS Pro. This was then visually analyzed to observe the relationship between food access and academic performance. This was done by using the "Select by Location" tool within ArcGIS Pro to observe which schools fell into which distance category from a grocery store. This was then viewed alongside the previously symbolized provincial test scores to observe the correlation. The purpose of this step was to see if there is a spatial relationship between high scoring districts academically and districts with elevated food access.

Chapter 4: Results

4.1 Grocery Store Location Distribution

This study found 63 grocery stores located within HRM. Of these, 11 of the stores were located on the Halifax peninsula. Of the 63 grocery stores, 34.92% were *Sobeys*, 26.99% were independently owned, 23.81% of stores were *Atlantic Superstores*, 6.35% were *Walmart Supercenters*, 4.76% were *No Frills* and 3.17% were *Foodlands*. Geocoded grocery store locations in Halifax Regional Municipality are represented in point form to visually represent where areas of food accessibility are located (Figure 1). Notably, an inset map was also produced to view the Halifax peninsula at a larger scale to observe the higher density of stores.

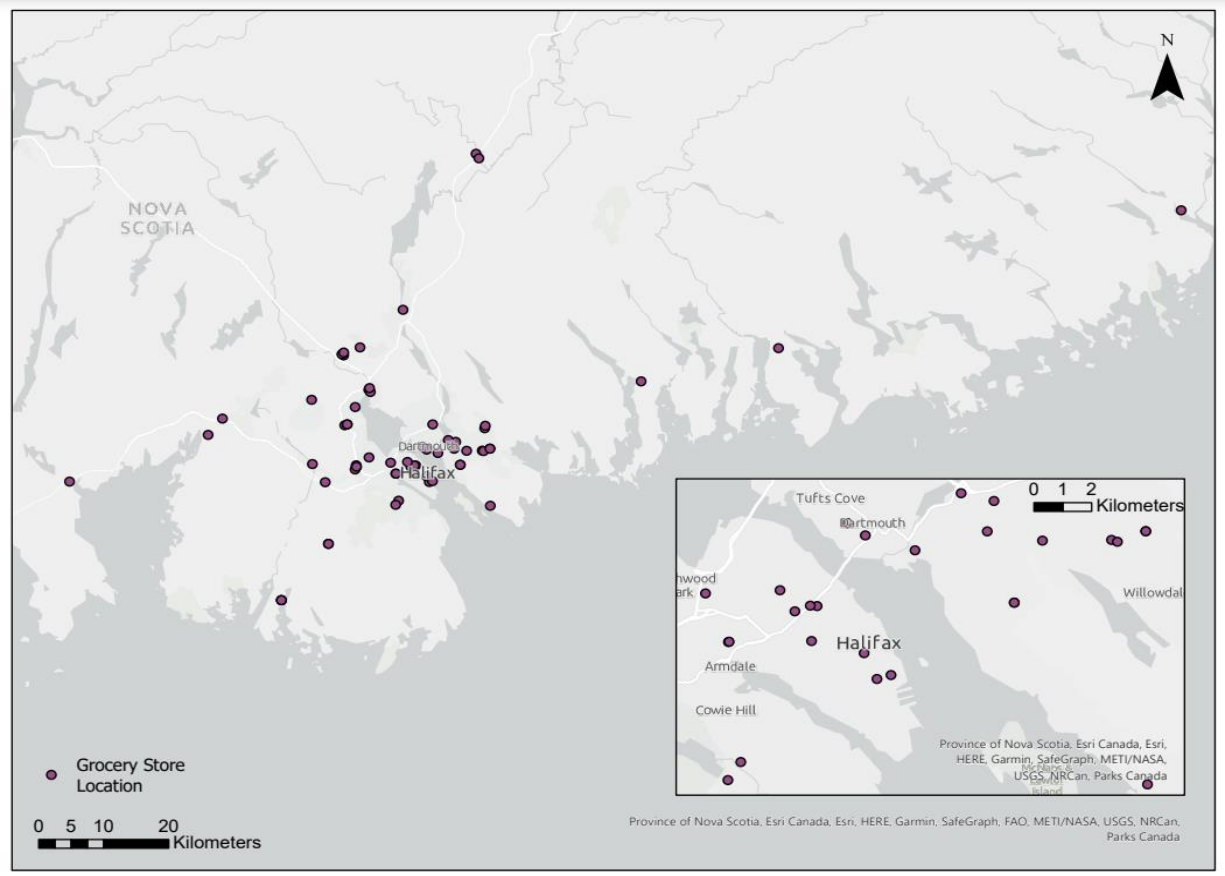

Figure 1: Geocoded grocery stores in the Halifax Regional Municipality, shown in WGS 1984 Web Mercator Auxiliary Sphere Spatial Reference.

An ArcGIS Pro Kernel Density shows a high density of stores surrounding the Halifax peninsula. A moderately high density of stores is also observed near Dartmouth. Areas of medium density surround the towns of Bedford, Hammonds Plains, Sackville, and Timberlea. The remaining areas of HRM show low store density. This analysis was conducted to observe grocery store density across the HRM. This map is shown in Figure 2, representing the highest grocery density in dark purple, and the lowest grocery density in light purple.

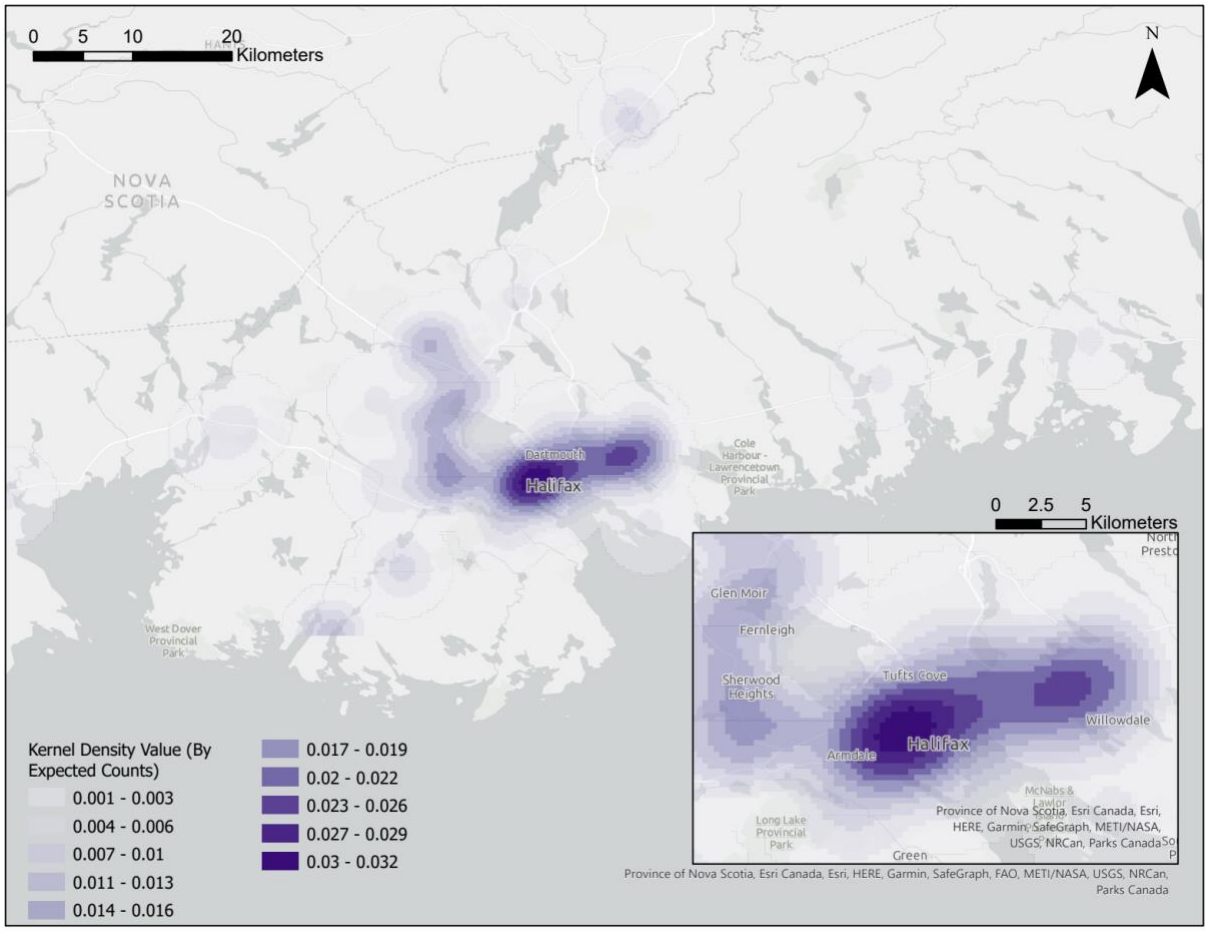

Figure 2: Grocery store Kernel Density analysis across HRM, shown in WGS 1984 Web Mercator Auxiliary Sphere Spatial Reference.

4.2 HRM Grocery Network

Using a network analysis, a 1 km, 8 km, and 16 km driving distance was calculated for each grocery store. This analysis showed the vast majority of the Halifax peninsula is within a 1 km driving distance from a grocery store. Nearing the boundary of the peninsula, the 8 km driving distance becomes more prevalent, and as more rural areas are observed, the 16 km driving distance becomes the most common observation. Areas such as Beaver Bank, Fall River,

Hubbards, and Musquodoboit Harbour are nearly exclusively within the 8 km driving distance. Towns within the 16 km driving distance are Milford, Upper Musquodoboit and Middle Stewiake. There is also a significant portion of HRM that is not within any accessible driving distance from a grocery store such as Middle Musquodoboit, Markland, and Indian Harbour. A comprehensive network of all three driving distances from a grocery store is illustrated in Figure 3.

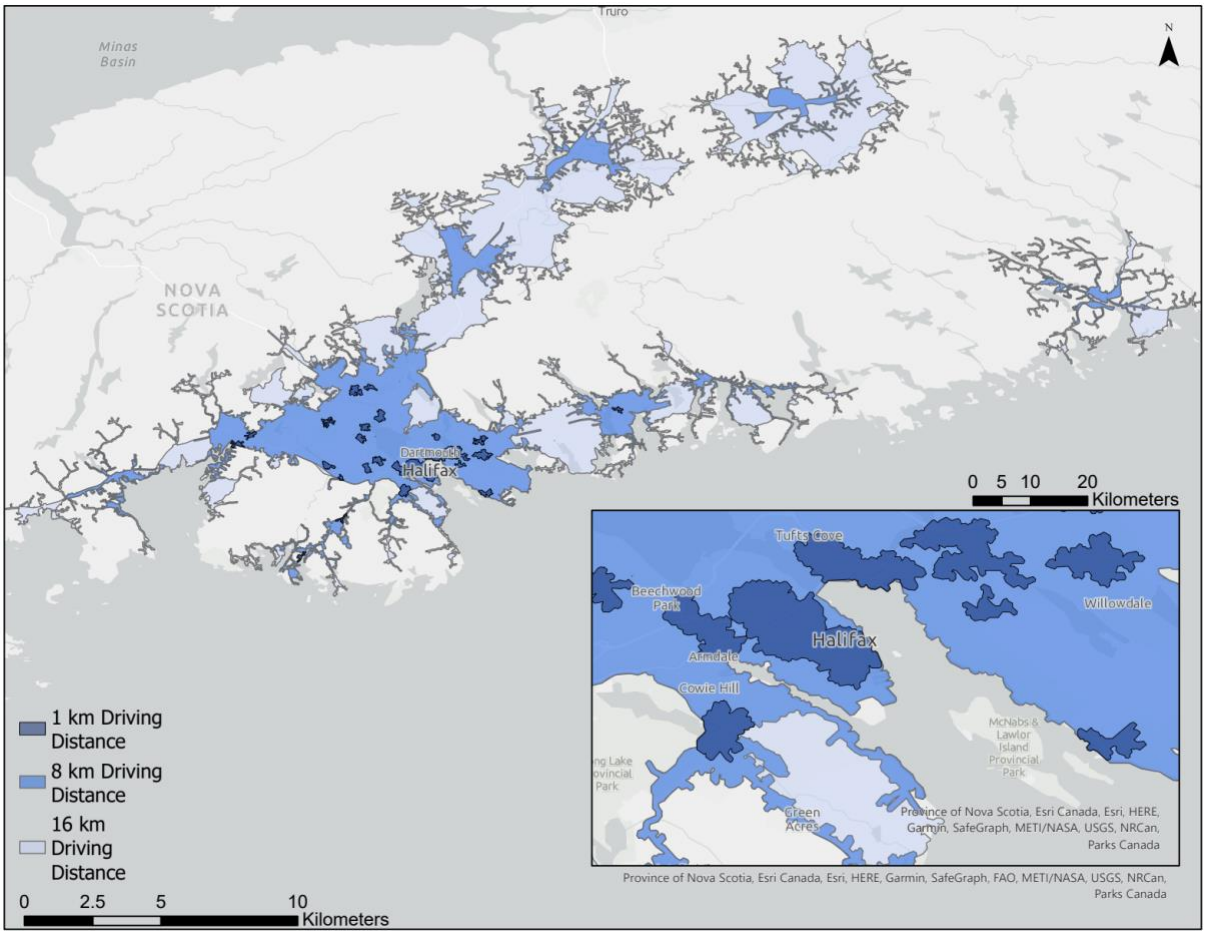

Figure 3: Driving distances (1km, 8km, 16km) from each HRM grocery store, shown in WGS 1984 Web Mercator Auxiliary Sphere spatial reference.

4.3 Provincial Test Score Distributions

This study found that provincial math scores are generally skewed lower than reading scores. This is represented by the mean reading score being 9.18% higher than mean math score, as well as the median reading score being 8.57% higher than the median math score. It is also notable that reading scores have a smaller range than math scores; reading scores have a range of 59% and math scores have a range of 86%. The difference in distributions is also visible when observing standard deviation values. Reading scores had a standard deviation value of 12.59, and math scores had a standard deviation value of 18.0. In Figure 4 and Figure 5, the distributions of both reading and math provincial examination scores are represented graphically.

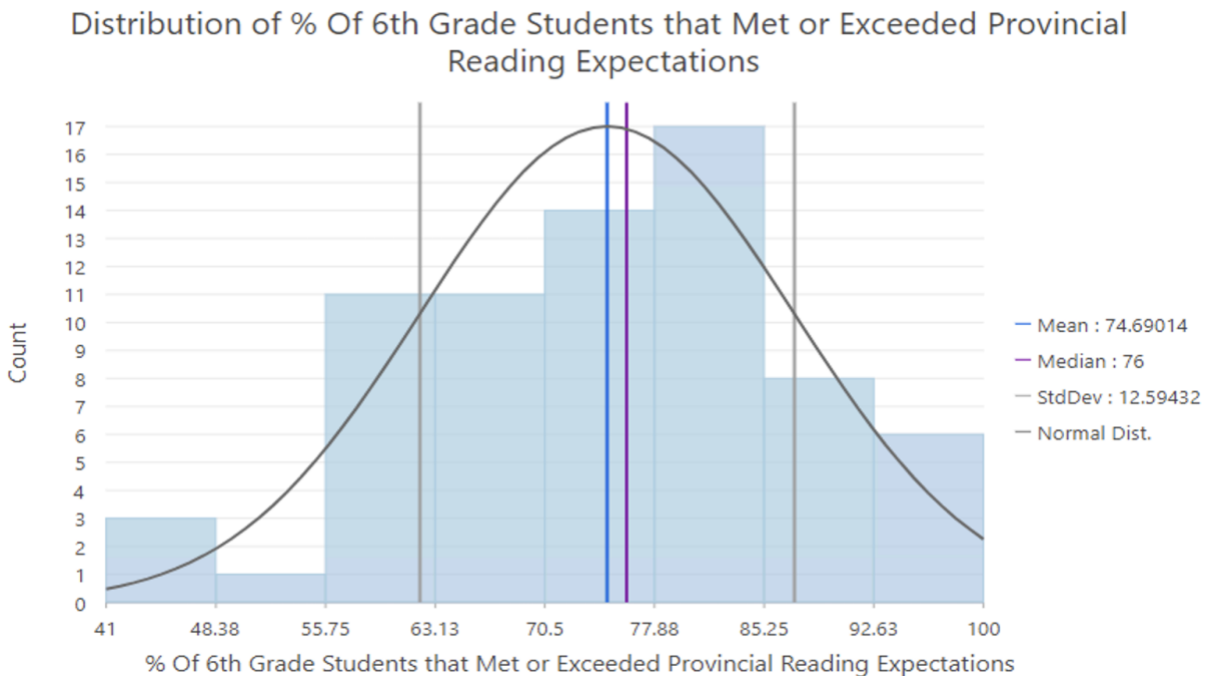

Figure 4: A histogram showing the distribution of the percentage of sixth grade HRCE students that met or exceeded provincial reading expectations in the 2015-2016 school year. The

percentage of students that achieved the provincial reading expectations is shown on the x-axis, and count, representing the number of schools, is shown on the y-axis.

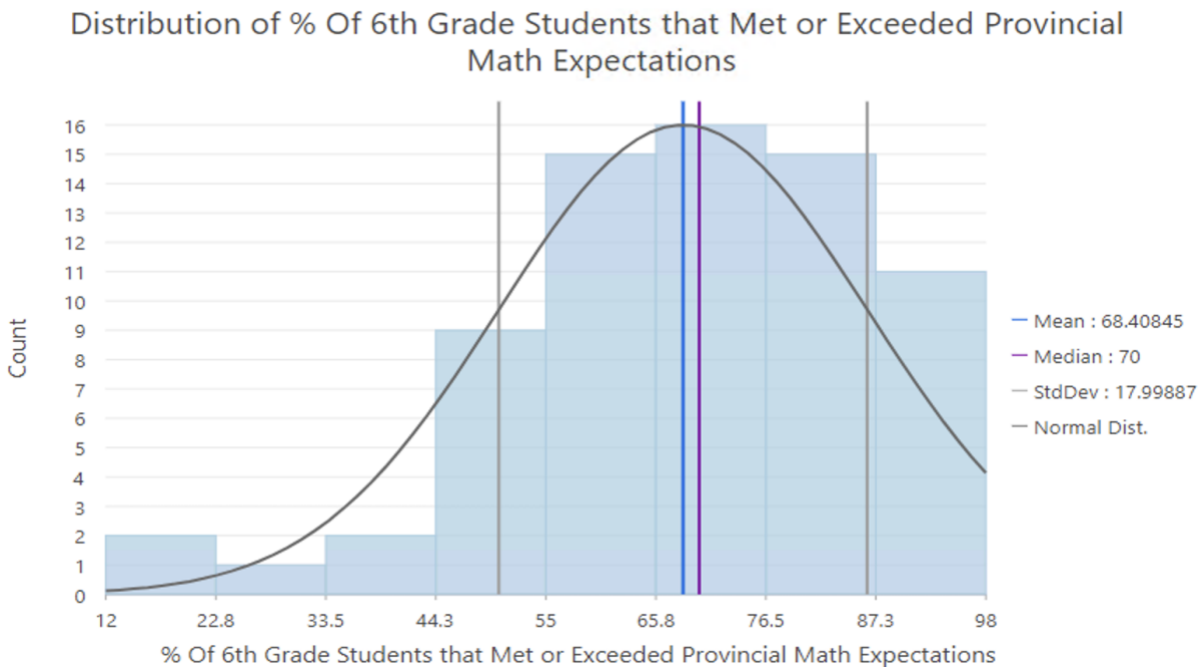

Figure 5: A histogram showing the distribution of the percentage of sixth grade HRCE students that met or exceeded provincial math expectations in the 2015-2016 school year. The percentage of students that achieved the provincial math expectations is shown on the x-axis, and count, representing the number of schools, is shown on the y-axis.

4.4 HRM Provincial Test Score Overlay – Reading

Out of the 71 schools within the HRM study area, 15 fell within a 1 km driving distance from a grocery store, 45 fell within the 8 km driving distance, 6 fell within the 16 km driving

distance, and 5 were greater than a 16 km driving distance. This pattern is observed in Figure 6, where the percentage of students who met provincial reading examinations are represented in point form, and overlaid with polygons representing a 1 km, 8 km, and 16 km driving distance from a grocery store.

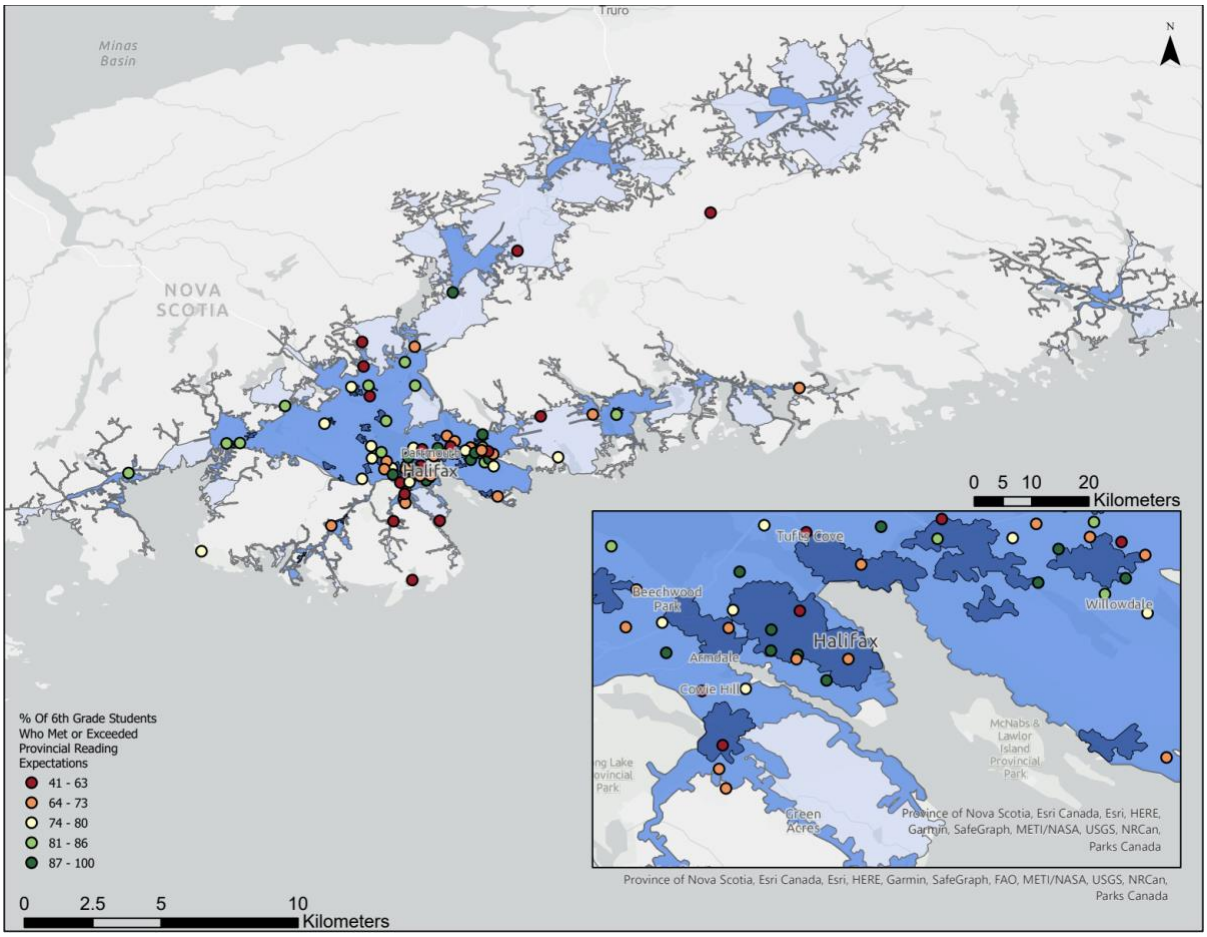

Figure 6: This map shows the 2015-2016 school year Provincial reading test scores, symbolized by quantiles, overlaid with the HRM grocery network.

Upon examining provincial reading scores, schools within the 1 km driving distance from a grocery store typically scored higher on provincial examinations than schools within other

distance categories. Schools within a 1 km driving distance held the lowest percentage of observations within the first quantile, with only 13.33% of schools falling within the 41-63% range. 46.67% of those schools performed in the highest two quantiles, considerably higher than the other distances. Schools within the 8 km distance had 37.78% of observations fall within the two highest quantiles whereas schools that fell within the 16 km, or greater than 16 km driving distance, both had zero observations within the two highest quantiles. The two greatest distances held the vast majority of their scores in the two lowest quantiles, showing within 16 km showing 83.33%, and greater than 16 km with 80% of observations in the lowest two quantiles. This pattern can be observed graphically in Figure 7.

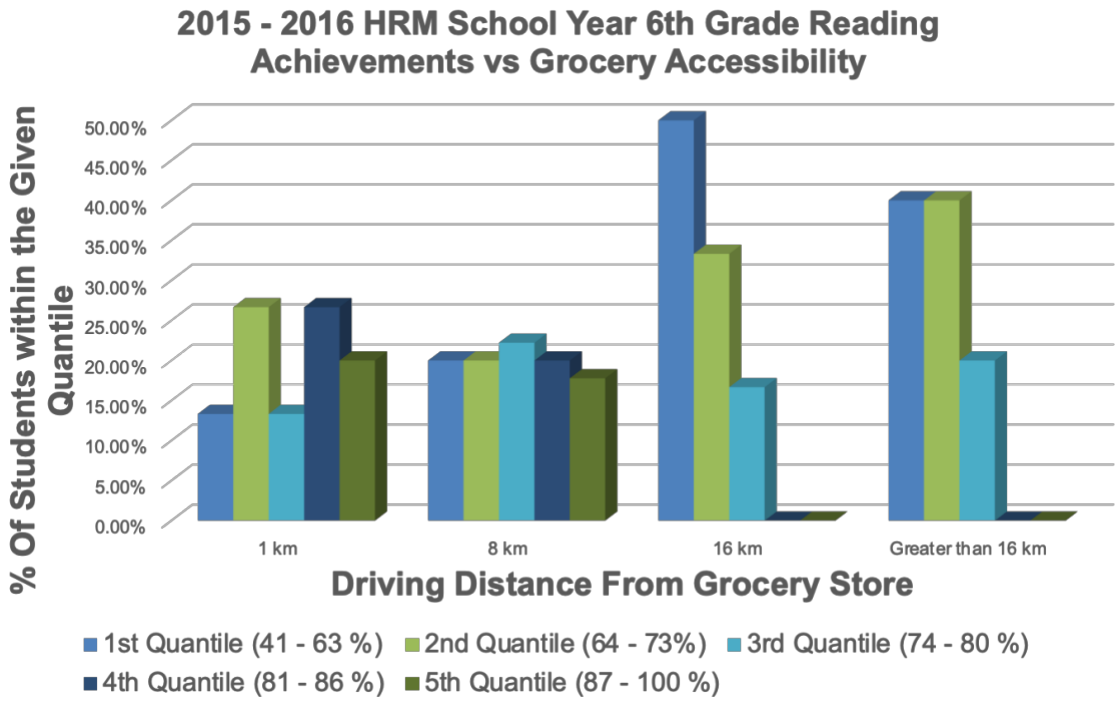

Figure 7: The percentage of HRCE schools that fell within the given reading quantiles for each grocery distance during the 2015-2016 school year.

The results of provincial math scores showed a slightly different relationship to reading scores. Observing math scores, the 1 km driving distance from a grocery store held 40% of scores within the two highest quantiles. The 8 km driving distance had 42.22% of math scores within the two highest quantiles. Figure 8 and Figure 9 show that in this study, there was not a significant difference in math scores between a 1 km driving distance from a grocery store, and an 8 km driving distance from a grocery store.

Similarly to reading, schools within the 16 km driving distance performed consistently low on provincial math examinations, with 50% of observations falling within the lowest quantile and 0% within the highest score quantile. This pattern differs from reading in the greater than 16 km distance category. For reading, 0% of provincial examination scores fall within the two highest quantiles. 20% of math scores within the 16 km or greater category fall within the two highest quantiles. 33.33% of math scores within the 1 km driving distance fall into the lowest quantile, another significant difference compared to reading. This analysis identifies variance between subjects across HRM; math scores had a more significant range with scores falling between 12 - 98% of students meeting or exceeding provincial expectations. Reading scores were elevated compared to math, with schools falling within the range of 41- 100 % of students meeting or exceeding provincial expectations.

4.5 HRM Provincial Test Score Overlay - Math

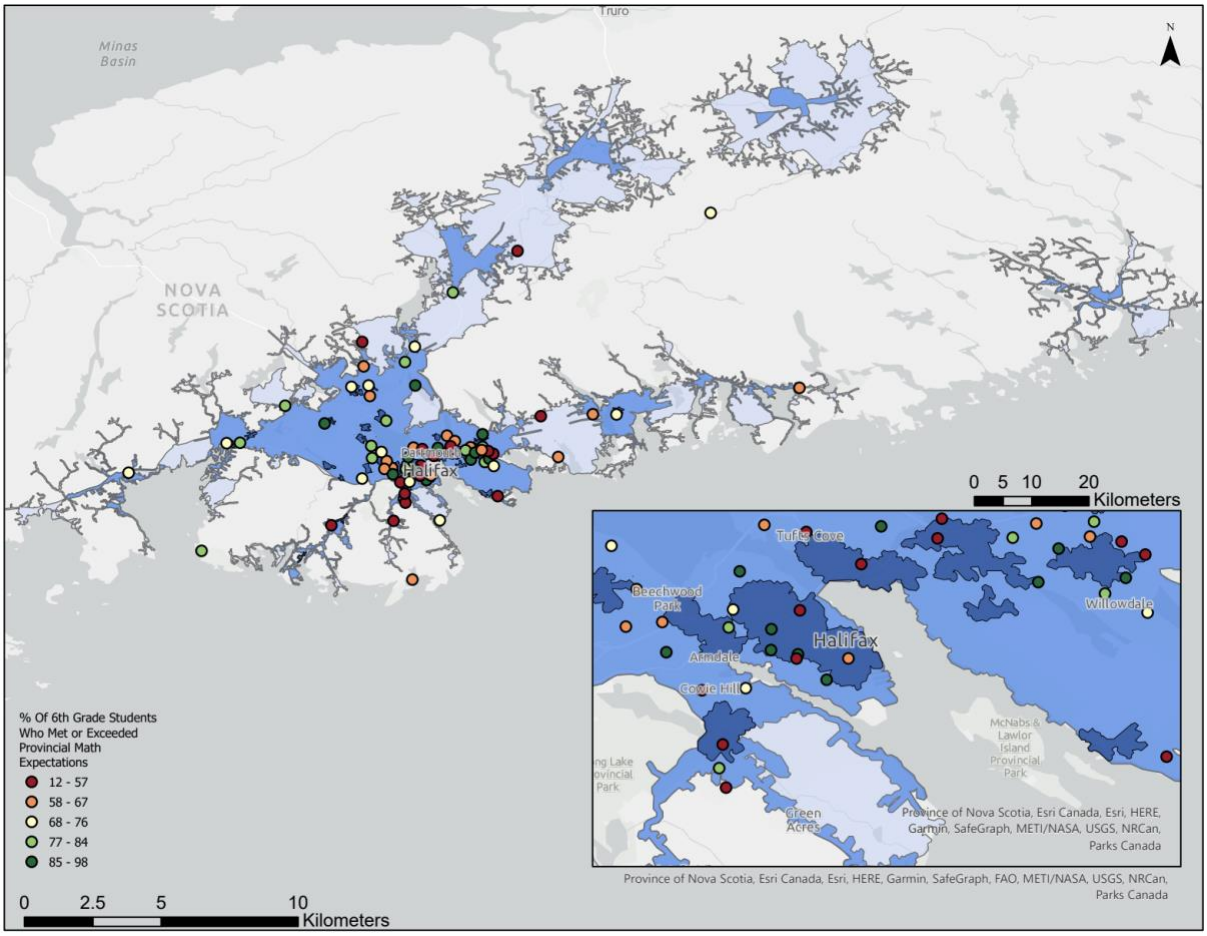

Figure 8: This map shows the 2015-2016 school year provincial math test scores, symbolized by quantiles, overlaid with the HRM grocery network.

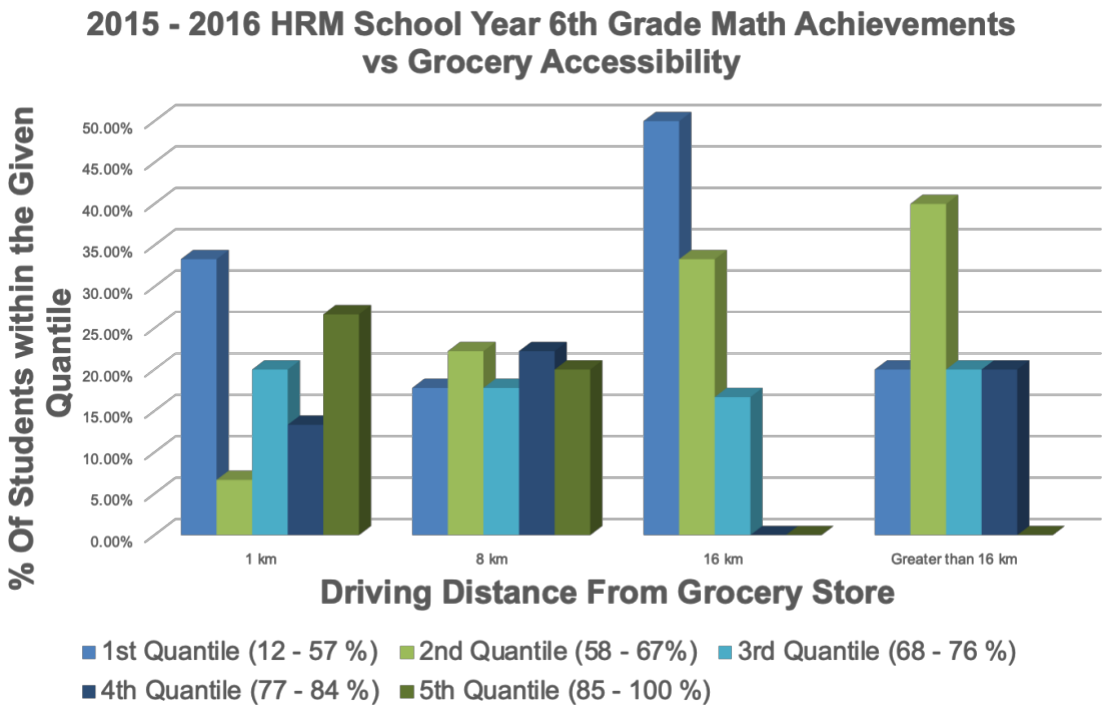

Figure 9: The percentage of HRCE schools that fell within the given math quantiles for each grocery distance during the 2015-2016 school year.

Chapter 5: Discussion

5.1 Implications of Results

It is evident that there is a relationship between the geographic location of food deserts and the academic performance of sixth grade students in HRM, as for both reading and math scores, there were no observations that were greater than 16 km away from a grocery store that also had a score in the highest quantile. This relationship differed between math and reading scores. Reading scores generally decreased as the distance from a grocery store grew. Math scores showed significantly fewer school observations in the highest quantile, where approximately ⅓ of schools within a 1 km distance from a grocery store had scores in the lowest quantile. Math is often perceived as a challenging subject (Fritz et al., 2019). This preconceived judgement can impact childhood learning abilities by instilling a sense of hopelessness in learning. These perceptions can limit students by making them feel like math is too difficult of a subject, and therefore cannot be learned if one does not perform highly initially (Fritz et al., 2019). On the contrary, other subject, such as English (reading, writing, grammar) may seem more approachable and less abstract to students. This difference in perception could influence childhood academic performance in HRM. A shift in math perceptions throughout HRCE to reinforce positive attitudes towards mathematics could encourage a shift to improve HRCE math scores.

Of the 63 grocery stores, 34.92% were *Sobeys*, and 23.81% of stores were *Atlantic Superstores.* This leaves only two retailers responsible for approximately 58.73% of HRM's grocery stores. *Atlantic Superstore*, which is owned by Loblaws, is exponentially increasing food prices. In 2023, Loblaw's fourth quarter analysis showed an increase in revenue of 260 million dollars from the same period in 2022 (Benchetrit, 2023). During this time, inflation stood at

approximately 5.9% in January 2023, while Loblaw's profits grew by 9.64%. Grocery prices are increasing at the fastest rate in 40 years (Benchetrit, 2023). This is significant as many Canadians are unable to afford essential items, and prices are continuing to increase. If food prices continue to grow at this rate, many Canadians will face food insecurity. Considering how Nova Scotia is largely dependent on two grocery chains, a supply chain issue could also create a substantial barrier to food access. If *Sobeys* or *Atlantic Superstore* face an issue such as a supply chain error that restricts food access, the majority of Nova Scotians would face difficulty in accessing food. This dependence is important to note, and increasing the variety of grocery store brands could assist Nova Scotia in grocery affordability and reduce dependency concerns.

5.2 Filling the Grocery Gap

The results of this study are significant for educators, policymakers, and community members in HRM. Since students who reside in food deserts typically showed lower test scores, addressing food resource availability could result in improved educational performance. These findings can be used to better support schools within food deserts by supplementing nutritional needs by providing a service such as a breakfast program within the school. Similar programs, such as the Boston breakfast program study noted in the literature review, resulted in significant academic improvement in other areas (Kleinman et. al., 2022). An Australian study completed a systemic, international review of different interventions to combat childhood food insecurity through meal prevention. They found that government funded breakfast programs are implemented in various countries such as USA, Australia, and Canada, but they are typically only offered once during the day at the school location (Thorpe et al., 2022). One intervention

could be the implementation of nutrition programs into before and after school childcare facilities. This could be through providing childcare facilities subsidies for nutritious food. Furthermore, this study found that rural childcare facilities were significantly less likely to provide meals for children compared to urban areas (Thorpe et al., 2022). As shown in the current study, rural areas are more at risk than urban areas to be a food desert. This, combined with the fact that rural childcare facilities were significantly less likely to provide meals for children shows an area for significant intervention. Programs that combat childhood food insecurity such as breakfast programs and government subsidies could have a significant impact, particularly in rural areas.

On a larger scale, resources such as mobile food markets could be implemented in areas outside of the grocery network to reduce barriers to food access. Furthermore, results of this study can also be utilized to make informed planning decisions when considering future grocery store placement within HRM. As shown in this study, areas in eastern HRM are in a deficit of grocery stores. Considering this, policy makers should encourage dominant food retailers such as *Sobeys* and *Atlantic Superstore* to prioritize these areas for development. Zepeda and Lohr (2014) examined the impacts of mobile food market implementation on food deserts. They found that mobile food markets can facilitate healthy eating opportunities in food deserts by increasing the number of fruits and vegetables available in rural areas. Furthermore, they found that food markets can serve as an educational point for community members to learn cooking techniques as well as nutritional information (Zepeda & Lohr, 2014). These can act as intermittent solutions when there are no grocery stores within a geographic area to ensure that residents have access to nutritious and safe food.

5.2 External Variables

Numerous external variables, other than food accessibility, can have an effect on childhood academic performance. A few of these variables such as school infrastructure, personal support, and income levels are discussed below.

5.2.1 School Infrastructure

School infrastructure encompasses many variables that can impact student success, such as teacher-student ratio, accessibility of technology, and learning environments. One study, located in the Philippines, further investigated the relationship between reading performance and student-teacher ratios. This study used the Programme for International Student Assessment (PISA) reading scores for students and student-teacher ratios from various locations across Southeast Asia (Ancho et. al, 2021). Their findings found that schools that had fewer students per teacher performed better than the alternative (Ancho et. al, 2021). Schools that had 8-11.6 students per teacher performed 1.2 to1.4 times better than schools with approximately 15-36 students in each classroom (Ancho et. al, 2021). In this study, rural schools typically scored lower than urban schools, therefore the relationship between rural schools and student-teacher ratios is an area for exploration. This relationship was investigated further in a study that analyzed rural teacher's turnover rates in China (Cheng & Ding, 2023). This study found that schools in rural areas often have low retention rates of teachers, particularly when a teacher does not feel that they are able to make meaningful connections within a school (Cheng & Ding, 2023). Considering the low retention rates and high turnover rates of rural schools, making meaningful connections is more difficult, thus creating an increasing loop of teachers leaving a rural school (Cheng & Ding, 2023). The challenge of retention often results in rural schools

being understaffed (Cheng & Ding, 2023). As noted by Ancho et. al (2021), having elevated teacher-student ratios can hinder students' academic performance. Thus, rural teacher-student ratios as well as teacher retention are key factors that could hold an influence on academic performance.

Another factor that can have an impact on a student's academic performance is accessibility of technology in the classroom. A social studies review in California noted how modern technology can impact learning. Jordan (2018) notes the importance of student access to tools such as Microsoft Office, the Adobe Suite, and Prezi in the classroom. These tools can facilitate presentation skills, collaboration, and student creativity (Jordan, 2018). Another study discusses the importance of technology in the classroom by studying how the use of an interactive whiteboard can facilitate childhood learning (Bourbour, 2020). Findings of this study noted that actions such as manipulating digital objects, colors, animating, and dragging and dropping can assist an educator in presenting information in an engaging way (Bourbour, 2020). Furthermore, the large screen enables integrating virtual and real-world activities by connecting abstract concepts to something students can physically manipulate and interact with (Bourbour, 2020). Technology can also be integrated in the classroom to support literacy. An Australian study found that using iPads in early years of schooling can support learners in practicing literacy (Lynch & Redpath, 2014). This is largely due to the interactive nature and simple navigation system of an iPad. This format can support learning in the form of games, as well as a personalized experience that students can use to increase their digital fluency in a learning environment (Lynch & Redpath, 2014). Evidently, modern technology is a powerful tool for learning in a multitude of applications. Thus, a school's access to technology may have an impact on the overall academic performance of the institution.

The environment in which a student learns can have an impact on learning and academic performance. One study examined the relationship between school facilities and learning across the United States and the United Kingdom (Edvantia, 2006). They found that environmental impacts such as excessive noise and poor ventilation can have an impact on childhood academic performance. Furthermore, the researchers found that improving these environmental impacts can have a positive effect on childhood learning (Edvantia, 2006). A second study examined the difference between urban, suburban, and rural school environments. This study found that children in both large urban and rural areas academically scored lower than children in small urban areas and suburbs in both reading and math (Miller & Votruba-Drzal, 2013). They found that children in rural areas typically start school with lower reading and math performance than suburban children, potentially because they are often exposed to fewer educational materials and activities (Miller & Votruba-Drzal, 2013). Additionally, the researchers found that children in rural areas are less likely to attend center-based care settings, where reading and math skills can begin to develop at an early age (Miller & Votruba-Drzal, 2013). This shows how the environment in which a student learns can have an impact on their academic performance.

5.2.2 Personal Support

The support students have within their learning through resources such as family support, social support, and accessibility for different needs can have an effect on academic performance. Hill & Tyson (2009) investigated the relationship between parental involvement in middle school and academic achievement. They found that often, parental engagement in learning that focuses on goals and learning strategies has a strong positive relationship with a student's academic

achievement (Hill & Tyson, 2009). A second study examined the relationship between parental math anxiety and childhood math performance. This research found that children with math-anxious parents typically learn less math over the course of a school year (Retanal, 2021). They also noted that children who have parental math help often achieve higher academically than children without (Retanal, 2021). Thus. highlighting the potential impact of parental intervention in childhood education. This shows another external variable that can have an impact on childhood academic performance.

Within the lens of the level of personal support a child has, social support is another factor that can facilitate academic achievement. Hoferichter et al. (2022) investigated how social support can impact childhood academic performance through factors such as peer support. Their study noted that peer support is crucial to social, emotional, and cognitive development (Hoferichter et al., 2022). Students who had elevated levels of peer support from classmates reported higher abilities to cope in stressful situations as well (Hoferichter et al., 2022). They also investigated how social support from teachers also correlates to both academic achievement, and students' stress levels. This research revealed that teacher support is also related to lower stress and higher academic achievement in students (Hoferichter et al., 2022). Peer and teacher support can be combined through integrating collaborative activities in the classroom and providing opportunities for peer feedback and teacher mentorship. Social support can also be integrated in an academic experience through activities such as sports, or other extracurricular activities. This relationship was investigated in British school children to better understand how extracurricular activities can facilitate academic achievement (Bradley & Conway, 2016). They found that regular practice of organized sport, such as rowing or rugby, resulted in elevated self-esteem, self-concept, and school attachment. This study also found that organized school sport

can result in elevated academic performance as well (Bradley & Conway, 2016). Researchers also investigated activities such as extracurricular music groups such as school ensembles. They found that spending more time and effort into school based extracurricular activities, such as a band, can result in more devotion to schoolwork due to an increased sense of connectedness to the school. This research shows that there are various ways that students can access social support and gain a sense of connectedness (Bradley & Conway, 2016). If a school does not facilitate these opportunities for support or connection, there is a possibility that the school may have an overall lower academic achievement average. This finding highlights essential roles in students' development, and their impact on a student's achievement.

Concerning ways children can benefit from personal support, accessibility is another area that can influence academic performance. Students with disabilities are often faced with barriers in accessing education (Shaheen, 2022). Adaptations for physical disabilities such as ramps, elevators, automatic doors, and accessible bathrooms are necessary, but this is often the extent of accommodations for students will disabilities (Shaheen, 2022). If students cannot access necessary resources that facilitate learning, their academic performance is likely to suffer. As education becomes more digital, accessibility of technology is important for student success (Shaheen, 2022). Ladner et al. (2020) note various areas for technological accessibility such as adding captions to videos shown in the classroom, providing sufficient colour contrast on visual materials, installing screen readers on school computers, and ensuring sensory needs are met. Accessibility within schools is necessary for equitable learning at all school levels for student's academic performance and well-being.

5.2.3 Income

Family income is another factor that can impact academic achievement in elementary school. Due to its close ties with financial assets, as the rate of household after-tax income increases, food insecurity typically decreases (Tarasuk et al., 2022).

Lower familial income is associated with lower academic achievement among children (Morrissey et al., 2014). Research suggests that children with low-income families often show elevated rates of school absence and tardiness (Morrissey et al., 2014). A second study examined the relationship between socio-economic status and economic performance. This study ranked familial socio-economic status through indicators such as material wealth and possessions, parental education backgrounds, parental occupations, and the number of books that were present in the family home. Researchers compared this status to academic achievement by using standardized tests in reading and mathematics for fifth and eighth grade children. They found that socio-economic status is positively associated with children's academic achievement, showing that children who have a more advantaged socio-economic status performed better on reading and math tests. Within that study, they found that the correlation is stronger within reading compared to math. Interestingly, the current study found a stronger relationship between reading provincial scores compared to math in correlation with food deserts. Considering the link between food insecurity and income levels, this is consistent with the findings in this study. It is also important to note that there is a significant racial wage gap in Canada. A 2023 study conducted by Statistics Canada found that Black, Southeast Asian, Filipino, Chinese, and Korean men earned 11% to 13% less than their Caucasian counterparts with the same level of education (Statistics Canada, 2023). They also found that West Asian and Arabic women have the largest

income gap, earning 15% to 16% less than Caucasian women with the same level of education (Statistics Canada, 2023). As observed in previously noted studies, children who have lower levels of familial income often face academic barriers. Since BIPOC individuals face a disproportionate income gap, this could result in increased academic barriers for BIPOC children. Family income is an important factor that can impact academic achievement, particularly in elementary school. The findings of these studies suggest that lower levels of familial income and socio-economic disadvantage can lead to academic barriers, which may be more pronounced for BIPOC children due to the racial wage gap in Canada.

5.3 Future Directions

Considering the review of external variables, a future research direction could be adding one or more of the external variables to the study as an additional independent variable. This would allow for the quantification of other variables in the relationship to both food deserts, and academic achievement. Another direction for future research could be conducting a similar study in a different location. This could be used to see if patterns are similar within different school boards in Nova Scotia or could even be expanded to a federal or global level. Furthermore, this study could be repeated at a different age group. Future researchers could build upon results to examine racialized decisions that negatively impact BIPOC by examining the relationship between food deserts, and areas that are more racially diverse. This study solely focuses on sixth grade students, but future research could examine the relationship at older or younger age groups to see if the pattern persists. Furthermore, repeating the study over time to explore how both

variables are changing, particularly due to significant changes in both food security and school systems during the Covid-19 pandemic, is a direction for future exploration.

Chapter 6: Conclusion

Food deserts within HRM were found to be most prominent within the easternmost boundary of the county, particularly in areas such as Middle Musquodoboit, Markland, and Indian Harbour. A correlation between an elevated driving distance from a grocery store and lower academic performance was found but was more evident concerning reading than math. Although this study did find a correlation between the studied variables, it is likely that there are other explanatory variables at play. These may include factors such as school environments, family income, and the level of personal support a student has available to them. Variables such as these can be an area for future studies to examine. This study's findings can be implemented to assist in grocery store planning, allocating resources for school breakfast programs, or adding solutions such as mobile food markets to areas that are considered a food desert. This research suggests that there is a correlation between whether a sixth-grade student resides within a food desert with their academic performance, but other variables must be observed to gain a better understanding of the pattern.

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