Relationships among the number of food stores around schools, school level academic performance and school neighbourhood household income

by

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A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Science

in

Health Studies and Gerontology

Waterloo, Ontario, Canada, 2013

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Objectives: This study aimed to investigate the number of food stores (FS) within 500m, 1000m and 1500m of Region of Waterloo schools and describe them by type: full-service restaurants, fast food restaurants, supermarket and convenience stores; and then by elementary and secondary school levels. In addition, the associations among FS counts, median family income for the school neighbourhoods and school level academic performance were also examined.

Methods: Data for 2008 and 2010 on food stores, school addresses and school results on provincial academic tests (EQAO) were obtained from publicly available information (Region of Waterloo food inspection premises data; Waterloo Region District School Board and Waterloo Catholic District School Board; and Ontario's Education Quality and Accountability Office (EQAO) as well as the Fraser Institute, respectively). The 2006 Statistics Canada census data on median household income for Dissemination Areas surrounding schools was used as the proxy for income. Food stores were classified into the four store types based on the North American Industry Classification System (NAICS). The ArcGIS program was used to geocode the addresses of food stores and schools in the Region of Waterloo. It was also used to create the buffer zones (500m, 1000m and 1500m) around schools and to calculate the number of food stores within each buffer. In addition, multiple linear regression and logistic regression were used to explore the associations between food store counts to school neighbourhood income and school level academic performance indicators. School neighbourhood family income, parent education, students' competency in English and population density were considered as study covariates.

Results: From 2008 to 2010, the number food stores of all types increased in the Region of Waterloo as a whole. However, within the three buffer zones (500m, 1000m and 1500m), while

the number of full-service restaurants, convenience stores and total stores were higher in 2010 than in 2008, food store counts of fast food restaurants and supermarkets were not always higher in 2010 compared to 2008. Nevertheless, of all food story types, the counts were highest for fast food restaurants in both years (2008 and 2010) and at all buffer zones around schools (500m, 1000m and 1500m) as well as for the Region of Waterloo as a whole. In addition, negative associations were found between fast food restaurant, convenience store and total store counts and school neighbourhood family income. Furthermore, these associations remained robust even after controlling for population density. Regarding food store counts and students' academic performance, most of the significant associations were negative and were found for supermarkets, convenience stores and total store, with more significant associations in 2010 than in 2008. Most of the significant associations were found for elementary schools and when EQAO scores were treated as continuous versus binary variables. Interestingly, Grade 3 EQAO scores tended to be associated with supermarket and total store counts, whereas Grade 6 EQAO scores tended to be associated with convenience store and total store counts. Although several associations became insignificant after adjusting for study covariates (school neighbourhood family income, parent education and students' competency in English), many significant associations remained and followed the trends observed before controlling for the covariates.

Implications for practice: The totality of evidence from the current study suggests that the number of food stores around a school has a relationship to academic performance even when key factors such as neighbourhood family income and parental education are considered. If such associations were confirmed and explained through further research, there would be potential policy implications, for example, regarding zoning of food stores around schools and school practices.

Acknowledgements

First and foremost, I would like to acknowledge and express my sincere thanks to Dr. Rhona Hanning for the guidance, encouragement and support thorough my time as her student. I have been extremely lucky to have a supervisor who cared so much about my work and strongly supported my goals. Her kindness and understanding helped me overcome many tough situations and finish this dissertation. It is such a pleasure to be one of Dr. Rhona Hanning students.

I would also like to thank my committee, Dr. Scott Leatherdale and Dr. Jane Law, for the inputs with my research. I also want to acknowledge Steve Xu, former GIS library association and Erin Harvey, Statistical consultant at Waterloo University for the help with the geocoding and data analysis.

Students in my research group, especially, Jess Lieffers, Taryn Orava, Renata Valaitis, Michelle Gates, and Allison Gates, also deserve my sincere thanks. I am very thankful to be a member of a very supporting research group. Their friendship and warmth helped me acclimate with this new environment faster. Also, I also would like to send special thanks to Noel Butler, Mary Vu and Byung Wook Chang for their support thorough my time as a Master candidate.

Finally, I wish to thank my family, especially my mother who has always been silently supporting me from Vietnam.

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Glossary

FFRs: Fast Food Restaurants
FS: Food store
SES: Socioeconomic status
EQAO: The Education Quality and Accountability Office

I. INTRODUCTION

The childhood obesity rate has been increasing dramatically for the last couple of decades. Globally, "[It] is one of the most serious public health challenges of the 21st century" (World Health Organization [WHO], 2012). According to the WHO, 42 million children under the age of five were overweight in 2010 (WHO, 2012), representing an estimated increase in global combined overweight and obesity prevalence from 4.2% in 1990 to 6.7% in 2010 (Wang & Lim, 2012). If this trend continues, 9.1% of children (approximately 60 million) globally will be obese in 2020 (Wang & Lim, 2012).

Similar to many other developed countries, Canada is in the midst of a childhood obesity epidemic. Childhood overweight and obesity have been increasing steadily since the 1970s. Between1978 and 2004, the combined prevalence of overweight and obesity in children and adolescents increased from 15% to 26% (Public Health Agency of Canada [PHAC], 2012). In other words, one in four Canadian children and adolescents are overweight or obese (PHAC, 2012). However, it is believed that these figures, based on the International Task Force definitions, are underestimated. According to Statistics Canada, approximately one-third (31.5%) rather than one quarter of 5- to 17-year-olds (1.6 million) were classified as overweight (19.8%) or obese (11.7%) based on the WHO definition (Statistics Canada, 2010). WHO defines the cut-points for overweight as 25.4 kg/m^2 for boys and 25 kg/m^2 for girls, and for obesity, 29.7 kg/m^2 for both sexes (Shields & Tremblay, 2010).

Obesity has been found to be a risk factor for health problems such as metabolic syndrome, type-2 diabetes, cardiovascular disease, fatty liver, and osteoarthritis in children and adolescents (Becque, Katch, Rocchini, Marks, & Moorehead, 1988; Dâmaso, Prado, Piano, Tock, Caranti, Lofrano, & Mello, 2008; Saha, Sarkar, & Chatterjee, 2010; Krombholz, 2012; Wang &

Veugelers, 2008). Together with the health risks, some studies found a negative impact of childhood obesity on children and adolescents' academic performance (Mo-suwan, Lebel, Puetpaiboon, & Junjana, 1999; Fuxa, & Fulkerson, 2011; Cho, Lambert, Kim, & Kim, 2009). Studies have found that overweight and obese students are more likely to be absent from classes, have low self-esteem, or experience depression than others (Allen, Byrne, Blair, & Davis, 2006; Latty, Carolan, Jocks, & Weatherspoon, 2007; Wang, Wild, Kipp, Kuhle, & Veugelers, 2009; Janssen, Craig, Boyce, & Pickett, 2004; Krukowski, Smith, Philyaw, Bursac, Phillips, & Raczynski, 2009; Datar & Sturm, 2006). This might explain the lower academic performance among overweight and obese students compared to their peers. Malnutrition itself, which can co-exist with excessive energy intake or with dieting, is known to have a negative impact on students' performance at schools (Jamison, 1986; Soleimani, & Abbaszadeh, 2011; Masalha, Afawi, Mahajnah, Mashal, Hallak, Alsaied, . . . Wirguin, 2008)

In addition, a link between an unhealthy neighborhood food environment and childhood obesity has been found. For example, two studies in the US found that the proximity and counts of convenience stores or FFRs to the neighbourhood are associated with increased risk of overweight and obesity in children living in that neighbourhood (Galvez, Hong, Choi, Liao, Godbold, & Brenner, 2009; Leung, Laraia, Kelly, Nickleach, Adler, Kushi, . . . Yen, 2011). Meanwhile, studies have also found that food stores [FSs] are more likely to cluster within a walking distance of schools, and inexpensive and energy-dense foods are available to students within a 5- or 10-minutewalk of schools as a result (Day & Pearce, 2011, Seliske, Pickett, Boyce, & Janssen, 2009b; Zenk & Powell, 2008; Gebauer & Laska, 2011). If the neighbourhood food environment has a negative impact on childhood obesity, the counts of FSs around schools might also have a negative impact on students' Body Mass Index (BMI).

Furthermore, evidence has indicated that a disproportionate number of obese children and adolescents are from low social economic status (SES) families (Singh, Siahpush, & Kogan, 2010; Evans, Jones-Rounds, Belojevic, & Vermeylen, 2012; O'Dea, & Dibley, 2010). A negative correlation between SES and the counts of FSs has been found in some communities (Smoyer-Tomic, Spence, Raine, Amrhein, Cameron, Yasenovskiy, . . . Healy, 2008; Hurvitz, Moudon, Rehm, Streichert, & Drewnowski, 2009). If FS counts are higher in low SES communities, then it might also be higher around low SES neighbourhood schools since students tend to study at schools in their neighbourhood, although this might not always be the case for high school students. All in all, if the FS counts are higher around low SES schools, students at these schools are put under a higher risk of being obese.

The literature review section will provide a detailed picture of the current knowledge and research findings regarding factors related to the relationships between the counts of FS around schools to students' academic performance and schools neighbourhoods' **household income**.

II. LITERATURE REVIEW

The etiology of obesity is very complex. It includes many factors such as genetic, physiologic, environmental, psychological, social, and economic (Atkinson, 1999; WIN, 2008). However, the fundamental cause of obesity is the energy imbalance (Butte, Christiansen, & Sørensen, 2007; Bouchard, 2008; WHO, 2012). In particular, the excess of energy consumption (dietary intake or "Energy IN") in relation to the energy expenditure (including energy loss via physical activities or "Energy OUT") overtime will lead to obesity (Butte et al., 2007). Therefore, eating behaviour plays an important role in the development of obesity because it directly affects individuals' energy consumption or "energy IN". According to the Ecological framework, eating behaviour is complex and results from the interplay of multiple factors, in particular, Individual level factors (personal factors), Social environments (networks), Physical environments (settings), and Macro-level environments (sectors) (Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008). "The physical settings within the community influence which foods are available to eat and impact barriers and opportunities that facilitate or hinder healthy eating" (Story et al., 2008, p. 255). For example, a healthy neighborhood food environment would likely increase healthy eating among residents and vice versa (Story et al., 2008). In other words, the neighbourhood food environment (physical environment) can have an impact on the obesity rate via eating behaviour.

Additionally, the Framework for Action, adopted by the Public Health Agency of Canada in an effort of curbing childhood obesity, also emphasized creating a healthy food environment for children and adolescents and confirmed the importance of the built environment on a person's eating behaviour and as a result, obesity (PHAC, 2012).

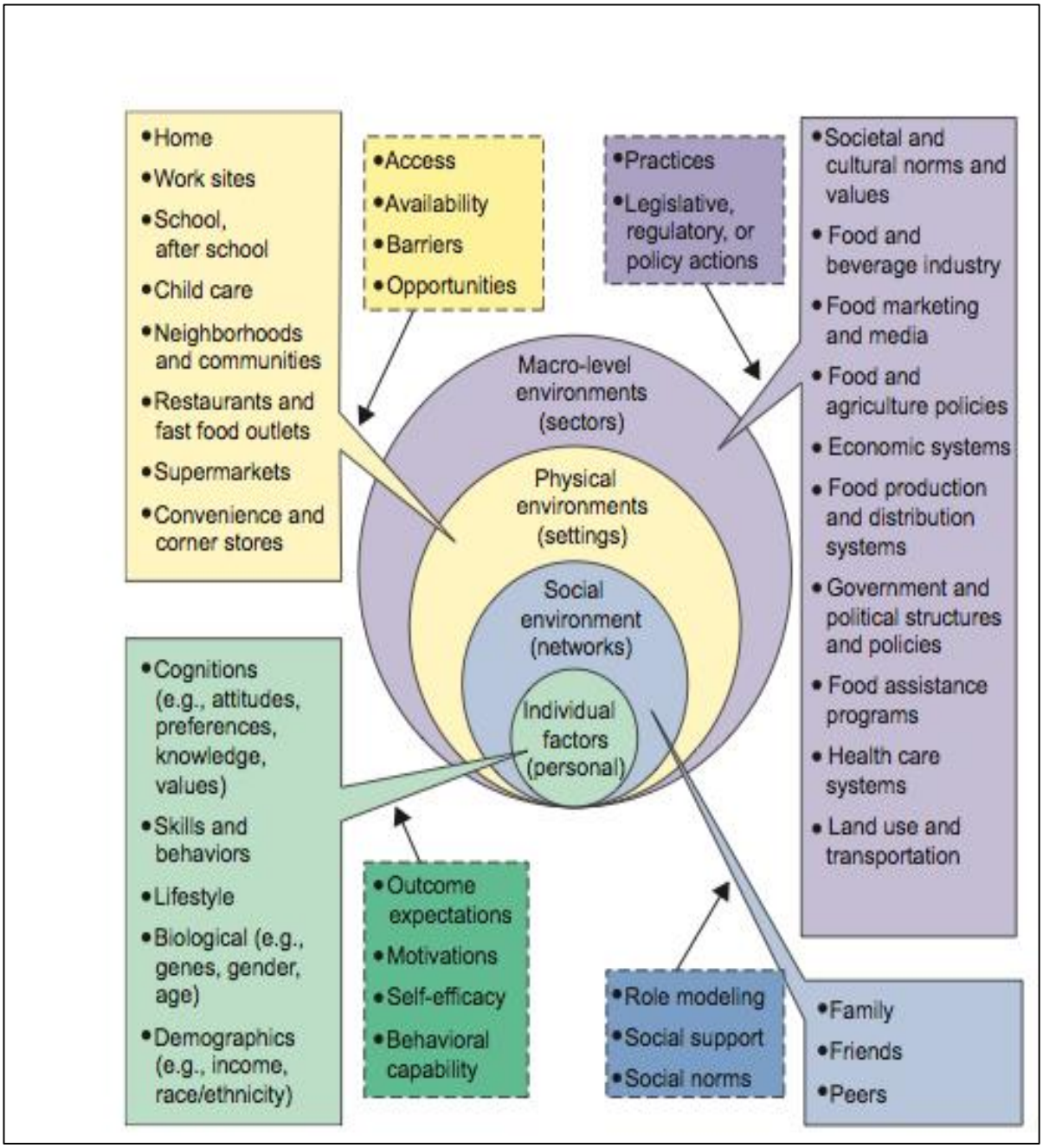


Figure II. 1: An ecological framework depicting the multiples influences on what people eat (Story et al., 2008).

This study will indirectly test the hypothesis about the impact of the built environment on people's eating behaviour by exploring the impact of the school neighbourhood food environment in the Region of Waterloo on students' academic performance and the relationship between the school neighbourhood food environment and school region **household income**.

Obesity has been found to link to negative school performance in students, an association that may potentially be mediated by, or may mediate, an association between SES and academic performance.

The literature section begins with findings about the school neighbourhood food environment. Next, it will provide the evidence about the impact of those environments on students' purchasing and consumption behaviour and BMI. Subsequently, the relationships between students' BMI and SES to their school performance and the relationship between school region household income and student performance will be explored. Finally, potential confounding factors will be discussed since they potentially affect study results.

1. Counts of FSs around schools

Studies have suggested that there is notable number of FSs around schools. For instance, in a study sample of 11 Maine high schools, six schools had at least one FFR within 800m; 23.3% and 64.8% of all public schools (1684 schools) in Los Angeles (LA) had one or more chain FFR located within 400m and 800m, respectively; and 35% and 80% of all public schools (1351 schools) in Chicago has at least one chain FFR within 400m and 800m (Harris, Blum, Bampton, O'Brien, Beaudoin, Polacsek, & O'Rourke, 2011; Simon, Kwan, Angelescu, Shih, & Fielding, 2008; Austin, Melly, Sanchez, Patel, Buka, & Gortmaker, 2005). Additionally, Austin (2005) found that FFR counts within 1500m from schools were three to four times higher than other areas thorough the city. A study sample of 13,462 youth aged 5-17 years drawn from the California Health Internet Survey showed that 55% of adolescents had at least one franchised FFR, and 28% had three or more within 10-minutes walking distance from their schools (An & Sturm, 2012). Nevertheless, only chain FFRs or chain restaurants that have more than ten outlets were included (An & Sturm, 2012; Austin et al., 2005). Hence, if all chain and non-chain or local

FFRs were included in each of these studies, the percentage of schools, which have at least one FFR within walking distance of schools, would be higher.

Similar to FFRs, convenience stores were also found to gather around school areas. Gebauer and Laska (2011) found that there was an average of 2.2 convenience stores around each junior high or high school in St. Paul, Minnesota, and 30 schools (83%) had at least one convenience store located within 800m (Gebauer & Laska, 2011). However, this study sample had a high percentage of low SES students (25 schools had more than 70% of students eligible for free or reduced price lunches compared to 70% of the national percentage) (New America Foundation, 2013). Also, the sample was drawn from an urban sample, which tends to have a higher FS counts compared to other areas (Zenk & Powell, 2008; Day & Pearce, 2011; Howard, Fritzpatrick, & Fulfrost, 2011). Hence, convenience store counts might be higher in this sample than a broad population-representative sample. Zenk and Powell (2008) also found approximately 37% and 33% of all public secondary schools in US (31,433 schools) have at least one FFR and convenience store within 805m, respectively. In the 20 largest cities in the US, this percentage was even higher: 68% and 56% for fast-food restaurant and convenience store, respectively (Zenk & Powell, 2008). A study conducted in New Zealand showed that the total number of FFRs and convenience stores within 800m of schools from five urban areas of Territorial Local Authorities (TLC) ranged from zero to 72 outlets, with a median of 3 (Day and Pearce 2011).

Similarly, studies conducted in Canada showed a cluster of FSs around Canadian schools. For example, in the Montreal Urban Community (MUC) schools (828 primary and 340 secondary schools), 50.4%, 72.9%, and 57.4% had one or more FFRs, full-service restaurants and fruit and vegetable stores within 750m, respectively (Kestens & Daniel, 2010). Another study conducted

in 118 schools across Canada also showed that 68% of the schools have one or more full service restaurants, 31.4% have FFRs, 28.2% have sub/sandwich shops, 34% have donut/coffee shops, 58% have convenience stores, but none of the schools had a grocery store within a 1km distance (Seliske et al., 2009b). Leatherdale, Pouliou, Church, & Hobin (2011) also found an average of 0.53 gas stations, 1.7 FFRs, 1.1 bakeries, 1.3 variety stores, and 1.8 supermarkets within 1 km distance among 30 elementary schools in Ontario.

Despite the differences in studied FS type, sample size, study population, and school location, all studies show that FSs are available within walking distance from schools. However, other than the studies conducted in Canada (Kestens & Daniel, 2010; Seliske et al., 2009b), studies did not include relatively healthy FS types, such as supermarkets or fruit and vegetable stores, in their analysis. Also, studies in Canada had contrasting results regarding the counts of such stores. While the studies in Montreal and Ontario found one or more fruit and vegetable stores within 750m or 1km around schools (Kestens & Daniel, 2010; Leatherdale et al., 2011), the study conducted in 188 schools across Canada found no supermarket within 1km distance from schools (Seliske et al., 2009b). Therefore, more studies conducted in Canada are needed to clarify the counts of other FS types around schools since these stores might also play a role in the food choices of students or families and, by association, the current obesity epidemic.

2. Counts of food stores (FS) by school levels

Available evidence shows that FSs gather around schools within a walking distance (5-10 minutes of walking). Nevertheless, FSs do not cluster to the same degree around all schools but appear to be at a higher surrounding secondary schools than middle and elementary schools. Regarding the fact that high school students are more likely to be allowed off campus activity during breaks and have greater access to finances, the results are understandable.

A study of 36 public junior high and high schools in Minnesota revealed that on average, junior schools have 1.9 convenience stores within 800m, while high schools have 2.5 stores located within 800m (Gebauer & Laska, 2011). Similarly, public high schools in Los Angeles had the highest percentage (30.9%) of one or more chain FFR within 400m compared to middle schools (24.3%) and elementary schools (21.7%) (Simon et al., 2008). One study conducted in New Zealand also found a higher FFR median (within 800m) around secondary schools compared to that (800m) of primary/intermediate schools (Day & Pearce, 2011). Interestingly, when all public middle and secondary schools (31,433 regular schools) across the US were included in the study, there was no difference in the counts of FFRs and convenience stores at different school levels (Zenk & Powell, 2008). Nevertheless, when only schools in the 20 largest cities in the US were included in the study, Zenk & Powell (2008) found that high schools had a higher FFR number (by 1.61 times), but a similar convenience store number within 805m (0.5 mile) of schools compared to middle schools

Although there were only a limited number of studies, findings indicated that the counts of FSs tended to be higher around high schools than elementary schools. However, this association seemed to occur only in urban areas, which have a higher population and commercial counts compared to rural areas (Langellier, 2012; Howard et al., 2011). It is possible that the number of FSs in rural areas is too small to form any trend in general. More studies are needed to explore the cluster of FSs around schools in rural areas. Furthermore, up to now, most of the studies were conducted outside Canada regarding this matter. More studies need to be conducted in Canada to reflect the pattern of FSs around Canadian schools according to school level.

3. Counts of FS around schools and students' purchasing and consumption behavior

As the Ecological framework proposes (Story et al., 2008), the built environment has an

influence on people's eating behaviour. For example, living near supermarkets increases the likelihood of consuming fruit and vegetables among residents (Morland, Wing, & Roux, 2002; Laraia, Siega-Riz, Kaufman, & Jones, 2004). Hence, home neighbourhood food environments, recreation centres where students go for out-of-school activities, route to schools, and school neighbourhood food environments all might have an impact on students' purchasing and consumption behaviour. Below are findings from the current literature about the relations between FSs around schools and students' purchasing and consumption behaviour.

A study conducted at 24 corner stores around ten elementary schools in Philadelphia showed that among students who shopped at corner stores, 53.3% reported shopping every day, 21.9% reported shopping two to four times per week, 42% reported shopping 2 times per day, 53.9% reported shopping once a day, and 28.8% reported shopping 2 times per day, 5 days/week (Borradaile, Sherman, Vander Veur, McCoy, Sandoval, Nachmani, & Foster, 2009). Additionally, the most frequently purchased items were energy dense, low-nutritive items such as sugar-sweetened and artificially flavored drinks, nacho cheese flavoured chips and candy (Borradaile et al., 2009). However, there are many limitations with the study. First, the study sample had a high percentage of low SES (80% of participants eligible for free and reduced meals compared to the national level of 70%) and minority participants (54% of students were black and 22.9% were Hispanic/Latino) (New America Foundation, 2013). Secondly, there were only 833 interviews, which might not be a large enough survey sample to generate a general conclusion about the effects of the FSs around schools to students' purchasing and consumption behaviour. Nevertheless, the one-on-one interview with the students provided in-depth information about students' purchasing behaviour.

Another study conducted at all middle and high schools in California, indicated that compared to

students at schools not located near a chain FFR, students attending schools located near a chain FFR had a significantly lower probability of reporting vegetable or juice consumption and a higher probability of reporting soda consumption on the day prior to the survey after controlling for age, gender, race and SES (Davis & Carpenter, 2009).

In Canada, findings from a study of 820 Grade 7-8 students from 21 elementary schools in London, Ontario suggestes that there is a positive correlation between the number of chain FFRs within a 1 km buffer of the school and the likelihood of students purchasing fast-food when parents or guardians were not present after controlling for grade, gender and father's level of educational attainment (He, Tucker, Gilliland, Irwin, Larsen, & Hess, 2012). However, there are some concerns with this study. For instance, the study sample is small (820 students) and predominantly white (82%). Furthermore, family SES information was also missing. Finally, "one purchase per week or more" was used as the cut point for the behavioural routine, which might not accurately reflect actual purchasing behaviour.

In contrast, a study used data from the 2005 and 2007 California Health Interview Survey (CHIS), which included 8226 children (aged 5-11 years) and 5236 adolescents (aged 12-17 years) and did not find any evidence to support the hypothesis that improving access to either supermarkets, FFRs or convenience stores would improve or worsen diet quality or California youth BMI (An & Sturm, 2012). Nevertheless, the response rate of the CHIS was relatively low (29.5% in 2005 and 21.1% in 2007), and a large proportion of participants (30.6% for children and 30.9% for adolescents) did not have valid school or residential addresses, which can affect study's results.

Most studies found positive associations the proximity of FSs such as FFRs or convenience stores around schools within a walking distance and students' purchasing and consumption of

fast food or packed foods. Only one study conducted in California, found no association between FS counts around schools and students' purchasing and consumption behaviour. However, most of studies were cross-sectional, which does not specify a causal relationship between the FS counts and students' purchasing and consumption behaviour, or if the association happened by chance. Furthermore, differences in sample characteristics (elementary student vs. high school student, high or low percentage of minority students, or high or low study SES sample) could lead to discrepancies in studies' results. No standard definition for portion size can also be a concern for the reliability of a study's findings where there is an attempt to relate food retail to actual student consumption (An & Sturm, 2012). Again, studies mostly focused on FFRs and convenience stores that provide unhealthy foods dominantly. While unhealthy FSs such as FFRs and convenience stores tend to have a negative impact on students' consumption behaviour, would healthy FSs such as supermarket or fruit and vegetable stores have a positive impact on students' eating behaviour? Comprehensive evidence and information is needed for policy makers in addressing the childhood obesity epidemic.

4. Counts of FSs around schools and students' BMI

Study findings suggested that FFRs and convenience stores around schools seem to be positively associated with the purchasing and consumption of fast food among students. Meanwhile, studies have also found clusters of FFRs and convenience stores around schools. Hence, it is expected that the high number of FSs around schools could have an impact on students' weight.

Two studies conducted in California, one including only Grade 9 students and the other including all middle and high school students, both found positive correlation between the FS counts within 400m and 800m around schools and students' BMI (Howard et al., 2011; Davis & Carpenter, 2009). In contrast, no association was found between counts of FFRs within 2km

driving distance of schools and BMI of 552 students in 11 high schools in Maine (Harris et al., 2011). However, this study population was small, predominantly white (96%) and from rural areas which can lead to a biased result. In addition, it is possible that students are more willing to walk 400m or 800m but not 2km to purchase foods at FSs around schools. Furthermore, if schools' vendors provide a good variety of food options, students are also less likely to walk 2km to purchase foods at FSs around schools.

A study of 2064 aged 9-10 children in North Fork, UK also revealed a positive correlation between the counts of convenience stores and FFRs around schools and student BMI among students who travel to school on foot or bike, after controlling for family SES (Harrison et al., 2011). The findings are not surprising because young children are usually not allowed to leave school property during breaks. Hence, if they traveled to school by car or bus, there would be fewer opportunities to purchase foods at FSs near to schools. As a result, the lack of a significant correlation between counts of FSs around schools and BMI among passive travelers is reasonable.

Findings from a study conducted in 30 elementary schools (Grade 5-8 students) in Ontario showed that the more FFRs and grocery stores surrounding a school, the more likely a student was to be overweight (Leatherdale et al., 2011). Nevertheless, the study sample was a convenience sample of schools participating in Play-Ontario (PLAY-ON) study; a study, which aimed to examine the correlation between physical activity and obesity. Also, BMI information was obtained from only 25% (1224 students) of eligible participants. Hence, the study sample and study design might not be optimal for finding the correlation between students' BMI and the counts of FSs around schools, and thus further study is warranted.

Interestingly, a study of 7176 Grades 6-10 students from 188 schools across Canada revealed a

completely different result from the above studies. This study found that students who had "access to fast-food restaurants, sub/ sandwich shops and doughnut/coffee shops were less likely to be overweight compared with those who did not have access to these types of food retailers within 1 km of their school". However, after adjusting for age, sex, physical activities, and SES, none of the associations between FS counts and student BMI remained significant (Seliske, Pickett, Boyce, & Janssen, 2009a). The study sample included schools across Canada and schools were selected in a manner that reflect the demographic characteristics (religion, community size, school size, and language of instruction) of each province and territory thorough Canada. However, 118 schools is a relative small sample and might not be a representative sample of Canadian students in Grades 6-10. Furthermore, it is possible that there was a positive correlation between the availability of FSs and the availability of facilities that promote physical activity, which was not controlled for in the study. As a result, the association between FFRs and students' BMI might be obscured.

In general, studies have shown mixed results regarding the association between FS counts around schools and students' weight status. Some found a positive correlation between the counts of FSs within 5-10 minute walking from schools and students' BMI (Howard et al., 2011; Harrison et al., 2011; Leatherdale et al., 2011; Davis & Carpenter, 2009). However, no association between the counts of FFRs around schools and students' BMI was also found in other studies (Harris et al., 2011; Seliske et al., 2009b). Also, it is surprising that the counts of supermarkets around schools increased the likelihood of obesity among students in those schools (Leatherdale et al., 2011). It is possible that students visited the supermarket to purchase chips or coke instead of fruit and vegetables. All in all, some studies either used a convenience sample (Leatherdale et al., 2011) or did not have a representative sample **(**Harris et al., 2011, Seliske et al., 2009b), which

might lead to reporting biased results. Furthermore, regarding the high prevalence of FFRs and convenience stores in other environment such as home neighbourhood, sport centres, theatres, students might purchase food at FSs but not necessary FSs around schools, a pattern that may reduce the impact of the counts of FSs around schools on students' weight status. Nevertheless, elementary students tended to attend schools close to their home. Also, children tend to use their pester power on parents to have their favourite food purchased during grocery shopping with parents at supermarkets (Turner, Kelly, & McKenna, 2006; Wimalasiri, 2004). This might partly explain for the negative association between supermarkets counts around school and students' BMI in the study conducted among elementary students in Ontario (Leatherdale et al., 2011

It is noteworthy that different growth references were used to measure students' weight status in different studies. Currently, there are three sets of growth references of overweight and obesity that can be used: Under the Centers for Disease Control and Prevention (CDC) produced in 2000, "children with a BMI at or above the 95th percentile for age and sex should be considered obese, and those with a BMI at or above the 85th percentile, but below the 95th percentile, should be considered overweight" (Shields & Tremblay, 2010). The growth reference standards of the International Obesity Task Force (IOTF), convened by an expert committee in 2000, indicate that a BMI$\geq$ 25 and BMI$\geq$30 are considered overweight and obese respectively (Cole, Bellizzi, Flegal, & Dietz, 2000). The WHO growth reference, produced in 2007, defines the cut-points for overweight as 25.4kg/m^2 for boy and 25kg/m^2 for girls, and obesity as 29.7kg/m^2 for both sexes (Shields & Tremblay, 2010). Due to the differences in the definition as well as the population used to create the reference, the three growth reference sets produce different obesity rates for the same population. Within that, the IOFT has the lowest obesity rate and the WHO has the highest rate of obesity when applied for the same population at all ages (Twells & Newhook,

2011). In other words, the prevalence of childhood obesity is dependent on the growth reference used. This could be another reason for the difference in study findings among studies. Finally, weight-collecting methods (self-report versus measured data) can also be a problem for the discrepancies among study results. Overall, measured weight and height is more accurate than self-report data (Shields & Tremblay, 2010). However, it is very hard to have measured weight and height of students; hence, self-report data would be a reasonable data for social science studies. Also, above studies discover the trend for longitudinal study in the future in exploring the causality of the relationship between FS counts around schools and student BMI. Furthermore, having a gold standard method for growth reference such as WHO growth reference is also important.

5. Student weight status and academic performance

Obesity has been linked not only physical health problems, one of the reasons for school absence among overweight and obese students, but also mental health problems such as low self-esteem, depression in children and adolescents due to he weight/shape concern, the negative stigma and teasing from peers (Allen et al., 2006; Latty et al., 2007; Wang et al., 2009; Janssen et al., 2004; Krukowski, Smith West, Philyaw Perez, Bursac, Phillips, & Raczynski, 2009; Datar & Sturm, 2006). Therefore, it is possible that physical and mental health problems might constrain obese children and adolescents from achieving as high academic performance as their peers. For example, a study conducted in 5200 Grade 5 student in Nova Scotia, Canada found that students who consumed more fruit and vegetables and fewer low nutrition foods were less likely to fail the reading and writing assessment (Florence et al., 2008). Certainly, poor nutritional status and poor diet have been linked to suboptimal academic achievement (Florence, Asbridge, & Veugelers, 2008; Galal & Hulett, 2003).

A 4-year follow-up study of 7,000 US kindergarteners drawn from the Early Childhood Longitudinal Study (ECLS) found an adverse association between girls who became overweight between kindergarten entry and third Grade and math and reading achievement after controlling for gender, age, race, household income, mother's education (Datar & Sturm, 2006). However, the link was not found in boys. Interestingly, a cross-sectional study of 13,680 children in third Grade, which was also drawn from the ECLS found no difference between the normal weight and overweight and obese groups in both genders for reading achievement after adjusting for family SES, maternal education, and race (Judge & Jahns, 2007).

A telephone survey of randomly selected parents of Arkansas public school children indicated a negative correlation between overweight status and school performance among elementary school students but not among middle school students (Krukowski et al., 2009). Another cross-sectional study with self-reported Grade point average (GPA) among 79,127 Grades 9 and 12 students in Minnesota showed a significant relationship between overweight and low GPA (Fuxa & Fulkerson, 2011). Nevertheless, the GPA was calculated by asking students to mark the two Grades that they received most often which might not accurately reflect the actual GPA of students. Three studies were conducted in Asia: a 2-year longitudinal study of 1764 students Grades 3 to Grade 9, a 6-year longitudinal study in one elementary district school in Taiwan and a cross-sectional study of 1,346 high school students in Korea (Mo-suwan, Lebel, Puetpaiboon, & Junjana, 1999; Chen, Fox, Ku, & Wang, 2012; Cho et al., 2009). Within that, there were no significant associations between GPA and BMI status for elementary students (Chen et al., 2012), but were for middle and high school students (Mo-suwan et al., 1999; Cho et al., 2009). Barrigas and Fragoso (2012) also found no differences in performance in Portuguese, Mathematics and Sciences between overweight and normal weight students aged 6-12 years old

in Lisbon, Portugal.

An 11-year follow-up study of a sample of 4,664 children in 10 provinces in Canada showed no differences in math performance between children in the two groups, "always overweight" and "become overweight", after controlling for grade, age, sex, and household income (Carter, Dubois, & Ramsay, 2010). However, students' weight was not measured every year but in the fourth and tenth year of the study, which might lead to a misclassification of students' weight status.

Logically, the damaging effects of obesity should be observed in older age students such as high school students rather than elementary school students due to having a longer exposure to obesity, assuming that overweight or obese status begin early in life. Generally, study findings showed the correlation between overweight status and low academic performance among high schools students (Judge & Jahns, 2007; Mo-suwan et al., 1999; Cho et al., 2009; Barrigas & Fragoso, 2012; Neckerman, Bader, Richards, Purciel, Quinn, Thomas, Rundle, 2010). However, some study results showed the opposite pattern in which there was a negative correlation between students' BMI and academic performance among elementary school students but not among middle school students (Krukowski et al., 2009; Datar & Sturm, 2006). It is possible that important confounders such as parent education or SES were not controlled in some studies resulting in biased results (Fuxa & Fulkerson, 2011; Krukowski et al., 2009). Study findings suggested that parent education as well as are positively associated with children's academic performance (Rindermann, Michou, & Thompson, 2011; Myrberg & Rosén, 2008; Davis-Kean, 2005; Boggess, 1998; Pong, 1997).

In addition, differences in study design, e.g., cross-sectional vs. longitudinal, are also a source for the discrepancies in study findings. Cross-sectional studies collect information and measure

the association between the exposure and outcomes at one point of time. Hence, it is impossible to establish the causal relationship between the exposure and outcomes. In contrast, longitudinal studies follow participants over time and hence can establish a causal relationship between the exposure and outcomes.

Furthermore, consequences of obesity take time to express. Hence, different study samples might have participants that experience the onset of overweight or obesity at different life stages, which might partly explain why the association between weight status and academic performance was found in elementary students but not middle or high school students. Finally, the reliability of self-report data, e.g., academic performance and students' BMI data, again can reduce the accuracy of study results.

6. SES and students' academic performance

Study findings are relatively consistent in term of the impact of family SES on students' academic performance. Sutton and Soderstrom (1999) found that variables such as race, SES, attendance, mobility and dropout rate were better predictors of Grade 3 and Grade 10 students' academic achievement in reading and mathematics than class size, teacher experience, teacher salary. In other words, students' performance at school is strongly influenced by their demographic and SES (Sutton & Soderstrom, 1999). Similarly, another study conducted at all 73 public schools in New Hampshire found that unemployment rate, adult education and parent SES explained for over half of the variation in average standardized test score [NHEIAP test]" (Toutkoushian & Curtis, 2005,). The NHEIP test included five measurements for each school: English, mathematics, proportion of graduating students attending 4-year college or university after graduation, and proportion of students who took the Scholastic Aptitude Test (PctSAT). Study results showed that students from lower SES community (high unemployment rate, low

percentage of adults with at least a bachelor degree, and high percentage of students eligible for free and reduced meals) had poorer NHEIP score than students from higher SES community (Toutkoushian, & Curtis, 2005). However, it should be noticed that the standardized test scores (one time test scores) might not always accurately reflects the average performance of students.

A study was conducted in 4,600 students aged 15 across regions in Turkey (Marmara, Aegean, Mediterranean, Middle Anatolia, Black Sea, East Anatolia, Southeast Anatolia, and Istanbul). Although the correlations between median household income and parent education and students' performance varied across the regions, study findings still showed that household income and parent education were positively correlated with students' achievement in mathematics, reading and science (Tomul & Çelik, 2009).

In Canada, a study aiming to assess the readiness to learn among 3,923 five-year-old children showed that compared to children in low SES families, children in higher SES families score higher in receptive vocabulary and in number knowledge (Thomas, 2006).

All in all, although different studies used different measurements for family SES and had study samples that were different in age, the findings suggested that household income or family SES is positively correlated with students' academic performance. Parent education was sometimes, but not always, considered as a confounder. It is unknown whether some of the variance in the relationship between SES and academic achievement may be affected by diet. Logically, any association found between FS counts and academic achievement might be influenced by school neighbourhood household income.

7. Counts of food outlets around schools and school neighbourhood household income

Health disparity by SES such that low SES populations tend to have lower health status than

higher SES populations is no longer a new issue for public health. There are several reasons for the disparities, and the built environment, including the neighbourhood food environment, is one of those. Hence, if there is higher counts of 'unhealthy' FSs around low SES region schools compared to other schools, students in low SES region schools are potentially at higher risk of obesity compared to their peers. Therefore, policy-makers should pay more attention to this specific environment in order to reduce inequities that might contribute to childhood obesity.

Two studies conducted in public schools in California both showed that schools located in low-income neighbourhoods were more likely to be located near to or have higher counts of convenience stores and FFR (Simon et al., 2008; Howard et al., 2011). However, one study included only chain FFR that have more than 10 outlets in Los Angeles (Simon et al., 2008). In contrast, another study also conducted in Chicago (n = 1478) showed a different result. Highest income areas ($43,700 or greater) had the highest counts of chain FFRs but there was no cluster of FFRs in the lowest income area (<$43,700) (Austin et al., 2005).

A study conducted in all US secondary and middle schools showed that schools in the highest SES neighbourhood had fewer FFRs and convenience stores compared to schools in the lowest SES neighbourhood (Zenk & Powell, 2008). Another study conducted in all US middle and secondary schools found a positive correlation between the number of low SES students and the counts of convenience stores and restaurants within 400m (Sturm, 2008). It should be noted that full-service restaurants and limited-service restaurants were included under the restaurant category in this study.

Similarly, a study in New Zealand found that the median number of all types of FFRs and convenience stores increased with the degree of social deprivation of the schools (Day & Pearce, 2011). In particular, schools in the most socially deprived areas had three times the median

number of FFRs and convenience stores compared to schools in the least deprived areas.

Two studies conducted in Canada also showed a similar association. In particular, a study of 28 primary schools and 340 secondary schools in Montreal Urban Community showed that compared to schools located in the highest neighbourhood SES quartile, schools in the lowest SES quartile neighborhood had a higher percentage of one or more FFRs (80.8% - 12.0%), full-service restaurants (97.6% - 34.6%) and fruit and vegetable stores (88.0% - 19.9%) within 750m (Kresten & Daniel, 2010). Another study with 118 schools across Canada found a positive association between full- service restaurant counts and school neighbourhood SES (Seliske et al., 2009b). In particular, 28.3% of low SES schools had one or more full-service restaurants, while this percentage in medium and high SES schools was 33.6% and 38.3%, respectively. However, 188 schools might not be a large enough sample to be representative of Canadian students and the Canadian neighbourhood school food environment. Furthermore, even though the sample was representative in terms of regional geography, students' religion, community size, school size and language of instruction, it was not representative in terms of SES, race and gender. A larger sample size or a more complete sample within one geographic area might provide a more reliable result.

Although study findings were relatively consistent, except for a study conducted in Chicago, it should be noted that studies used different definition of SES. For example, some studies used census tract median annual household income (Day & Pearce, 2011; Kresten & Daniel, 2010; Simon et al., 2008; Austin et al., 2005; & Zenk & Powell, 2008), other used the percentage of students eligible for free and reduced meals (Howard et al., 2011), or a combination of household income, occupation, household crowding, and parent education (Seliske et al., 2009b). However, all in all, studies showed that there was a negative correlation between the FS counts around

schools and school regions' SES.

8. Study covariates

Several covariates that were considered in previous research such as SES and parent education were also relevant to the current thesis research. In addition, physical activity, students' competency in English and population counts were also controlled for.

8.1. Parent education

Evidence suggested that parent education has an impact on students' academic performance. For instance, Rindernmann (2011) found an association between parent education and their children's writing ability (Rindermann et al, 2011). Similarly, a study in seven countries (Hungary, France, Bulgaria, Norway, Sweden, Italy, Hong Kong) suggested that that parent educational level is an important predictor of reading achievement in children in all countries, except for Hong Kong. In particular, the higher the parent education is, the higher the reading achievement by their children (Myrberg & Rosén, 2008). Another study found that for African American students, parent education had an indirect influence on children's academic achievement through the parent educational expectations and parent–child interactions. However, for the European American students, parent education had both a direct and indirect relation to children's academic achievement (Davis-Kean, 2005). Hence, parent education could be a confounder in any relationship between the counts of FS around schools and students' academic performance.

8.2. Students' competency in English

As a cultural diversity country, Canada is made up by people from different ethnicities and mother languages. However, only English and French are the main languages in Canada, in

which English is the more predominant counterpart. Even though there were several programs, for example English for Academic Success, to help immigrants students to improve their competency in English, being master in English as their counter parts is till a matter for many immigrant students. Studies found that students with limited English proficiency (LEP) seemed to lag behind their counterparts, native-born students, in school performance. Stranda & Demieb (2005) found that compared to students who were native-born in UK, new immigrant students who were not fluent in English had lower reading, writing, math and science scores on the national test at the end of primary school. The differences in the test scores were more profound for reading and writing than math and science. The results were robust after controlling for factors such as age, sex, free school meal eligibility, and race (Strand & Demie, 2005). Another study conducted among first year ESL nursing students in Australia found that English language proficiency, measured by English Language Acculturation Scale (ELAS) scores, was a strong predictor for students' Grades. In particular, students with the lowest ELAS scores had the lowest mean Grades in all the tested subjects (behavioural science in nursing, Theoretical frameworks in nursing, Nursing practice, and Bioscience in nursing) (Salamonson, Everett, Koch, Andrew, & Davidson, 2008).

8.3. Physical activity (PA)

Physical activity (PA) was found to have a negative relationship with the level of obesity. For example, a study conducted in Japan found that compared to their counter parts in urban areas, Grade 7 students in rural areas were less likely to walk to schools (lower step counts) and more likely to be overweight and obese (Itoi, Yamada, Watanabe, & Kimura, 2012). Another study conducted in 7908 adults in Australia showed that participants engaged in a minimum of 150 minutes of moderate-to-vigorous intensity physical activity in at least five sessions the week

before the survey were less likely to be classified as overweight or obese" (Duncan, Vandelanotte, Caperchione, Hanley, & Mummery, 2012). Similarly, Dwyer, Freedman, Engell, Fleming, Lim, Murray, & Mokdad (2013) found a negative correlation between physical activity and obesity rate in adults aged 20 or older across several counties in US. Even though the correlation was weak, it was robust after adjusting for race, education, poverty, unemployment, and urban–rural status and thus obesity should be considered an indirect factor that may affect students' school performance. Hence, PA, as a substitute measurement for students' weight status, was also controlled for in the relationships between FS counts and EQAO scores

8.4. Population density

Evidences have showed that high population density areas tend to have higher number of FSs (Zenk & Powell, 2008; Day & Pearce, 2011, Howard et al., 2011; Austin et al., 2005; Neckerman et al., 2009). In other words, urban areas might have higher FS counts compared to those in rural areas, which might affect the association between FS counts and school neighbourhood SES. Therefore, population density were also controlled for in the relationship between FS counts and school neighbourhood income.

III. RATIONALE FOR THIS STUDY

1. The gap in the current literature

All in all, the literature review showed that none of the studies conducted in Canada examined the counts of FSs by school levels. Hence, it is necessary to have more focused studies to examine such relationships. Moreover, to date, studies mostly investigated the relationships between the FS counts around schools to students' eating behaviour or BMI. A relationship between the FS counts around school and students' academic performance has not been explored in Canada or elsewhere. Since academic achievement is the core business of schools, demonstrating its link to diet could support efforts to enhance health promotion within schools.

Furthermore, FFRs and convenience stores are the FS types that have been studied dominantly. While most studies showed a negative association of these types of FSs to students' eating behaviour and BMI, it is possible that healthy FSs such as fruit and vegetables or supermarkets might have a positive impact on students' eating behaviour and BMI. The scant number of studies seems to yield mixed results for the impact of healthy FSs on students. For example, Leatherdale (2011) and Kestens (2010) found the presence of supermarkets within 700m to 1000m buffers around schools. In contrast, Seliske (2009a) did not find any supermarket within 1000m-distance from schools, so the association wasn't able to test for. Hence, it is necessary to have more studies to shed light on this matter. Studies also seem to focus on chain and brand FFRs and leave out local stores. This could lead to distorted results since local FSs might also influence students' food consumption and hence BMI or academic performance.

Finally, findings about the association between FS counts and EQAO scores from this study could be used as the baseline measurement data for future studies in evaluating the impact on the

policy on students' academic performance.

2. This study

This study is a part of a larger research project – Evaluating the Ontario School Food and Beverage Policy (P/PM150). The P/PM150 policy aimed to create a healthy school food environment for students to reduce the obesity rate and maximize/enhance students' social well-being and academic performance (Ministry of Education Ontario, 2010). According to this policy, 80% of the foods offered for sale in all school venues (Sell Most category) have to be healthy foods (defined as low in sugar, fat and salt), and the remaining 20% (Sell Less category) can have slightly higher amounts of sugar, fat or salt compared to foods in the Sell Most category. A further category of foods must be unavailable altogether (Ministry of Education Ontario, 2010). As a result, the policy created a healthier school food environment if schools had sold less healthy foods previously. However, a change in the school food environment might not guarantee a change in students' purchasing and eating behaviour spontaneously. It is possible that students will opt out to purchase foods at FSs around schools. As a consequence, improvement in wellbeing and academic performances might not be realized regardless the ongoing of the P/PM150 policy applied in schools.

Hence, this study will focus on the potential impact of an environment factor, in particular, the counts of four types of FSs (full-serviced restaurants, fast-food restaurants, supermarkets, and convenience store) within 500m, 1000m and 1500m around each school on student performance in the Region of Waterloo.

In addition, this study set out to fill in gaps in the current literature about the effects of the FS counts of around schools on students. First, this study aimed to provide more evidence and

knowledge about the counts of FSs around schools in general and specifically by school levels in the Canadian context, in particular, schools in the Region of Waterloo. Second, the study aimed to explore the relationships between the counts of FSs around schools in relation to the schools' students' academic performance and school neighbourhood income. This relationship had not been studied elsewhere to-date. Third, other store type such as full-service restaurants and supermarkets in addition to FFRs and convenience stores were were also included in the analyses.

Furthermore, it is hypothesized that FS counts mediates academic performance through students' eating behaviour and weight status. However, students' eating behaviour and BMI data are missing in this study. Nevertheless, there is merit in describing the food retail environment around schools and documenting any changes over time within that environment. There is a perception that FSs such as FFRs and convenience stores congregate around schools, but the reality of the situation in Region of Waterloo is unstudied. Moreover, if an association between FS counts and students' academic performance is indicated, this will resonate with educators and may suggest potential intervention, e.g., regarding school zoning regulation. If a relationship between FS counts and school neighbourhood income is found, such that dominantly unhealthy food retail is more available in areas of lower SES, the disparity will need to be addressed.

Moreover, current knowledge also suggested that SES might associate with students' academic performance, such that, students from high SES families tend to have better performance at school compared to those from lower SES families. Hence, the association between FS counts and EQAO were examined with and without controlling for SES or **household income** in the current study to explore the impact of **household income** on the association. In addition, parent education, students' competency in English and students' physical activity were controlled since

those factors could all independently affect students' academic performance.

Furthermore, consequences of food choice tend to happen after a certain time of exposure. Hence, older children (Grade 9) might experience stronger effects than younger children (Grade 3 and Grade 6). Therefore, a comparison of the impacts of the counts of FSs across elementary and secondary schools on students' academic performance would clarify whether the counts of FSs around schools has a stronger impact on older students (Grade 9 compared to Grade 3 and 6).

3. Study objectives

There are three main objectives to this study

I. To describe and compare the counts of different types of food outlets within 500m, 1000m and 1500m around all schools in the Region of Waterloo using 2008 and 2010 geocoding data.

To compare the counts by school levels (elementary schools/middle schools and secondary schools).

II. To explore the relationships between FS counts around schools within 500m, 1000m and 1500m in the Region of Waterloo in 2008 and 2010 and school neighbourhood income (based on 2006 dissemination data).

III. To explore the relationships between FS counts around schools (within 500m, 1000m and 1500m) in the Region of Waterloo and students' academic performance (based on 2008 and 2010 Education Quality and Accountability Office's [EQAO] test scores) with and without adjusting for potential influences of school neighbourhood SES, parent education and students' competency in English.

To compare the associations above by school level (elementary/middle schools versus

secondary schools).

To compare the associations between FS counts and EQAO scores between 2008 and 2010.

4. Study hypotheses

There are eight hypotheses for this study

I. There would be at least one FS around schools within each buffer zone around schools (500m, 1000m and 1500m) on average.

II. There would be more FSs around schools in 2010 than in 2008.

III. There would be more FSs around high schools then elementary (middle) schools.

IV. There would be negative associations between the FS counts around schools and school neighbourhood income.

V. There would be negative associations between the FS counts around schools and students' academic performance.

VI. There would be more associations between FS counts and secondary students' academic performance than elementary students.

VII. The associations between FS counts and students' academic performance would be insignificant or weakened after controlling for school neighbourhood income, parent education and students' competency in English.

VIII. Given the postulated higher number of FSs in 2010, there would be more consistent and stronger associations between FS counts and students' academic performance in 2010 compared to those in 2008.

IV. METHODS

1. Introduction

This study aimed to describe FS pattern around schools in the Region of Waterloo and explore the change in FS counts between 2008 and 2010. Then, the relationships between FS counts (in 2008 and 2010) and school neighbourhood household income studied. Next, the relationships between FS counts and students' academic performance (EQAO scores) in 2008 and 2010 were examined with and without school neighbourhood household income, parent education, students' competency in English and students' physical activity.

2. Data collection

The data collection process included collecting the addresses of all schools and FSs, EQAO scores of Grade 3, Grade 6, Grade 9 and Grade 10 students, school neighbourhood household income, parent education, students' physical activities, the students' competency in English, and population density. The data were collected in the Region of Waterloo.

2.1 Addresses of all schools and food outlets in the Region of Waterloo

In order to measure the counts of FSs around schools, all FSs and schools' addresses in the Region of Waterloo in 2008 and 2010 were collected and geocoded.

2.1.1. Food outlet addresses

Food outlet data were obtained from the 2008 and 2010 food premises inspection data published by the Region of Waterloo (RW Public Health, 2012). The data included all facilities/stores that sell food either to the public or to certain type of customers such as business sector employees or home care residences only. It is recognized that a more current and longer period of data

collection would provide a more accurate results about the relationship between EQAO and FS counts. However, due to the data availability issues, only 2008 and 2010 FS counts and EQAO scores were included in this study.

2.1.2. School addresses

All public and catholic schools within the Region of Waterloo at the time of data collection (2012) were included. The list of public school in Waterloo was obtained from Waterloo Region District School Board (WRDSB, n/d) and Catholic schools were obtained from Waterloo Catholic District School Board (WCDSB, n/d) in 2012 at the time of the data collection, assuming that there was the same number of schools in 2008 and 2010 to the time of the data collection (2012).

2.2. Students' academic performance

2008 and 2010 Education Quality and Accountability Office's (EQAO) test scores, obtained from the EQAO web site and the Fraser Institute website, for Grade 3, Grade 6, Grade 9, and Grade 10 were used as a measurement of students' academic performance (EQAO, 2012; Fraser Institute, n/d). The EQAO scores is a provincial test that measures students in relation to the Ontario Curriculum expectations (Appendix A) (EQAO, 2012). Grade 3 and 6 students were assessed in reading, writing and mathematics; Grade 9 students were assessed in mathematics (applied mathematics and academic mathematics); and Grade 10 students were assessed in literacy (Fraser Institute, n/d; EQAO, 2012). EQAO scores were available for each subject for each Grade and were standardized into four levels (1, 2, 3, and 4), except for the Grade 10 literacy score, which was reported as the percentage of students of that school who passed the literacy test (EQAO, 2012; Fraser Institute, n/d). Level 3 is considered as the provincial standard

and a score higher than 3 is considered as above provincial standard (EQAO, 2012). The overall score, an overall rating out of 10, of each elementary school is a composite of reading, writing and mathematics average score from Grade 3 and Grade 6 (Appendix B) (Fraser Institute, n/d). The overall score, an overall rating out of 10, of each secondary school is a composite of applied mathematics and academic mathematics average scores from Grade 9, literacy scores for Grade 10 (Appendix C) (Fraser Institute, n/d). The overall score for each school can also be obtained from Fraser Institute website (EQAO, 2012; Fraser Institute, n/d).

2.3. School neighbourhood household income

The 2006 median household income data for each school at dissemination area (DA) from the Statistics Canada census data were used as a proxy for school region income (Statistics Canada, 2012) (Appendix D). The six-digit postal code of each school was used to search for the corresponding DA code using the postal code conversion file (PCCF) 2007 (University of Waterloo, 2012). Then, the DA code was used to define the median household income of families reside in a specific DA. These were the most recent census data available at the time of data collection. If the income data at the DA level for a specific school were not available, the median income level at the census tract level was used.

2.4. Parent education

The 2006 education attainment of the population aged 25-64 at census tract level was used as a proxy for parent education for students at schools reside within that census tract (Statistics Canada, 2012). There are three categories for parent education used in this study: less than high school, high school, some colleges, and bachelor degree or over.

2.5. Physical activity and English competency

Information of student physical activities and English competency were obtained from the EQAO reports (EQAO, 2010). PA information was only available for 2010 elementary students. Therefore, only PA information in 2010 was obtained for this study. Data of PA were the percentage of students who indicated that they participated in sports or other physical activities everyday when they were not at schools (EQAO, 2010). Similarly, data of English competency was the percentage of Grade 3, Grade 6 and Grade 10 students who indicated that they speak only or mostly English at home.

2.6. Population density

The 2006 population density at dissemination areas from Statistics Canada was obtained. The six-digit postal code of each school was used to search for the corresponding DA code using the postal code conversion file (PCCF) 2007 (University of Waterloo, 2012). Then, the DA code was used to define the population density of each dissemination area, in which a school resided.

3. Data processing

Data processing included geocoding FS and school addresses as well as calculating FS counts around school within 500m, 1000m and 1500m buffers.

3.1. Geocoding process

"Geocoding is the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface" (ESRI, n/d). For example, addresses of FSs and schools in the Region of Waterloo were located to the Waterloo Region street map. The ArcGIS (ESRI, version 10.0), a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data, was used to

geocode and calculate the counts of FOs around schools within 500m, 1000m and 1500m buffer (ESRI,n/d).

The 500m, 1000m and 1500m buffer zones were chosen because these distances have been used in other studies (Day & Pearce, 2011; Austin et al., 2005; Neckerman et al., 2010; Zenk and Pwell, 2008; Seliske et al., 2009a; He et al., 2012; An & Sturm, 2012; Van der Horst et al., 2008; Harrison et al., 2011; Davis and Carpenter, 2009; Seliske et al., 2009b), and they represent 5-15 minute walk, which is reasonable for students to walk during breaks or before and after school.

Also, the ArcGIS program was used by several precedent studies to geocode school and FS addresses, create buffers around schools and calculate FS counts around schools (Howard et al., 2011; Harrison et al., 2011; Van der Horst et al., 2008; An and Sturm, 2012; He et al., 2012; Seliske et al., 2009a; Zenk and Powell, 2008; Simon et al., 2008; Neckerman et al., 2010; Day & Pearce, 2011).

3.1.1. Preparing the address data file

First, this study only focused on FSs that were open to public and were accessible to elementary and secondary students. Therefore, FSs that served certain type of customers exclusively such as FSs installed in office buildings, hospitals, retirement homes, sport centers, theaters, etc., were not be included. In addition, apartment or unit numbers were deleted from the address because they are not needed for geocoding and can cause geocoding errors since ArcGIS may interpret an apartment number as a street number (Tufts Open Courseware, n/d). Furthermore, FSs with range addresses, such as 70-94 Bridgeport Street, were checked by Yellow Pages listing or the telephone directory to determine the exact street number to reduce geocoding error. Then, address files were converted into the data based-compatible file format, comma separated values

(.csv), the proper file format for the geocoding by the ArcGIS program (Tufts Open Courseware, n/d).

BusinessNa	City	Address
KINGS BUFFET	CAM	1 HESPELER RD
SUBWAY - 1 HESPELER	CAM	1 HESPELER RD
FRESH CO.	CAM	1 HESPELER RD
SMOKE & VARIETY	CAM	1 HESPELER RD
COFFEE CULTURE CAFE AND EATERY	KIT	1 KING ST W
RUM RUNNERS PUB	KIT	1 KING ST W
CAPER'S SPORTS BAR	KIT	1 QUEEN ST N
EQUITABLE LIFE	WAT	1 WESTMOUNT RD N
PHO BEN THANH VIET-THAI RESTAURANT	CAM	10 PINEBUSH RD
FLOW CAFE & CATERING	ELMIRA	10 CHURCH ST W
BRESLAU EXPRESS	BRESLAU	10 DOLMAN ST

Figure IV.3.1.1.1: The address file of food outlets in the Region of Waterloo (RW Public Health, 2012)

BusinessNa: Food store name or school name

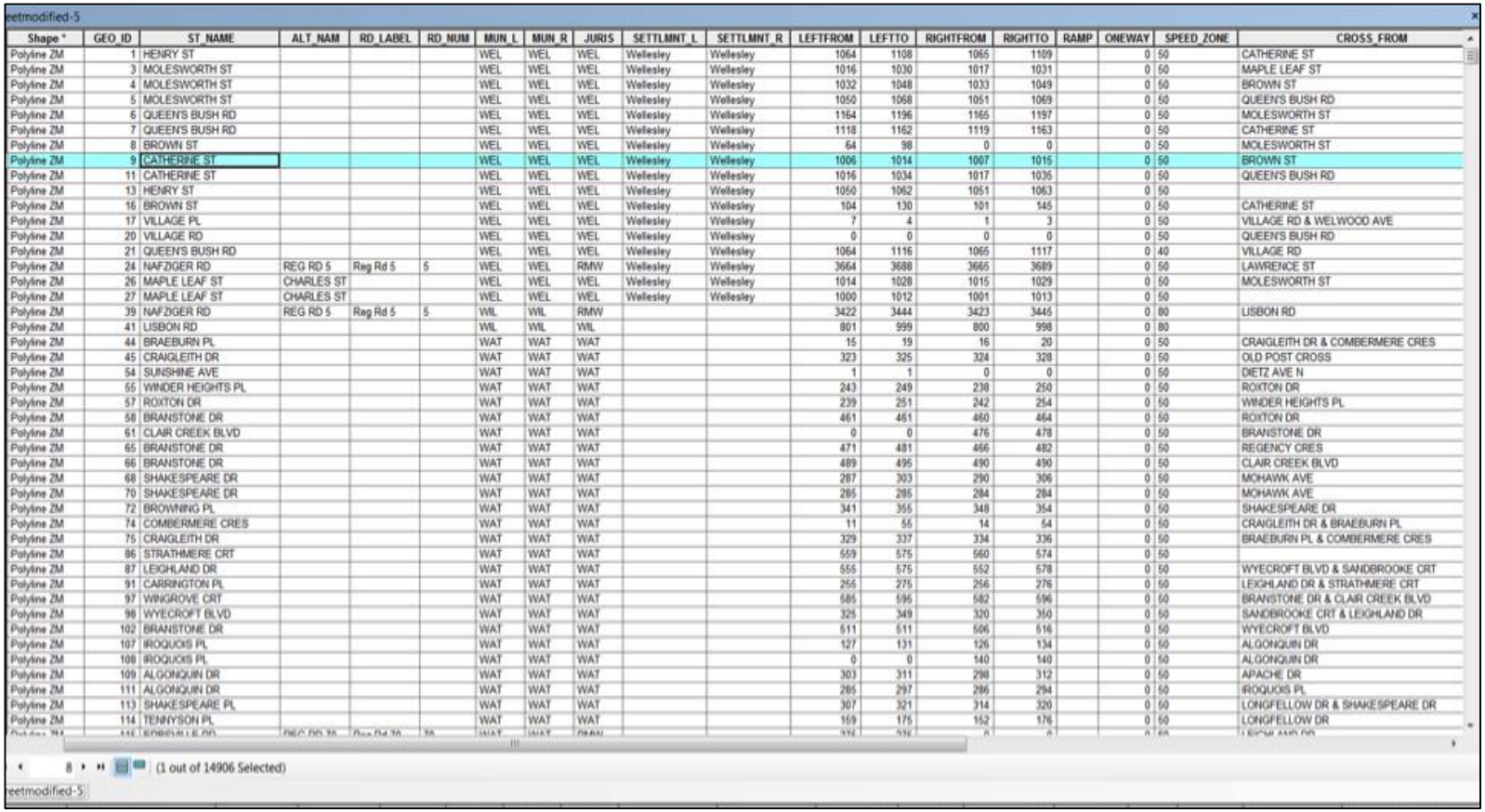
Address: Street address and the direction (North, South, East, West) of stores or schools

City: The cities (Waterloo, Kitchener, Cambridge, North Dumfries, Welllesley, Woolwich, Wilmot) where stores or schools located

3.1.2. Choosing a street file or reference street network

The reference street network acts as a reference layer in geocoding. Hence, it was important that the reference layer must have the detail of the area to which addresses will be geocoded (Tufts Open Courseware, n/d). The 2009 and 2010 street file of the Region of Waterloo, which includes the map to the street address level of Waterloo, Kitchener, Cambridge, Wellesley, Woolwich, North Dumfries, and Wilmot, were used as the street reference layer (Regional Municipality of Waterloo Streets and Planning Data, 2011) to geocode addresses in 2008 and 2010 respectively.

Figure IV.3.1.2.1: **2010 street reference file (street network) of the Regional Municipality of Waterloo, including township of Wellesley, township of Woolwich, township of North Dumfries, township of Wilmot, city of Cambridge, city of Kitchener, and city of Waterloo** (Regional Municipality of Waterloo Streets and Planning Data, 2011)



eetmodified-5

Shape *	GEO_ID	ST_NAME	ALT_NAM	RD_LABEL	RD_NUM	MUN_L	MUN_R	JURIS	SETTLMNT_L	SETTLMNT_R	LEFTFROM	LEFTTO	RIGHTFROM	RIGHTTO	RAMP	ONEWAY	SPEED_ZONE	CROSS_FROM
Polyline ZM	1	HENRY ST				WEL	WEL	WEL	Wellesley	Wellesley	1064	1108	1065	1109		0	50	CATHERINE ST
Polyline ZM	3	MOLESWORTH ST				WEL	WEL	WEL	Wellesley	Wellesley	1016	1030	1017	1031		0	50	MAPLE LEAF ST
Polyline ZM	4	MOLESWORTH ST				WEL	WEL	WEL	Wellesley	Wellesley	1032	1048	1033	1049		0	50	BROWN ST
Polyline ZM	5	MOLESWORTH ST				WEL	WEL	WEL	Wellesley	Wellesley	1050	1068	1051	1069		0	50	QUEEN'S BUSH RD
Polyline ZM	6	QUEEN'S BUSH RD				WEL	WEL	WEL	Wellesley	Wellesley	1164	1196	1165	1197		0	50	MOLESWORTH ST
Polyline ZM	7	QUEEN'S BUSH RD				WEL	WEL	WEL	Wellesley	Wellesley	1118	1162	1119	1163		0	50	CATHERINE ST
Polyline ZM	8	BROWN ST				WEL	WEL	WEL	Wellesley	Wellesley	64	98	0	0		0	50	MOLESWORTH ST
Polyline ZM	9	CATHERINE ST				WEL	WEL	WEL	Wellesley	Wellesley	1006	1014	1007	1015		0	50	BROWN ST
Polyline ZM	11	CATHERINE ST				WEL	WEL	WEL	Wellesley	Wellesley	1016	1034	1017	1035		0	50	QUEEN'S BUSH RD
Polyline ZM	13	HENRY ST				WEL	WEL	WEL	Wellesley	Wellesley	1050	1062	1051	1063		0	50	
Polyline ZM	16	BROWN ST				WEL	WEL	WEL	Wellesley	Wellesley	104	130	101	145		0	50	CATHERINE ST
Polyline ZM	17	VILLAGE PL				WEL	WEL	WEL	Wellesley	Wellesley	7	4	1	3		0	50	VILLAGE RD & WELWOOD AVE
Polyline ZM	20	VILLAGE RD				WEL	WEL	WEL	Wellesley	Wellesley	0	0	0	0		0	50	QUEEN'S BUSH RD
Polyline ZM	21	QUEEN'S BUSH RD				WEL	WEL	WEL	Wellesley	Wellesley	1064	1116	1065	1117		0	40	VILLAGE RD
Polyline ZM	24	NAFZIGER RD	REG RD 5	Reg Rd 5	5	WEL	WEL	RMW	Wellesley	Wellesley	3664	3688	3665	3689		0	50	LAWRENCE ST
Polyline ZM	26	MAPLE LEAF ST	CHARLES ST			WEL	WEL	WEL	Wellesley	Wellesley	1014	1028	1015	1029		0	50	MOLESWORTH ST
Polyline ZM	27	MAPLE LEAF ST	CHARLES ST			WEL	WEL	WEL	Wellesley	Wellesley	1000	1012	1001	1013		0	50	
Polyline ZM	39	NAFZIGER RD	REG RD 5	Reg Rd 5	5	WIL	WIL	RMW			3422	3444	3423	3445		0	80	LISBON RD
Polyline ZM	41	LISBON RD				WIL	WIL	WIL			801	999	800	998		0	80	
Polyline ZM	44	BRAEBURN PL				WAT	WAT	WAT			15	19	16	20		0	50	CRAIGLEITH DR & COMBERMERE CRES
Polyline ZM	45	CRAIGLEITH DR				WAT	WAT	WAT			323	325	324	328		0	50	OLD POST CROSS
Polyline ZM	54	SUNSHINE AVE				WAT	WAT	WAT			1	1	0	0		0	50	DIETZ AVE N
Polyline ZM	55	WINDER HEIGHTS PL				WAT	WAT	WAT			243	249	238	250		0	50	ROXTON DR
Polyline ZM	57	ROXTON DR				WAT	WAT	WAT			239	251	242	254		0	50	WINDER HEIGHTS PL
Polyline ZM	58	BRANSTONE DR				WAT	WAT	WAT			461	461	460	464		0	50	ROXTON DR
Polyline ZM	61	CLAIR CREEK BLVD				WAT	WAT	WAT			0	0	476	478		0	50	BRANSTONE DR
Polyline ZM	65	BRANSTONE DR				WAT	WAT	WAT			471	481	466	482		0	50	REGENCY CRES
Polyline ZM	66	BRANSTONE DR				WAT	WAT	WAT			489	495	490	490		0	50	CLAIR CREEK BLVD
Polyline ZM	68	SHAKESPEARE DR				WAT	WAT	WAT			287	303	290	306		0	50	MOHAWK AVE
Polyline ZM	70	SHAKESPEARE DR				WAT	WAT	WAT			285	285	284	284		0	50	MOHAWK AVE
Polyline ZM	72	BROWNING PL				WAT	WAT	WAT			341	355	348	354		0	50	SHAKESPEARE DR
Polyline ZM	74	COMBERMERE CRES				WAT	WAT	WAT			11	55	14	54		0	50	CRAIGLEITH DR & BRAEBURN PL
Polyline ZM	75	CRAIGLEITH DR				WAT	WAT	WAT			329	337	334	336		0	50	BRAEBURN PL & COMBERMERE CRES
Polyline ZM	86	STRATHMERE CRT				WAT	WAT	WAT			559	575	560	574		0	50	
Polyline ZM	87	LEIGHLAND DR				WAT	WAT	WAT			555	575	552	578		0	50	WYECROFT BLVD & SANDBROOKE CRT
Polyline ZM	91	CARRINGTON PL				WAT	WAT	WAT			255	275	256	276		0	50	LEIGHLAND DR & STRATHMERE CRT
Polyline ZM	97	WINGROVE CRT				WAT	WAT	WAT			585	595	582	596		0	50	BRANSTONE DR & CLAIR CREEK BLVD
Polyline ZM	98	WYECROFT BLVD				WAT	WAT	WAT			326	349	320	350		0	50	SANDBROOKE CRT & LEIGHLAND DR
Polyline ZM	102	BRANSTONE DR				WAT	WAT	WAT			511	511	506	516		0	50	WYECROFT BLVD
Polyline ZM	107	IROQUOIS PL				WAT	WAT	WAT			127	131	126	134		0	50	ALGONQUIN DR
Polyline ZM	108	IROQUOIS PL				WAT	WAT	WAT			0	0	140	140		0	50	ALGONQUIN DR
Polyline ZM	109	ALGONQUIN DR				WAT	WAT	WAT			303	311	298	312		0	50	APACHE DR
Polyline ZM	111	ALGONQUIN DR				WAT	WAT	WAT			285	297	286	294		0	50	IROQUOIS PL
Polyline ZM	113	SHAKESPEARE PL				WAT	WAT	WAT			307	321	314	320		0	50	LONGFELLOW DR & SHAKESPEARE DR
Polyline ZM	114	TENNYSON PL				WAT	WAT	WAT			159	175	152	176		0	50	LONGFELLOW DR

(1 out of 14906 Selected)

eetmodified-5

Figure IV.3.1.2.2: **Attribute table of the 2010 Region of Waterloo street file (Regional Municipality of Waterloo Streets and Planning Data, 2011)**

3.1.3. Creating the address locator

The address locator is the major component in the geocoding process. It contains the geocoding properties or a set of address parsing rules that guide the address matching

For this study, an Address Locator was created with the following settings:

***Address locator style*:** US address – Dual range. "This locator style includes address range for both sides of a street segment, which helps finding an address on a specific side of the street" (ESRI, 2011). In addition, "[I]t is common that some street names, such as King street and Queen Street, can be found in almost every city. Selecting the "US-Dual Ranges" address locator style will ensure that only the records that match both the street addresses and the zones (municipalities or three-digit postal codes) will be geocoded. This minimized misclassification errors" (Law, 2012, p.7). The 2009 and 2010 street network of the Regional Municipality of Waterloo (2010streetrmow) was used as the street reference or reference data.

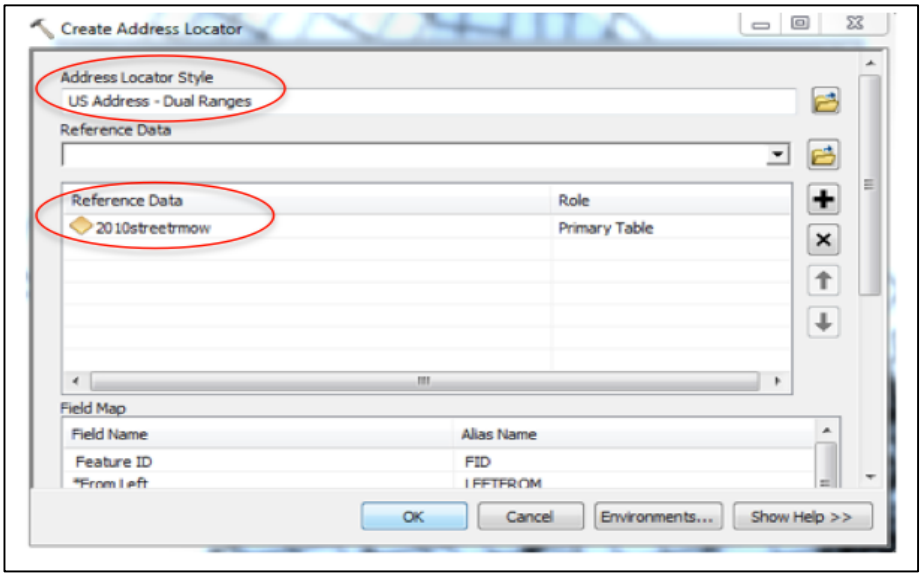


Figure IV.3.1.3.1: Chosen Address Locator Style (US address – Dual range) and Reference data (2010 street reference file of the Regional Municipality of Waterloo)

Choosing geocoding type: "Geocode addresses" option was chosen since both stores and school addresses need to be geocoded to the street number level.

***Address Geocoding settings* (geocoding options):** This step sets out the parsing rules for the address locator to search for the potential matching addresses (candidates) for an address.

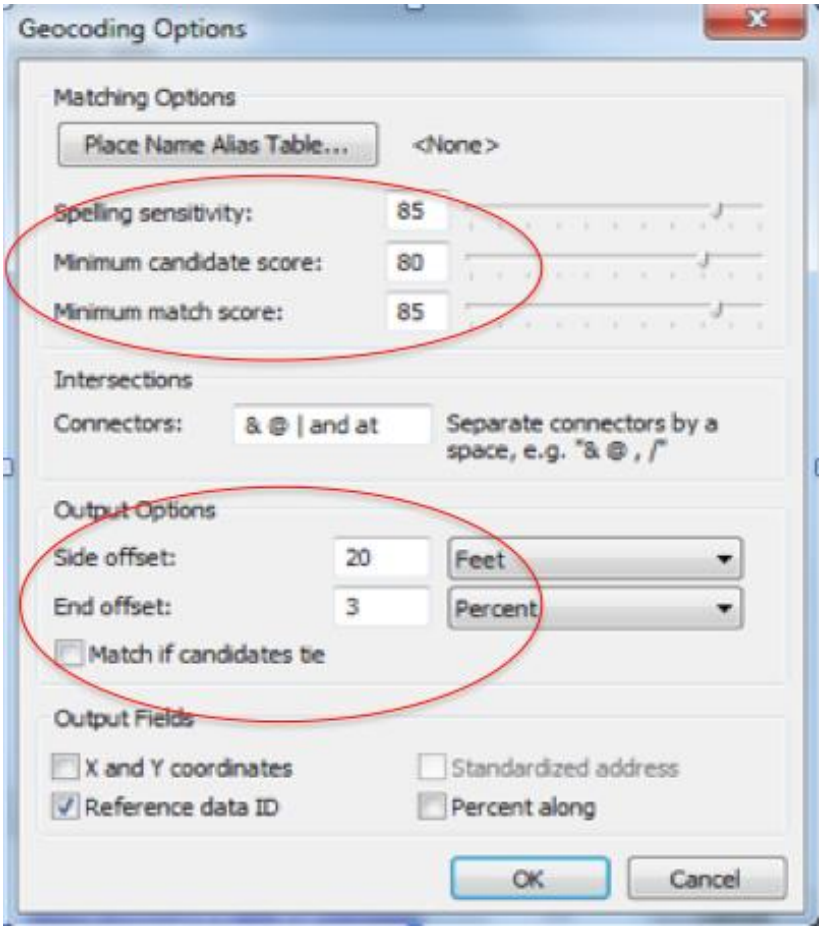


Figure IV.3.1.3.2: Geocoding options chosen, including Spelling sensitivity, Minimum candidate score, Minimum match score, Side offset, End offset, and Match if candidates tie

Spelling sensitivity: 85

"The spelling sensitivity setting controls how much variation the address locator allows when it searches for likely candidates in the reference data" (ESRI, 2013). The value for spelling sensitivity ranges from 0 to 100, and 80 is the default setting, which allows for only minor

variation between the geocoding addresses and the candidates in the reference data (ESRI, 2013). A value of 85 was chosen to increase the accuracy of the geocoding results.

Minimum candidate score: 80

Each candidate in the reference data was given a score depending on the matching level of those candidates to the geocoding address. Only candidates with scores that are equal or higher to the minimum candidate score setting are presented in the Interactive Review and Find dialog boxes. The value for the Minimum candidate score ranges from 0 to 100 (ESRI, 2013).

Minimum match score: 85

"The minimum match score setting controls how closely addresses have to match their most likely candidate in the reference data to be considered a match for an address. A perfect match yields a score of 100. A match score between 80 and 99 can generally be considered a good match" (ESRI, 2013).

Side offset: 20 feet or approximately 6 meters (defaulted by the program)

The Side offset function specifies the distance, based on map units, an address will be located from the street centerline on the correct side of the street (ESRI, 2013).

End offset: 3 percent (default by the program)

The End offset function helps to prevent "features that are located at the end of a reference feature from falling on top of other features (for example, a cross street)". By default, the end offset setting for an address locator is 3 percent (ESRI, 2013).

Match if candidates tie: this function was turned off

If there are two or more candidates that have the same highest match score but locate at different locations, a candidate will be chosen arbitrary, which does not base on any criteria, if the match if candidates tie function was turned on (ESRI, 2013). Hence, this function was turned off in this study to decrease geocoding errors due to the arbitrary matching.

It is noticeable that high-setting value of spelling sensitivity and minimum match score can increase the accuracy of geocoding results but also increase the automatically unmatched addresses. However, unmatched addresses were geocoded manually. Hence, all addresses were geocoded.

3.2. Calculating the number of FSs around each school in the Region of Waterloo

Buffers of 500m, 1000m and 1500m will be created around each school, and counts of FSs around each school within each buffer will be identified using the ArcGIS software.

3.3. Categorizing food stores

FSs around each school within 500m, 1000m and 1500m buffer will be classified using the North American Industry Classification System (NAICS) codes, a new industry classification system (Statistics Canada, 2010). "[T]he NAICS codes were developed by the U.S. federal government in cooperation with Canadian and Mexican statistical agencies" (Department of Revenue Washington State, n/d). Therefore, it is appropriate to categorize Canadian FS using the NAICS code. The NAICS was also used by several studies to categorize the FSs type (An & Sturm, 2012; Laska et al., 2010; Howard et al., 2011; Gebauer & Laska, 2011).

FSs were classified into four categories in the NAICS code, including full-service restaurant, limited-service restaurant, supermarket/grocery store, and convenience store. National chain or franchised stores were classified based on their name. For example, Tim Horton, McDonald's or Taco Bell restaurants were classified into the second category (limited-service restaurants) simply based on the store name. Local FSs were classified based on the information and menu on their business website. FSs that did not have a business website were categorized based on information of those FSs on website such as profilecanada.com, canpages.ca, phonepages.ca, n49.ca, kwpages.com, and ourbis.ca. FSs that could not be found by all of the above websites were classified using customer review websites of restaurants such as yelp.ca, restaurantica.ca, dinehere.ca, urbanspoon.com. Finally, FSs that could be found by all of the above methods will be classified based on their name only, for example, small local FSs or FSs at farmer markets.

Table IV.3.3.1: North American Industry Classification System (NAICS) codes (Statistics Canada, 2010)

Food store types	**Title**	**Description**
1	Full-service restaurants	**722511** "This industry comprises establishments primarily engaged in providing food services to patrons who order and are served while seated and pay after eating. These establishments may sell alcoholic beverages, provide take-out services, operate a bar or present live entertainment, in addition to serving food and beverages" (Statistics Canada, 2010).
2	Limited-service eating places	**722512** "This industry comprises establishments primarily engaged in providing foodservices to patrons who order or select items at a counter, food bar or cafeteria line (or order by telephone) and pay before eating. Food and drink are picked up for consumption on the premises or for take-out, or delivered to the customer's location. These establishments may offer a variety of food items or they may offer specialty snacks or non-alcoholic beverages" (Statistics Canada, 2010).
3	Supermarkets and Grocery stores	**445110** "This industry comprises establishments, known as supermarkets and grocery stores, 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, such as household paper products, toiletries and non-prescription drugs" (Statistics Canada, 2010).

		Super store (452910) "This industry comprises establishments, known as warehouse clubs, superstores or super centres, primarily engaged in retailing a general line of grocery items in combination with a general line of non-grocery items, and typically selling grocery items in larger formats. Exclusion(s): Establishments primarily engaged in: + Retailing a general line of merchandise in department stores (45211, Department Stores)" (Statistics Canada, 2010).
		Meat markets (44521) "This Canadian industry comprises establishments primarily engaged in retailing fresh, frozen, or cured meats and poultry. Delicatessens primarily engaged in retailing fresh meat are included" (Statistics Canada, 2010)
		Fish and seafood markets (44522) "This Canadian industry comprises establishments primarily engaged in retailing fresh, frozen, or cured fish and seafood products" (Statistics Canada, 2010).
		Fruit and vegetable markets (44523) "This Canadian industry comprises establishments primarily engaged in retailing fresh fruits and vegetables" (Statistics Canada, 2010).
4	Convenient stores	**Baked goods stores (445291)** "This Canadian industry comprises establishments primarily engaged in retailing baked goods not baked on the premises, and not for immediate consumption" (Statistics Canada, 2010). "Exclusion(s): Establishments primarily engaged in: + Retailing goods baked on premises, not for immediate consumption (31181, Bread and Bakery Product Manufacturing)" (Statistics Canada, 2010).
		Confectionary and nut stores (445292) "This Canadian industry comprises establishments primarily engaged in retailing candy

		and other confections, nuts and popcorn. Exclusion(s): Establishments primarily engaged in: + Retailing confectionery goods and nuts made on premises, not for immediate consumption (3113, Sugar and Confectionery Product Manufacturing)" (Statistics Canada, 2010).
		A**ll other specialty FSs (445299)** "This Canadian industry comprises establishments, not classified to any other Canadian industry, primarily engaged in retailing specialty foods" (Statistics Canada, 2010).
		Convenience stores (44512) "This industry comprises establishments, known as convenience stores, primarily engaged in retailing a limited line of convenience items that generally includes milk, bread, soft drinks, snacks, tobacco products, newspapers and magazines. These establishments may retail a limited line of canned goods, dairy products, household paper and cleaning products, as well as alcoholic beverages, and provide related services, such as lottery ticket sales and video rental" (Statistics Canada, 2010).
		Pharmacies and drug stores (44611) "This Canadian industry comprises establishments, known as pharmacies and drug stores, primarily engaged in retailing prescription or non-prescription drugs and medicines. These establishments also typically retail snacks, cosmetics, personal hygiene products, greeting cards and stationery, and health aids, and may also retail confectionery, tobacco products, novelties and giftware, and cameras and photographic supplies" (Statistics Canada, 2010).

3.4. Verifying the accuracy of the geocoding results

The 2008 food premise inspection data published by the Region of Waterloo were also geocoded by the Waterloo Public Heath Unit (PHU) in a purpose to identify FS counts around households in the urban area within the Waterloo Region. Then, the geocoding results were used to calculate FS counts around schools within 500m, 1000m and 1500m in 2008 in the Region of Waterloo. The 2008-geocoding results used for the current study were compared with the those from PHU to verify the accuracy of the geocoding results.

4. Data analysis

4.1. Verifying the accuracy of the geocoding results

FS counts of each FS types and of total store within each buffer zone (500m, 1000m and 1500m) in 2008 between the current study and PHU were compared. Subtracting method was used to explore the trend of FS counts from 2008 to 2010.

4.2. General descriptive data

Descriptive information/data of the FSs (mean, median, minimum and maximum of each FS type and total FSs) within 500m, 100m and 1500m around elementary/middle schools and secondary schools separately and all schools combined in 2008 and 2010 will be generated using the SAS version 9.3 program (SAS Institute, Cary NC).

4. 3. Exploring the relationships between the counts of each food outlet type to school neighbourhood household income and students' academic performance

School neighbourhood income was the response variable in examining the relationships between FS counts and school neighbourhood income. The overall EQAO scores, ranked from 0 to 10,

from all schools combined were response variables in exploring the association between FS counts and overall students' academic performance. Finally, EQAO scores from each grade for each subject by school were response variables to examine the relationships between the FS counts around schools and students' academic performance on a specific subject.

Since Grade 3 and 6 (elementary students) were tested in reading, writing and math, while Grade 9 (secondary students) were tested in applied mathematics, academic mathematics and Grade 10 was tested in literacy, comparison of the association between school FS counts and students' academic performance for each subject across school levels is considered excessive. Hence, the overall scores of elementary schools and secondary schools, a score ranked from 0 to 10 and given by the Ministry of Education, will be used as the response variables to compare the association between the counts of FSs and student performance by elementary schools and secondary schools.

To protect the confidentiality of students, schools and Boards' performance, a minimum number of 15 participating students from each school were needed for the publication of the EQAO's (EQAO, n/d).

Statistical methods

All analyses were performed in SAS version 9.3 (Cary, NC).

Objective 1 – To describe and compare the number of FSs around schools within 500m, 1000m and 1500m in 2008 and 2010

The mean, median, minimum, and maximum of each FS type around all schools in the Region of Waterloo in 2008 and 2010 were generated by the SAS program. Then, the subtraction method was used to explore the difference in the FS counts between 2008 and 2010.

Objective 1.1 – To describe and compare the counts of FSs around schools in 2008 and 2010 within 500m, 1000m and 1500m buffers across school levels (elementary and secondary schools)

Minimum, maximum, median of each FS type around elementary and secondary schools in the Region of Waterloo in 2008 and 2010 was generated by the SAS program. The trend in the FS counts around each school level was explored by comparing FS counts over the two-year period (2008 and 2010).

Objective 2 – To explore and compare the relationships between FS counts around schools within 500m, 1000m and 1500m and school neighbourhood income with and without population density

Two regression methods, multiple linear regression (5% significance) and logistic regression (95% CI does not include the value of 1), were employed in exploring the above relationships. In the first method (multiple linear regression), school neighbourhood income, response variable, ranges from the minimum $37,060 to the maximum $130,280. Nevertheless, in the second method (logistic regression), school neighbourhood income were coded as 1 or 0 based on the school neighbourhood median income ($75,000). Schools with the regional household income equal or higher than $75,000 were coded as 1, and schools with the regional household income lower than $75,000 were coded as 0. Similarly, the explanatory variables, including four FS types (full-service restaurants, FFRs, supermarkets, convenience stores) and total number of all stores around schools within 500m, 1000m and 1500m were tested as continuous variables, using the count of FSs, and as binary variables, in which FSs were categorized as 1 and 0 based on the presence (coded as 1) or absence (coded as 0) of each store type within each buffer. The analysis was completed for each year (2008 and 2010).

Table IV.4.3.1: Summary the statistical analyses in exploring the associations between FS counts and school neighbourhood household income

Regression analyses	Variables
Multiple linear regression	- Response variables: School neighbourhood income ranges from $37,060 to $130,280- Explanatory variables: FS counts
Logistic regression	- Response variables: School neighbourhood income ≥ $75,000 was coded as 1 School neighbourhood income < $75,000 was coded as 0 - Explanatory variables: FS counts

Forward stepwise selection methods, with the entry significance level set at 0.2, were used to find the potential final models. The forward selection technique begins with only the intercept and then sequentially adds the variable that is the most significant for the model. After a variable has been added, all variables in the current model were checked to see if any of them become insignificant and should be removed before adding another variable into the model (IBM, 2011; SAS, n/d). The process terminates when adding any other variable would not add significant improvement of the model (SAS, n/d). Then, multiple linear regression (5% significance) and logistic regression (95% CI does not include the value of 1) were used to re-test the significance of the exploratory variables from the forward stepwise selection. Then, significant associations between school neighbourhood income and FS counts around schools were tested with population density.

Objective 3 – To explore and compare the relationships between FS counts within 500m, 1000m and 1500m around schools and the EQAO scores in 2008 and 2010

Two statistical methods, multiple linear regression and logistic regression, were employed to examine the relationships between FS counts and EQAO scores. Forward stepwise selection methods, with the entry significance level set at 0.2, were used to find the potential final model.

Then, multiple linear regression (5% significance) and logistic regression (95% CI does not include the value of 1) were used to re-test the significance of the exploratory variables from the forward stepwise selection as well as to explore the correlation between FS counts and EQAO scores. The FSs (explanatory variables) was also tested as continuous variables (counts) and binary variables (presence or absence of a specific store type). Furthermore, due to the nature of the data, FS counts might not always follow the normal distribution. Therefore, regression plots of the associations between EQAO scores and FS counts were performed for further examining the reliability as well as the strength of the associations (Appendix E).

Objective 3.1 – To explore and compare the relationships between FS counts within 500m, 1000m and 1500m around schools and the overall EQAO scores from all schools combined in 2008 and 2010

In the linear regression method, EQAO scores ranged from 0 to 10 for each school. However, when logistic regression was applied, EQAO scores were divided into two categories using the average of the mean of the overall scores from 2008 and 2010 since the overall scores were normally distributed. If the overall EQAO scores were equal or higher than 5.9, it was coded as 1. If the overall EQAO scores were lower than 5.9, it was coded as 0.

Objective 3.2 – To explore and compare the relationships between FS counts within 500m, 1000m and 1500m around schools and the overall EQAO scores from elementary schools and secondary schools separately in 2008 and 2010

Similar to the objective 3.1, in case of linear regression, EQAO scores ranged from 0 to 10 for each elementary and secondary school. However, in the logistic regression method, a score of 5.7 (mean) and 6.5 (mean) were used as the thresholds for the overall EQAO scores of elementary

and secondary schools respectively. The thresholds were calculated by taking the average of the mean of the overall scores from 2008 and 2010 since the overall scores are normally distributed.

Objective 3.3 – To explore and compare the relationships between FS counts within 500m, 1000m and 1500m around schools and specific EQAO scores in 2008 and 2010

In the first method (multiple linear regression), EQAO scores, response variables, range from 0 to 4, the standardized scores divided by the Ministry of Education (EQAO, 2012). However, in the second method (linear regression), EQAO scores of each subject were coded as 0 or 1, except for the literacy scores. If the EQAO score for a specific subject is equal to or higher than 3, it is coded as 1. If the EQAO score for a specific subject is lower than 3, it is coded as 0. An EQAO score equal or higher than 3 is considered meeting the provincial standard of performance for that subject and vice versa (EQAO, 2012). Nevertheless, in case of the Grade 10 literacy score, since the scores were presented as the percentage of students who passed the literacy test and the scores were not normally distributed, scores of 86.6 (median) and 84.3 (median) were used as the threshold for 2008 and 2010 respectively.

Similarly, forward stepwise selections, with the entry significance level set at 0.2, were used to find the potential final models for each response variables. There were eleven response variables in total, including, EQAO scores for Grade 3 reading, Grade 3 writing, Grade 3 mathematics, Grade 6 reading, Grade 6 writing, Grade 6 mathematics, Grade 9 applied mathematics, Grade 9 academic mathematics, Grade 10 literacy, the overall score for each elementary and secondary school separately, and the overall EQAO scores from all schools combined. The explanatory variables were four store types and total number of all stores around each school within 500m, 1000m and 1500m. Then, regression methods were used to re-test the significance of the explanatory variables in each model as well as the correlations between the response and

explanatory variables. The analysis was done for each year (2008 and 2010).

Table IV.4.3.2: Summaries of the four statistical methods in exploring the relationships between FS counts and EQAO scores

<table>
<tr><td rowspan="2">Multiple linear regression</td><td colspan="2">Response variables
- EQAO scores rank from 0 to 10 for the overall EQAO scores from all schools combined
- EQAO scores rank from 0 to 10 for the overall EQAO scores from elementary schools and secondary schools separately
- EQAO scores rank from 0 to 4 for specific subjects, except for Grade 10 literacy that ranks from 0% to 100%</td></tr>
<tr><td>Explanatory variables
- Raw FS counts</td><td>Explanatory variables
- Within specific buffering levels (500m, 1000m and 1500m), if FS counts ≥ 1, it was coded as 1; if FS counts < 1, it was coded as 0</td></tr>
<tr><td rowspan="2">Logistic regression</td><td colspan="2">Response variable
- If the overall EQAO scores from all schools combined ≥ 5.9, they were coded as 1; if the overall EQAO scores from all schools combined < 5.9, they were coded as 0

- If the overall EQAO scores from elementary schools and secondary schools separately ≥ 5.7 and 6.5 respectively, they were coded as 1; if the overall EQAO scores from elementary schools and secondary schools separately < 5.7 and 6.5 respectively, they were coded as 0

- For specific subject:
If EQAO scores ≥ 3, they were coded as 1; if EQAO scores < 3, they were coded as 0
If Grade 10 literacy scores in 2008 and 2010 ≥ 86.6 and 84.3 respectively, they were coded as 1; If Grade 10 literacy scores in 2008 and 2010 < 86.6 and 84.3 respectively, they were coded as 0</td></tr>
<tr><td>Explanatory variables
- Raw FS counts</td><td>Explanatory variables
- Within specific buffering levels (500m, 1000m and 1500m), if FS counts ≥ 1, it was coded as 1; if FS counts < 1, it was coded as 0</td></tr>
</table>

Objective 4 – To explore the relationships between FS counts within 500m, 1000m and 1500m around schools and the EQAO scores controlling for school neighbourhood income, parent education, students' competency in English, and PA

Final model from the objective 3.1, 3.2 and 3.3 were tested with school neighbourhood income, parent education, students' competency in English using regression methods (multiple linear regression and logistic regression) to explore the impact of the above factors on the association between FS counts and students' academic performance. PA data were available in 2010 but were unavailable in 2008. Hence, PA was tested for its impact on the relationships between FS counts and EQAO scores in 2010 only and was not included in the final regression models that included all other potential confounding factors. Furthermore, since there were potential associations between FS counts and school neighbourhood income, interaction terms between school neighbourhood income and with any FS counts remained significant after correcting for income were created. Remained significant associations between FS counts and EQAO scores after adjusting for school neighbourhood income were controlled for the interaction terms.

Each of the potential confounding factors was tested separately. Then, all were added to the final regression model, except for the PA, to test their combined impacts on the relationships between FS counts and EQAO scores.

Even though there were a number of tests, given the exploratory nature of this research, there was no statistical adjustment for multiple comparisons. Outlines of all regression analyses without controlling for any potential confounding factors are presented in Appendix F.

V. RESULTS

1. Sample

1.1. Number of schools

A total of 167 school addresses were collected in 2012, including 147 elementary schools (including 11 middle schools) and 20 secondary schools. Within that, there were 117 public schools and 50 catholic schools. There were 31 schools located in Waterloo, 69 schools located in Kitchener, and 50 schools located in Cambridge, with the remaining 17 schools in other areas (Ayr, Baden, Breslau, Elmira, Conestogo, Wellesley, Linwood, Mary Hill, New Dundee, New Hamburg, St. Clements, St Jacobs, and St. Agatha).

1.2. Number of FSs in 2008 and 2010

In total, there were 1,215 and 1,357 FSs that were accessible to students in 2008 and 2010, respectively. FFRs had the highest counts and supermarkets had the lowest counts around schools compared to other store types in the Region of Waterloo in either 2008 or 2010 (Table V.1.2.1). Convenience stores had higher counts than full-service restaurants in 2008 by only 1% in 2008 but had the same counts as full-service restaurants in 2010. From 2008 to 2010, all FS types have increased in absolute number. Nevertheless, FSs in percentage over total stores did not necessarily increase. In particular, the percentage of full-service restaurant and convenience store counts over total store increased, whereas the percentage of supermarkets was unchanged and that of FFRs decreased.

Table V.1.2.1. FSs in the Region of Waterloo in 2008 and 2010 from the food premise data published on the Waterloo Region website (Region of Waterloo Public Health, 2012)

Year	2008 n (% of total FSs)	2010 n (% of total FSs)
Full-service restaurants	269 (22%)	322 (24%)
Fast-food restaurants	548 (45%)	564 (42%)
Supermarkets	124 (10%)	140 (10%)
Convenience stores	274 (23%)	331 (24%)
Total stores	1215 (100%)	1357 (100%)

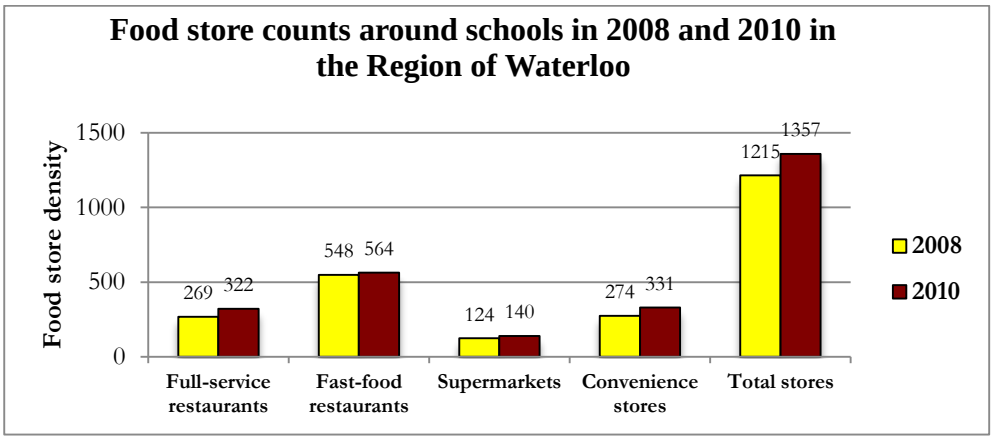


Figure V.1.2.1: FS counts (number in the whole region) in 2008 and 2010, obtained from food premise inspection data in the Region of Waterloo

2. Verifying the accuracy of the geocoding results

The geocoding results of the FSs around schools in the Region of Waterloo from the current study were compared to those from the local Public Health (PH) Unit. Due to difference in classification of FSs between the current study and PH for the 2010 FS data, only the 2008 geocoded results were compared. In summary, while total number of outlets and the number of full-service restaurants and convenience stores were larger in the results from PH than those from this current study, the number of FFRs and supermarkets were slightly higher in the current study geocoding results compared to those from PH results. However, the results showed that FFRs had the highest counts and supermarkets had the lowest counts around schools in either PH results or the current study results. Table V.2.1 summaries the geocoding results from the current study and from PH Unit.

Table V.2.1: Comparing the 2008 geocoding results of FS counts within 500m, 1000m and 1500m from the current study (C) to previous data from Region of Waterloo Public Health (PH)

Store types	Full-service restaurants		FFRs		Supermarket		Convenience stores		Total store	
Source of Data	C	PH	C	PH	C	PH	C	PH	C	PH
FS counts at 500m	119	137	237	231	64	37	146	189	566	594
Difference (#)	-18		6		27		-43		-28	
Difference (%)	-15%		3%		42%		-29%		-5%	
FS counts at 1000m	524	721	1064	1022	253	187	651	835	2492	2765
Difference (#)	-197		42		66		-184		-273	
Difference (%)	-38%		4%		26%		-28%		-11%	
FS counts at 1500m	1214	1704	2383	2236	520	401	1342	1777	5459	6118
Different (#)	-490		147		119		-435		-659	
Difference (%)	-40%		6%		23%		-32%		-12%	

C: Current study geocoding results
PH: Geocoding results from Region of Waterloo Public Health Unit

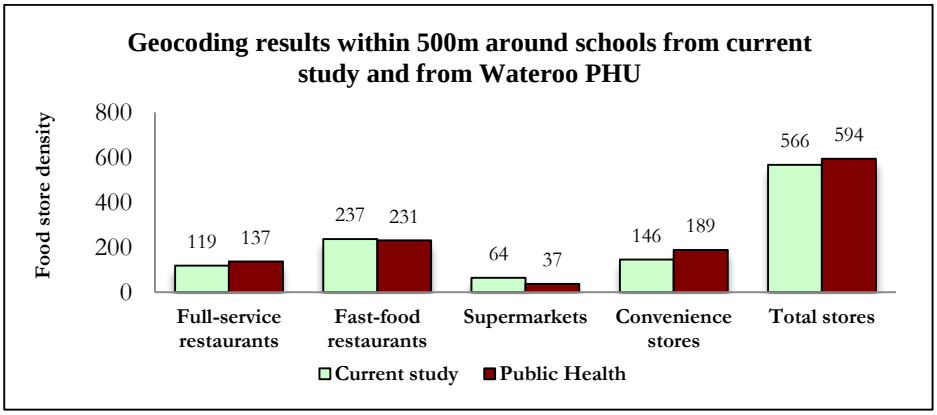


Figure V.2.1. Comparison of geocoding results within 500m be around schools tween the current study and Public Health Unit in 2008

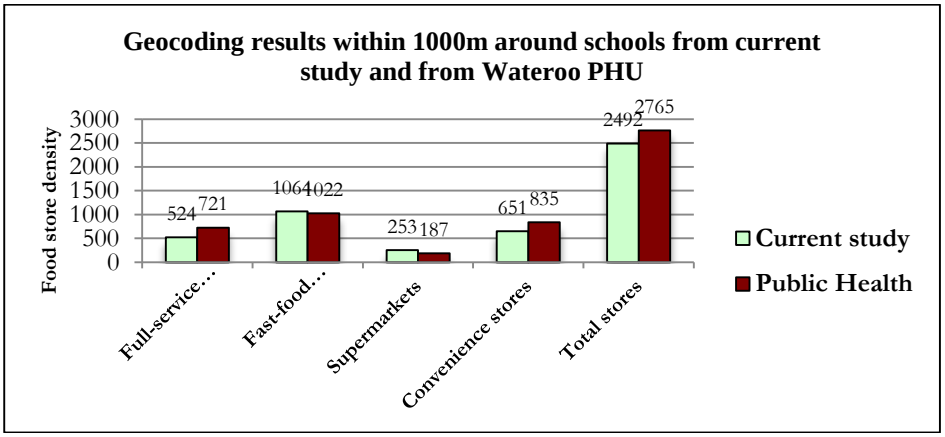


Figure V.2.2. Comparison of geocoding results within 1000m around schools between the current study and Public Health Unit in 2008

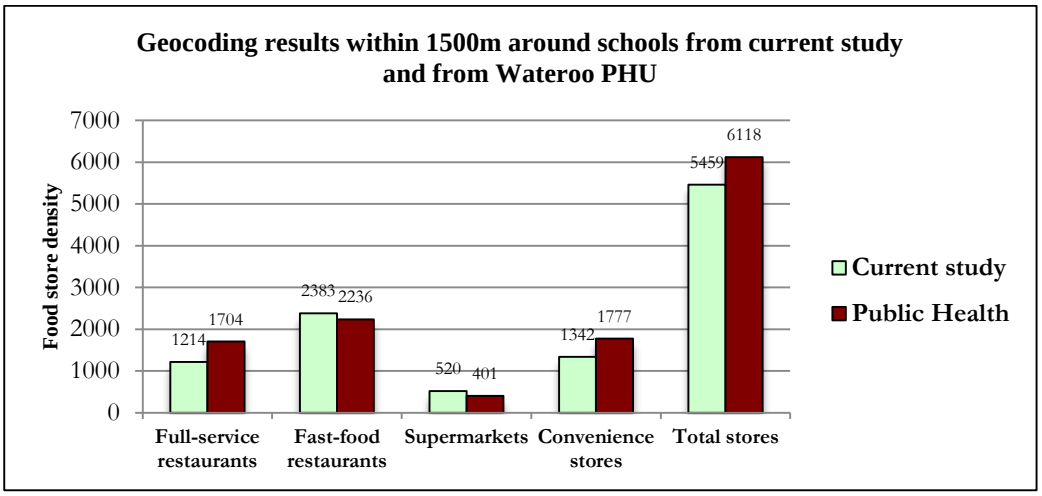


Figure V.2.3. Comparison of geocoding results within 1500m around schools between the current study and Public Health Unit in 2008

3. Exploring and comparing the FS counts around schools in the Region of Waterloo between 2008 and 2010

3.1. Comparison of FS counts around schools between 2008 and 2010

In general, the mean of FSs around schools in the Region of Waterloo was higher in 2010 compared to those in 2008, with some exceptions (Table V.3.1.1). For example, from 2008 to 2010, the mean of total stores increased from 3% to 5%, depending on the buffer zones. Similarly, the mean of convenience stores and full-service restaurants increased from 2008 to 2010 However, FFRs and supermarkets did not seem to follow this trend. The mean of FFRs decreased by 4% within 1000m and 1500m, and supermarket counts decreased 6% within 500m from 2008 to 2010. Nevertheless, even with the downward trend, FFRs remained the densest FS type around schools, followed by convenience stores. Also, the median and maximum of all FSs at all buffer zones in 2010 were either equal to or higher than those in 2008 in most of the case, which reflects the increase of FS counts from 2008 to 2010 in general.

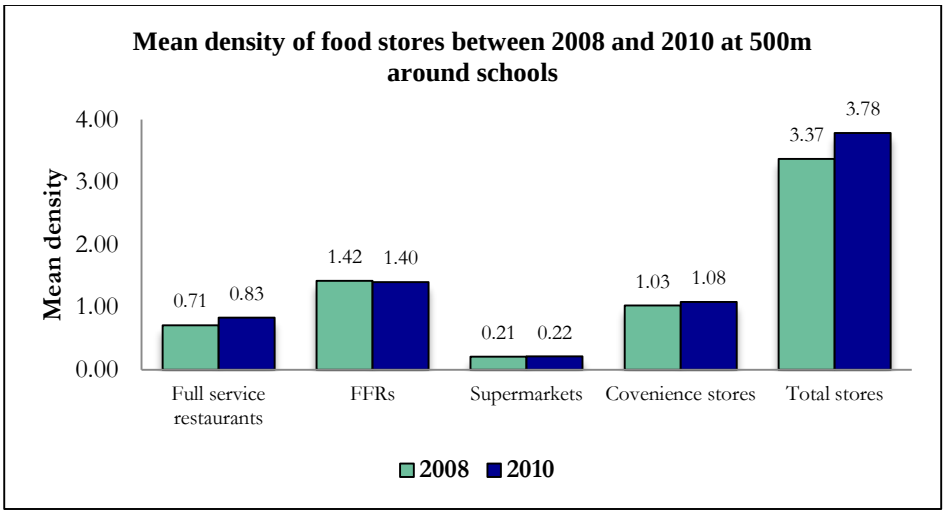


Figure 3.1.1. Mean of FSs within 500m around schools between 2008 and 2010

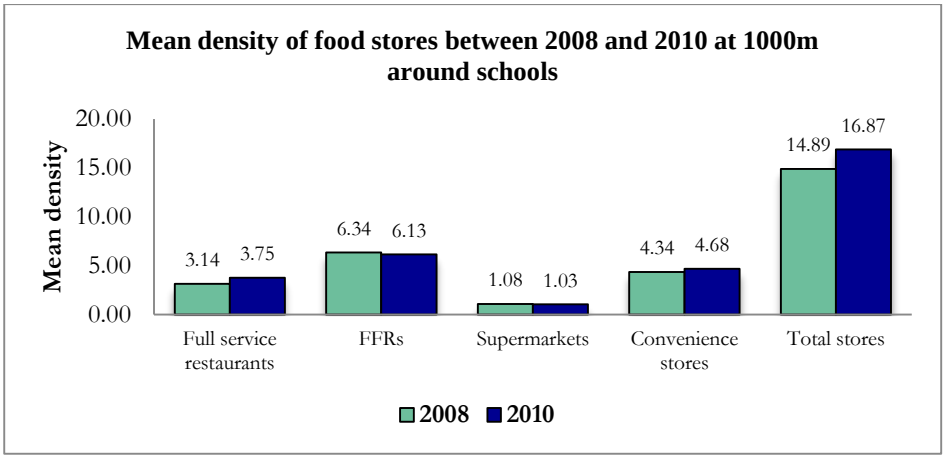


Figure 3.1.2. Mean of FSs within 1000m around schools between 2008 and 2010

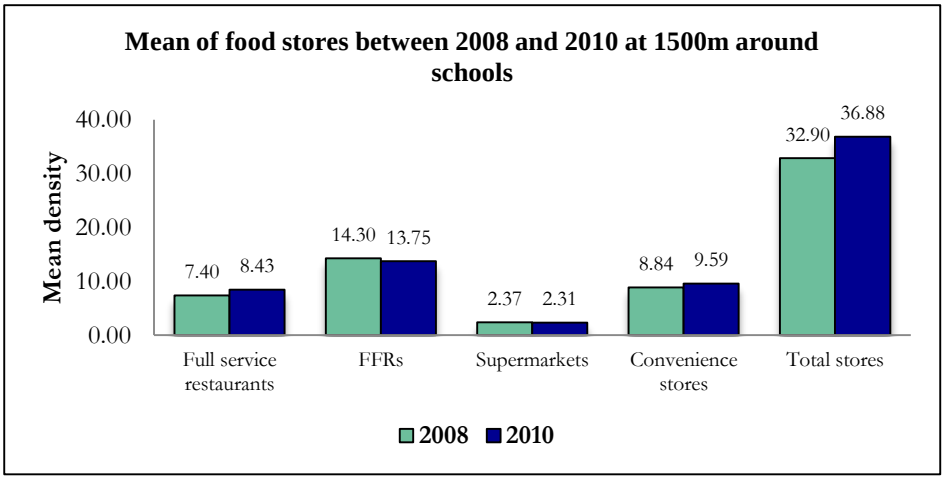


Figure 3.1.3. Mean of FSs within 1500m around schools between 2008 and 2010

3.2. Comparison of FS counts around elementary schools between 2008 and 2010

FS counts around 147 elementary schools (88% of the school sample) in the Waterloo Region showed similar trends as those around all schools; the mean, median and maximum of total stores, full-service restaurants and convenience stores were higher in 2010 compared to those in 2008, but those of FFRs and supermarkets did not always follow these trends. For example, mean of total store around elementary schools showed a 5% increase at 500m, 3% increase at 1000m and 3% increase at 1500m from 2008 to 2010. Meanwhile, there was a decrease in the mean of FFRs (from 1% to 4%) and supermarkets (14% at 500m) from 2008 to 2010. Table V.3.2.1 provides details of the FS counts around elementary schools from 2008 to 2010.

3.3. Comparison of FS counts around secondary schools within 500m, 1000m and 1500m between 2008 and 2010

Similarly, the mean, median and maximum of FSs increased from 2008 to 2010, except for those of FFRs and supermarkets (Table V.3.3.1). While the mean and median of FFRs at 1000m and 1500m decreased, the mean and median of other FS types increased between the years around secondary schools (up to 26% for the mean). Meanwhile, the maximum number of FSs was higher in 2010, with the exception of the FFR counts at the 1000m-buffer (2% decrease) (Table V.3.3.1).

3.4. Comparison of FS counts between elementary and secondary schools from 2008 to 2010

The mean and median of FSs around secondary schools were higher than those of elementary schools, with an exception that the mean of FFR at 1500m was higher among elementary schools compared to secondary schools in either 2008 or 2010 (Table V.3.4.1). Interestingly, the maximum of FSs around elementary schools was higher than those around secondary schools (Table V.3.4.1).

Table V.3.1.1: Comparing FS counts around all schools within 500m, 1000m and 1500m between 2008 and 2010

FS		Mean			Median			Maximum		
Buffer	**Year**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**
500m buffer around schools	**Full-service restaurants**	0.71	0.84	**15%**	0	0	**0%**	7	9	**22%**
	FFRs	1.42	1.42	**0%**	0	0	**0%**	14	15	**7%**
	Supermarkets	0.38	0.36	**-6%**	0	0	**0%**	12	12	**0%**
	Convenience stores	0.87	0.96	**8%**	0	0	**0%**	19	22	**14%**
	Total stores	3.39	3.58	**5%**	2	2	**0%**	46	50	**8%**
1000m buffer around schools	**Full-service restaurants**	3.13	3.75	**17%**	2	2	**0%**	31	41	**24%**
	FFRs	6.37	6.13	**-4%**	4	4	**0%**	48	48	**0%**
	Supermarkets	1.52	1.53	**1%**	1	1	**0%**	17	17	**0%**
	Convenience stores	3.90	4.08	**4%**	2	3	**33%**	41	43	**5%**
	Total stores	14.92	15.46	**3%**	10	10	**0%**	126	138	**9%**
1500m buffer around schools	**Full-service restaurants**	7.27	8.44	**14%**	4	5	**20%**	39	51	**24%**
	FFRs	14.27	13.76	**-4%**	10	9	**-11%**	69	68	**-1%**
	Supermarkets	3.13	3.29	**5%**	2	3	**33%**	18	21	**14%**
	Convenience stores	8.04	8.61	**7%**	5	6	**17%**	53	57	**7%**
	Total stores	32.69	34.05	**4%**	22	22	**0%**	159	168	**5%**

Table V.3.2.1: Comparing FS counts around elementary schools within 500m, 1000m and 1500m between 2008 and 2010

FSs		Mean			Median			Maximum		
Buffer	**Year**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**
500m buffer around schools	**Full-service restaurants**	0.67	0.79	15%	0	0	0%	7	7	0%
	FFRs	1.31	1.3	-1%	0	0	0%	14	15	7%
	Supermarkets	0.33	0.29	-14%	0	0	0%	3	3	0%
	Convenience stores	0.81	0.88	8%	0	0	0%	7	8	13%
	Total stores	3.11	3.26	5%	2	0	0%	29	29	0%
1000m buffer around schools	**Full-service restaurants**	2.89	3.52	18%	2	2	0%	31	41	24%
	FFRs	5.99	5.75	-4%	4	4	0%	48	48	0%
	Supermarkets	1.46	1.46	0%	1	1	0%	13	16	19%
	Convenience stores	3.84	3.99	4%	2	2	0%	41	43	5%
	Total stores	14.17	14.68	3%	9	9	0%	126	138	9%
1500m buffer around schools	**Full-service restaurants**	7.12	8.04	11%	4	5	20%	39	51	24%
	FFRs	13.9	13.33	-4%	10	9	-11%	69	68	-1%
	Supermarkets	3.16	3.32	5%	3	3	0%	18	21	14%
	Convenience stores	7.84	8.4	7%	5	5.5	9%	53	57	7%
	Total stores	32	33.04	3%	22	22	0%	159	168	5%

Table V.3.3.1: Comparing FS counts around secondary schools within 500m, 1000m and 1500m between 2008 and 2010

FSs		Mean			Median			Maximum		
Buffer	**Year**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**	**2008**	**2010**	**Difference**
500m buffer around schools	**Full-service restaurants**	1.05	1.25	16%	0	0	0%	6	9	33%
	FFRs	2.25	2.3	2%	1	1	0%	9	10	10%
	Supermarkets	0.8	0.9	11%	0	0	0%	12	12	0%
	Convenience stores	1.35	1.5	10%	0	0	0%	19	22	14%
	Total stores	5.45	5.95	8%	2	2	0%	46	50	8%
1000m buffer around schools	**Full-service restaurants**	4.9	5.45	10%	2	2.5	20%	23	26	12%
	FFRs	9.2	8.9	-3%	6	5	-20%	42	41	-2%
	Supermarkets	1.95	2.05	5%	1	1	0%	17	17	0%
	Convenience stores	4.35	4.75	8%	3	3	0%	27	32	16%
	Total stores	20.4	21.15	4%	10	11	9%	95	102	7%
1500m buffer around schools	**Full-service restaurants**	8.35	11.35	26%	5.5	7.5	27%	34	42	19%
	FFRs	17	16.9	-1%	12	11	-9%	61	63	3%
	Supermarkets	2.9	3.1	6%	2	2	0%	17	19	11%
	Convenience stores	9.5	10.1	6%	6.5	7	7%	44	48	8%
	Total stores	37.75	41.45	9%	26	27	4%	142	154	8%

Table V.3.4.1: Comparing FS counts between elementary and secondary schools within 500m, 1000m and 1500m from 2008 to 2010

Buffer	FSs	Mean						Median						Maximum					
	Year	2008			2010			2008			2010			2008			2010		
	School type	ES	SS	Difference	ES	SS	Difference	ES	SS	Difference	ES	SS	Difference	ES	SS	Difference	ES	SS	Difference
500m buffer around schools	Full-service restaurants	0.67	1.05	36%	0.79	1.25	37%	0	0	0%	0	0	0%	7	6	-17%	7	9	22%
	FFRs	1.31	2.25	42%	1.3	2.3	43%	0	1	100%	0	1	100%	14	9	-56%	15	10	-50%
	Supermarkets	0.33	0.8	59%	0.29	0.9	68%	0	0	0%	0	0	0%	3	12	75%	3	12	75%
	Convenience stores	0.81	1.35	40%	0.88	1.5	41%	0	0	0%	0	0	0%	7	19	63%	8	22	64%
	Total stores	3.11	5.45	43%	3.26	5.95	45%	2	2	0%	0	2	100%	29	46	37%	29	50	42%
1000m buffer around schools	Full-service restaurants	2.89	4.9	41%	3.52	5.45	35%	2	2	0%	2	2.5	20%	31	23	-35%	41	26	-58%
	FFRs	5.99	9.2	35%	5.75	8.9	35%	4	6	33%	4	5	20%	48	42	-14%	48	41	-17%
	Supermarkets	1.46	1.95	25%	1.46	2.05	29%	1	1	0%	1	1	0%	13	17	24%	16	17	6%
	Convenience stores	3.84	4.35	12%	3.99	4.75	16%	2	3	33%	2	3	33%	41	27	-52%	43	32	-34%
	Total stores	14.17	20.4	31%	14.68	21.15	31%	9	10	10%	9	11	18%	126	95	-33%	138	102	-35%
1500m buffer around schools	Full-service restaurants	7.12	8.35	15%	8.04	11.35	29%	4	5.5	27%	5	7.5	33%	39	34	-15%	51	42	-21%
	FFRs	13.9	17	18%	13.33	16.9	21%	10	12	17%	9	11	18%	69	61	-13%	68	63	-8%
	Supermarkets	3.16	2.9	-9%	3.32	3.1	-7%	3	2	-50%	3	2	-50%	18	17	-6%	21	19	-11%
	Convenience stores	7.84	9.5	17%	8.4	10.1	17%	5	6.5	23%	5.5	7	21%	53	44	-20%	57	48	-19%
	Total stores	32	37.75	15%	33.04	41.45	20%	22	26	15%	22	27	19%	159	142	-12%	68	154	56%

ES: Elementary schools
SS: Secondary schools

4. Relationships between school neighbourhood income and FS counts around schools within 500m, 1000m and 1500m in the Region of Waterloo

Overall, school neighbourhood income showed significant negative relationships with the number of total stores, FFRs and convenience stores. Among these, associations between total FSs and FFRs to school neighbourhood income tended to be more consistent across the buffer zones (500m, 1000m and 1500m) and years (2008 and 2010). Furthermore, the associations were stronger at the 500m buffer compared to those at 1000m and 1500m when considering the same store types (Table V.4.1 & Table V.4.2).

The associations were relatively consistent either when school neighbourhood income was treated either as a continuous variable or as a binary variable. In particular, total FS counts around schools was negatively associated with school neighbourhood income at all buffer zones (500m, 1000m and 1500m) and years (2008 and 2010). When specific store types were considered, in 2008, school neighbourhood income had negative relationships with both supermarkets and convenience stores although the associations did not occur at all buffer zones. In 2010, school neighbourhood income had negative relationships with FFR counts at all buffer zones. Table V.4.1 and table V.4.2 summaries all of the associations between FS counts within 500m, 1000m and 1500m around school and school neighbourhood **household income**. Furthermore, all of the associations were robust even after adjusting for population density (Appendix G).

Table V.4.1: Relationships between school neighbourhood household income and the FS counts within 500m, 1000m and 1500m around schools using multiple linear regressions

School neighbourhood median household income	Year	Full-service restaurants			FFRs			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
	2008					-0.78 [c]					-1.98[a]		-0.83 [c]	-1.01 [c]	-0.33 [c]	-0.25 [c]
	2010				-2.58[c]	-0.81 [c]	-0.63 [c]							-1.03 [c]	-0.29 [c]	-0.24 [c]

All four explanatory variables (Full-service restaurants, fast-food restaurants, supermarkets and convenience stores) were run in one model and the total store was run in a separate model
Based on 2006 medium household income for the census neighbourhood of the schools
500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001

Table V.4.2: Relationships between school neighbourhood household income and the FS counts within 500m, 1000m and 1500m around schools using logistic regression

School neighbourhood median household income	Year	Full-service restaurants			FFRs			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
	2008					0.93	0.95				0.63			0.89	0.97	0.98
						0.874-0.983	0.917-0.976				0.458-0.878			0.818-0.972	0.941-0.992	0.961-0.989
	2010				0.78	0.92	0.93							0.89	0.97	0.97
					0.653-0.933	0.86-0.977	0.902-0.967							0.815-0.965	0.947-0.994	0.96-0.987

As a dichotomous variable, above and below the median.
Yes: School neighbourhood median household income ≥ 75,500 was coded as 1; * No: School neighbourhood median household income < 75,500 was coded as 0
All four explanatory variables (Full-service restaurants, fast-food restaurants, supermarkets and convenience stores) were run in one model and the total stores was run in a separate model
500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

5. Relationships between students' academic performance (EQAO scores) and FS counts within 500m, 1000m and 1500m around schools in the Region of Waterloo without adjusting for any potential confounding factors

In general, significant associations between EQAO scores and FS counts were mostly found for supermarkets, convenience stores and total stores. Associations between EQAO scores to full-service restaurant and FFR counts were sporadic and inconsistent across the years (2008 and 2010), as well as analysis methods (multiple linear regression and logistic) (Appendix H). It is possible that such associations occurred by chance due to the large number of analyses were performed. Therefore, only supermarket, convenience store and total store counts was discussed in this study.

In addition, most associations between EQAO scores and FS counts (supermarket, convenience store and total store) were found when EQAO scores were treated as continuous response variables. When EQAO scores were binary response variables, fewer associations were found, and the trends in associations were inconsistent (Appendix H). Hence, only analyses in which EQAO scores were treated as continuous response variables were used to investigate the relationships between EQAO scores and FS counts in the current study.

Furthermore, except that the overall EQAO scores from secondary schools and Grade 9 applied mathematic scores had some relationships with FS counts; none of other specific EQAO scores of secondary students were associated with FS counts. Given the number of analyses were performed between EQAO scores of secondary students and FS counts around schools, those significant associations between EQAO scores from secondary schools and FS counts might occur by chance. Hence, those associations were also omitted from the results and discussion in this thesis.

5.1. Relationships among EQAO scores, and FS counts within 500m, 1000m and 1500m around schools in 2008 and 2010 when EQAO scores were treated as continuous response variables

All of the associations between EQAO scores and FS (supermarket, convenience store and total store) counts were negative associations (Table V.5.1). In other words, an increase in the number of FSs (supermarkets, convenience stores or total stores) would associate with a decrease in the EQAO scores.

Among elementary schools, total store counts tended to negatively associate with every single EQAO score. Nevertheless, looking at specific store types, supermarket counts tended to be associated with Grade 3 performance, while convenience store counts tended to be associated with Grade 6 performance. In addition, more associations were found in 2010 than in 2008. Within that, associations between supermarket counts and EQAO scores were more likely to be found in 2010 than in 2008, while associations between convenience store counts and EQAO scores were more likely to be found in 2008 than in 2010 (Table V.5.1).

5.1.1. Relationships between the overall EQAO scores from all schools combined and FS counts within 500m, 1000m and 1500m around schools in 2008 and 2010

It is interesting that while all associations between EQAO scores and FSs were found when FSs were treated as continuous variables (Method I) in 2008, most of the associations were found when FSs were treated as binary variables (Method II) in 2010 (Table 5.1). When method I was used, EQAO scores were negatively associated with total store counts within 1500m in either 2008 or 2010 and with convenience store counts within 1000m and 1500m in 2008. When method II was used, the presence of supermarkets, convenience stores and total stores all had negative relationships with EQAO scores. For example, EQAO scores were associated with the presence of

total stores and convenience store within 500m and 1000m and with the presence of supermarket within 1000m and 1500m.

5.1.2. Relationships between the overall EQAO scores from elementary and secondary schools, separately, and FS counts within 500m, 1000m and 1500m around schools, in 2008 and 2010

Again, most associations were found in 2008 using method I, whereas associations were found using both methods in 2010. Also, no significant associations were found for supermarket in 2008, and no significant associations were found for convenience stores in 2010 (Table V.5.1). As all associations between EQAO scores of secondary students and FS counts were omitted from the as the associations were inconsistent, only associations between EQAO scores of elementary students and FS counts were included in the analysis.

Among elementary schools, EQAO scores were negatively associated with convenience store counts at all buffer zones and total store counts at 1000m and 1500m in 2008, whereas, EQAO scores were negatively associated with supermarket counts at 500m and 1000m and total store counts at all buffer zones in 2010 using method I. Meanwhile, EQAO scores were negatively associated with supermarket counts all buffer zones and total store counts within 500m and 1000m in 2010 but only with total store counts within 500m in 2008 using method II.

5.1.3. Relationships between Grade 3 EQAO scores and FS counts around elementary schools within 500m, 1000m and 1500m in 2008 and 2010

While EQAO scores had negative relationships with all FS types (supermarkets, convenience stores and total stores) in 2008, only supermarkets and total stores were found to have negative relationships with EQAO scores in 2010. Also, the associations between convenience store counts and EQAO scores tended to be more consistent in 2008 than those in 2010, whereas the

associations between supermarket counts and EQAO scores tended to be more consistent in 2010 than those in 2008.

When FSs were treated as continuous variables, total store counts had negative relationships with all EQAO scores but the relationships tended to be inconsistent across buffer zones (500m, 1000m and 1500m) and years (2008 and 2010). When specific stores were considered, in 2008, supermarket counts were negatively associated with writing and mathematic scores within 1000m and 1500m. In 2010, supermarket counts had negative relationships with all EQAO scores within 1000m, with writing scores within 500m and with mathematic scores within 1500m. Convenience store counts had negative relationships with reading scores in all buffer zones and with writing scores at 500m in 2008. No significant associations between convenience store and EQAO scores in 2010.

When FSs were treated as binary variables, total store counts in 2010 had significant relationships with reading and writing scores at 1000m only. In 2008, total store counts within 500m and 1000m had negative relationships with reading and writing scores and, at 1000m, with mathematics scores. While supermarket counts were negatively associated with all EQAO scores at all buffer zones in 2010, significant associations were only found at 1500m in 2008 (Table V.5.1). The presence of convenience stores had no significant relationship with EQAO scores in 2010 but had negative relationships with reading and writing scores in 2008.

5.1.4. Relationships between Grade 6 EQAO scores and FS counts around elementary schools within 500m, 1000m and 1500m in 2008 and 2010.

Almost all significant associations were found for convenience stores and total stores; there was only one single significant association between supermarket counts and EQAO scores (Table V.5.1). In 2010, total store counts had negative relationships with EQAO scores within all buffer

zones (500m, 1000m and 1500m) using either method I or method II. In 2008, total stores had negative relationships with reading and writing scores within 500m and with all EQAO scores within 1000m in both analysis methods. At 1500m, total stores were negatively associated with all EQAO scores but only when method I was applied.

For specific store types, using method I, in 2008, convenience store counts were negatively associated with reading and writing scores at all buffer zones but with mathematic scores within 1000m and 1500m only. In 2010, convenience store counts were negatively associated with writing and mathematic scores at all buffer zones but with reading scores within 500m and 1000m only. When method II was used, In 2008, convenience store counts had negative relationships with reading scores at all buffer zones, with writing score within 500m and with mathematic score within 1500m. In 2010, convenience store counts had negative relationships with reading scores at all buffer zones, with writing score within 1000m and with mathematic score within 500m. All of the associations between Grade 6 EQAO scores and FSs are presented in table V. 5.1.

5.2. Relationships between EQAO scores and FS counts around schools within 500m, 1000m and 1500m after adjusting for potential confounding factors

School neighbourhood household income, interactions between school neighbourhood household income and FS counts, parent education, and student competency in English were treated as confounding factors in the relationships between EQAO scores and FS counts. Each factor was tested separately, except that school neighbourhood income and the interactions were tested together. Then all were combined to explore their influence on the above relationships. Due to the unavailability of physical activity data in 2008, physical activity was only tested separately in 2010 and was not included in the final regression models to test the as other potential confounding factors. Among those potential confounding factors, school neighbourhood income and parent

education seemed to have the strongest impact on the associations between FS counts and EQAO scores.

5.2.1 Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m in 2008 and 2010 of schools after adjusting for school neighbourhood household income and the interactions

School neighbourhood income had fairly strong impact on the associations between students' academic performance and FS counts independently. When school neighbourhood income was corrected for, many significant associations between EQAO scores and FS counts became insignificant. Within that, associations in 2008 were more likely to turn insignificant after correcting for household income compared to those in 2010 (Table V.5.2.1.1). However, for Grade 3 EQAO scores, most significant associations were found for supermarkets and total stores, while for Grade 6 EQAO scores, most significant associations were found for convenience stores and total stores after correcting for school neighbourhood income.

In 2008 the associations between FS counts (convenience stores and total stores) and the overall EQAO scores from all school combined or from elementary and secondary schools separately almost disappeared after adjusting for school neighbourhood income, whereas, those associations in 2010 mostly remained significant. For Grade 3 performance, most associations in 2008 turned insignificant after adjusting for school neighbourhood income, especially when FSs were treated as continuous variables. In contrast, in 2010, most associations remained significant after considering for the income factor, especially those within 500m and 1000m. For Grade 6 performance, associations with total store counts in 2010 tended to be robust after correcting for household income. Similarly, majority of the associations with convenience stores remained significant in either 2008 or 2010 after correcting for income.

All of the significant associations after correcting for income were summarized in table V.5.2.1.1. Interestingly, almost all of the significant associations between FS counts and EQAO scores after adjusting for income factor turned insignificant when the interactions were added to the regression analyses. Nevertheless the interactions themselves were also insignificant in all of the analyses. Only school neighbourhood income remained significant in most of the cases (Appendix I). Therefore, the interaction terms were not included in the final models that controlled for all potential confounding factors.

5.2.2 Relationships between EQAO scores and FS counts around schools within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for parent education

Parent education also had relatively strong impact on the associations between EQAO scores and FS counts presented as the number of significant associations turned insignificant after correcting for parent education. Within that, significant associations in 2008 were more likely to disappear than those in 2010 after correcting for parent education. For example, only the association between Grade 3 reading and total store counts at 500m remained significant in 2008, while most of the associations between the overall EQAO scores from all schools combined, the overall EQAO score from elementary schools and Grade 3 EQAO scores to FS counts in 2010 remained significant at all buffer zones after adjusting for parent education. For Grade 6 performance, the associations in 2008 were more likely to stayed significant than those in 2010.

5.2.3. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for students' competency in English

In general, most associations remained significant after correcting for students' competency in English. However, the results showed that the associations between reading and writing scores to FS counts were more likely to be affected (weaken or disappeared) by the students' competency in

English factor than those between mathematic scores and FS counts. For example, while some of the associations between Grade 6 reading and writing scores and FS counts turned insignificant, all the associations between mathematic scores and FS counts remained significant in either 2008 or 2010.

5.2.4. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for physical activity

Obesity, which can lead to physical and mental health problems, might indirectly influence students' academic performance. Therefore, findings about the associations between EQAO scores and FS counts would be more reliable if students' weight status were controlled for. However, since either measured or self-report students' BMI were unable to obtain for the current, PA or out of school activities was used as a substitute for students' weight status. Due to the unavailability of physical activity in 2008, only associations between EQAO scores and FS counts in 2010 were controlled for physical activity. The results suggested that most associations remained significant after adjusting for physical activity with some exceptions. In particular, the associations between supermarket counts and EQAO scores all remained significant, but some associations between convenience and total store counts to EQAO scores became insignificant after controlling for physical activity.

5.2.5. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for school neighbourhood income, parent education and students' competency in English

When all confounding factors (school neighbourhood income, parent education and students' competency in English) were controlled for, several associations between EQAO scores and FS

counts turned insignificant, especially those in 2008 and those when FSs were treated as binary variables. For example, except for one single association between total store counts at 1000m and Grade 3 mathematic score remained significant, other associations between Grade 3 performance and FS counts in 2008 disappeared after correcting for all of the confounding factors. In addition, only the association between total store counts in 2010 and Grade 3 mathematic score remained robust, other associations in either 2008 or 2010 when FSs were treated as binary variables turned insignificant.

However, the remained associations still follow the trends that Grade 3 EQAO scores tended to be negatively associated with supermarket and total store counts, while Grade 6 EQAO scores tended to be negatively associated with convenience and total store counts. Also, the overall EQAO scores from all schools combined and the overall EQAO scores from elementary schools only were associated with all store types (supermarkets, convenience stores and total stores).

Table V.5.1. Relationships between EQAO scores and FS counts around schools within 500m, 1000m and 1500m in 2008 and 2010 when EQAO scores were treated as continuous variables

Year		2008									2010								
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I					0.123 [b]	-0.047 [b]			-0.012 [a]									-0.012 [b]
	II											0.734 [b]	-1.036 [b]	-0.755 [b]	-0.693 [a]		-0.574 [a]	-1.578 [c]	
The overall EQAO scores from elementary schools	I				-0.327 [a]	-0.069 [a]	-0.062 [c]		-0.021 [a]	-0.017 [b]	-0.551 [a]	-1.020 [c]					-0.111 [b]	-0.026 [c]	-0.018 [c]
	II							-0.683 [a]			-1.242 [c]	-1.020 [c]	-1.079 [b]				-0.734 [a]	-1.682 [c]	
The overall EQAO scores from secondary schools	I																		
	II														-1.606 [a]	-1.606 [a]			
Grade 3 reading score	I				-0.070 [a]	-0.011 [a]	-0.011 [c]		-0.003 [b]	0.003 [b]		0.142 [b]					-0.014 [a]	-0.003 [a]	-0.002 [a]
	II			-0.173 [a]	-0.130 [a]			-0.151 [a]	-0.236 [a]		-0.174 [b]	0.142 [b]	-0.190 [b]					-0.222 [a]	
Grade 3 writing score	I		-0.022 [a]	-0.019 [b]	-0.039 [a]					-0.002 [a]	-0.1 [c]	-0.129 [c]					-0.012 [a]		-0.002 [b]
	II			-0.112 [a]	-0.082 [a]			-0.106 [b]	-0.177 [b]		-0.159 [c]	-0.129 [c]	-0.137 [b]						
Grade 3 mathematic score	I		-0.027 [a]	-0.024 [a]					-0.030 [b]	-0.002 [a]		-0.172 [c]	-0.020 [a]						-0.002 [a]
	II			-0.155 [a]					-0.295 [a]		-0.204 [c]	-0.172 [c]	-0.148 [a]					-0.251 [b]	
Grade 6 reading score	I				-0.064 [c]	-0.011 [b]	-0.010 [c]	-0.013 [a]	-0.003 [b]	-0.002 [c]				-0.060 [a]	-0.157 [a]		-0.012 [a]	-0.004 [c]	-0.003 [c]
	II				-0.096 [a]	-0.162 [c]	-0.223 [b]	-0.103 [a]	-0.183 [a]					-0.104 [a]	-0.157 [a]	-0.220 [a]	-0.102 [a]	-0.244 [b]	-0.332 [a]
Grade 6 writing score	I				-0.071 [c]	-0.011 [c]	-0.010 [c]	-0.016 [c]	-0.003 [b]	-0.002 [c]				-0.063 c	-0.115 [a]	-0.017 [c]	-0.014 [b]	-0.005 [c]	-0.003 [c]
	II				-0.098 [b]			-0.111 [c]	-0.188 [c]			-0.085 [a]			-0.113 [a]		-0.102 [b]	-0.185 [a]	-0.289 [a]
Grade 6 mathematic score	I					-0.016 [c]	-0.013 [c]		-0.005 [b]	-0.004 [c]				-0.105 c	-0.208 [b]	-0.013 [c]	-0.019 [a]	-0.006 [c]	-0.004 [c]
	II						-0.258 [a]		-0.256 [a]					-0.178 [a]			-0.150 [a]	0.002 [a]	-0.426 [a]

[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

I: Method I or when FSs were treated as continuous variables, II: Method II or when FSs were treated as binary variables

Table V.5.2.1.1. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m of schools in 2008 and 2010 after adjusting for school neighbourhood household income

Year	2008																	
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I					-0.114[b]													
	II											-0.615[a]	-0.664[a]						
The overall EQAO scores from elementary schools	I						-0.043[a]				-0.498[a]	-0.207[c]					-0.085[a]	-0.017[a]	-0.010[a]
	II										-1.089[c]	-0.784[b]					-0.600[a]	-1.061[a]	
The overall EQAO scores from secondary schools	I																		
	II																		
Grade 3 reading score	I						-0.006[a]										-0.083[a]	-0.003[a]	
	II				-0.119[a]			-0.119[a]			-0.142[a]	-0.107[a]							
Grade 3 writing score	I			-0.014[a]							-0.088[c]	-0.016[a]					-0.009[a]		
	II				-0.086[a]			-0.096[b]			-0.153[c]	-0.112[c]	-0.099[a]						
Grade 3 mathematic score	I			-0.018[a]									-0.015[a]						
	II								-0.295[b]		-0.207[c]	-0.164[c]						-0.184[a]	
Grade 6 reading score	I					-0.007[a]	-0.007[b]								-0.009[a]			-0.003[a]	
	II							-0.075[a]											
Grade 6 writing score	I				-0.057[c]	-0.009[b]	-0.008[c]	-0.014[b]	-0.002[a]	-0.002[b]				-0.046[a]	-0.014[c]	-0.015[c]	-0.01	-0.004[c]	-0.002[b]
	II				-0.087[a]			-0.097[b]							-0.122[a]		-0.087[a]		
Grade 6 mathematic score	I					-0.013[a]	-0.011[c]		-0.004[a]	-0.003[b]				-0.072[a]	-0.015[b]	-0.009[b]			-0.002[a]
	II													-0.130[a]					

[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

I: Method I or when FSs were treated as continuous variables, II: Method II or when FSs were treated as binary variables

Coloured cells showed the significant associations before controlling for school nenighbourhood **household income**

Table V.5.2.2.1. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for parent education

Year		2008									2010								
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I																		
	II											-0.539 [a]	-0.605 [a]	-0.553 [a]			-0.485 [a]	-1.104 [a]	
The overall EQAO scores from elementary schools	I									-0.016 [b]	-0.570 [a]	-0.153 [b]					-0.105 [c]	-0.021 [b]	-0.017 [c]
	II										-0.652 [c]	-0.648 [a]					-0.105 [c]	-1.130 [a]	
The overall EQAO scores from secondary schools	I																		
	II																		
Grade 3 reading score	I						-0.008 [b]			-0.003 [b]							-0.015 [a]	-0.003 [a]	-0.002 [a]
	II							-0.014 [a]			-0.095 [a]	-0.100 [a]	-0.124 [a]					-0.168 [a]	
Grade 3 writing score	I		-0.018 [a]	-0.014 [a]						-0.001 [a]	-0.093 [c]	-0.015 [a]					-0.011 [a]		-0.002 [b]
	II										-0.093 [c]	-0.103 [c]	-0.102 [a]						
Grade 3 mathematic score	I		-0.024 [a]	-0.020 [a]						-0.002 [a]			-0.015 [a]						
	II								-0.215 [a]		-0.114 [b]	-0.144 [b]						-0.217 [a]	
Grade 6 reading score	I					-0.009 [a]	-0.009 [c]	-0.012 [a]	-0.003 [a]	-0.002 [c]					-0.01 [b]			-0.004 [b]	-0.003 [c]
	II					-0.108 [a]		-0.012 [a]											
Grade 6 writing score	I				-0.051 [b]	-0.009 [b]	-0.009	-0.014 [c]	-0.003 [b]	-0.003 [c]				-0.035 [a]		-0.008 [c]	-0.010 [a]		-0.002 [c]
	II				-0.051 [b]			-0.014 [c]									-0.010 [a]		
Grade 6 mathematic score	I					-0.013 [a]	-0.013 [c]		-0.004 [a]	-0.004 [c]				-0.074 [a]	-0.016 [c]	-0.012 [c]	-0.016 [a]	-0.005 [c]	-0.004 [c]
	II													-0.074 [a]			-0.016 [a]		

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
I: Method I or when FSs was continuous variables, II: Method II or when FSs was binary variables
[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001
Coloured cells showed the significant associations before controlling for parent education
Parent education was based on the 2006 education attainment of the population aged 25-64 at census tract level

Table V.5.2.3.1. Relationships between EQAO scores and FS counts within 500m, 1000m and 1500m around schools in 2008 and 2010 after adjusting for students' competency in English

Year		2008									2010								
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I					-0.065 [a]	-0.058 [b]			-0.015 [a]									-0.013 [c]
	II											-0.690 [a]		-0.696 [b]	-0.776 [a]		-0.496 [a]	-1.500 [c]	
The overall EQAO scores from elementary schools	I				-0.359 [a]	-0.061 [a]	-0.058 [b]			-0.015 [a]	-0.547 [a]	-0.204 [c]					-0.107 [b]	-0.027 [c]	-0.018 [c]
	II										-1.161 [c]	-0.950 [c]	-1.015 [a]				-0.648 [a]	-1.577 [c]	
The overall EQAO scores from secondary schools	I																		
	II														-1.747 [a]	-1.747 [a]			
Grade 3 reading score	I				-0.067 [a]		-0.021 [a]			-0.003 [a]							-0.014 [a]	-0.003 [a]	-0.002 [a]
	II			-0.155 [a]	-0.118 [a]			-0.135 [a]	-0.221 [a]		-0.159 [a]	-0.130 [b]	-0.169 [a]					-0.205 [a]	
Grade 3 writing score	I			-0.018 [a]						-0.002 [a]	-0.099 [c]	-0.020 [a]					-0.011 [a]		-0.002 [b]
	II			-0.141 [a]	-0.077 [a]			-0.099 [b]			-0.151 [c]	-0.123 [c]	-0.127 [b]						
Grade 3 mathematic score	I			-0.021 [a]						-0.002 [a]		-0.023 [a]	-0.019						-0.002 [a]
	II								-0.283 [b]		-0.192 [b]	-0.162 [c]	-0.131 [a]					-0.238 [a]	
Grade 6 reading score	I				-0.063 [b]	-0.012 [c]	-0.011 [c]	-0.013 [a]	-0.004 [b]	-0.003 [c]				-0.060 [a]	-0.013 [c]			-0.004 [b]	-0.003 [c]
	II				-0.097 [a]	-0.161 [c]	-0.223 [b]	-0.110 [b]	-0.185 [a]					-0.104 [a]	-0.155 [a]	-0.216 [a]	-0.101 [a]	-0.241 [b]	-0.324 [a]
Grade 6 writing score	I				-0.072 [c]	-0.011 [c]	-0.010 [c]	-0.016 [c]	-0.003 [b]	-0.003 [c]				-0.064 [c]	-0.016 [c]	-0.010 [c]	-0.014 [b]	-0.005 [c]	-0.003 [a]
	II				-0.097 [b]			-0.113 [c]	-0.187 [a]						-0.143 [b]				-0.285 [a]
Grade 6 mathematic score	I					-0.016 [c]	-0.014 [c]		-0.005 [b]	-0.004 [c]				-0.105 [c]	-0.019 [c]	-0.013 [c]	-0.019 [a]	-0.006 [c]	-0.004 [c]
	II						-0.271 [a]		-0.256 [a]					-0.178 [c]			-0.149 [a]	-0.286 [a]	-0.417 [a]

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
I: Method I or when FSs was continuous variables, II: Method II or when FSs was binary variables
[a] $p \leq 0.05$, [b] $p \leq 0.005$, [c] $p \leq 0.001$
Coloured cells showed the significant associations before controlling for students' competency in English
Percentage of students who indicated that they speak only or mostly English at home

Table V.5.2.4.1. Relationships between EQAO scores and FS counts around schools within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for physical activity

Year		2010								
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I									
	II		-0.746 [b]	-1.038 [b]	-0.752 [b]	-0.700 [a]		-0.569 [a]	-1.570 [c]	
The overall EQAO scores from elementary schools	I	-0.927 [a]	-0.175 [a]					-0.617 [a]	-0.021 [a]	
	II	-1.089 [b]	-0.895 [c]	-0.994				-0.617 [a]	-1.570 [c]	
The overall EQAO scores from secondary schools	I									
	II									
Grade 3 reading score	I		-0.127 [a]						-0.209 [a]	-0.002 [a]
	II	-0.156 [a]	-0.127 [a]	-0.180 [b]					-0.209 [a]	
Grade 3 writing score	I	-0.142 [c]	-0.116 [c]							-0.001 [a]
	II	-0.142 [c]	-0.116 [c]	-0.128 [b]						
Grade 3 mathematic score	I		-0.159 [c]	-0.017 [a]						
	II	-0.187 [b]	-0.159 [c]	-0.138 [a]						
Grade 6 reading score	I				-0.087 [a]	-0.141 [a]		-0.086 [a]		-0.002 [b]
	II				-0.087 [a]	-0.141 [a]	-0.220 [a]	-0.228 [a]		-0.337 [a]
Grade 6 writing score	I				-0.092 [a]		-0.008 [c]	-0.084 [a]	-0.167 [a]	-0.002 [c]
	II					-0.127 [a]		-0.084 [a]	-0.167 [a]	-0.295 [a]
Grade 6 mathematic score	I					-0.184 [a]	-0.011 [c]	-0.125 [a]		-0.003 [c]
	II				-0.154 [b]			-0.125 [a]	-0.265 [a]	-0.434 [a]

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
I: Method I or when FSs was continuous variables, II: Method II or when FSs was binary variables
[a] $p \leq 0.05$, [b] $p \leq 0.005$, [c] $p \leq 0.001$
Coloured cells showed the significant associations before controlling for school PA
Physical activity: percentage of students who indicated that they participated in sports or other physical activities everyday when they were not at schools

Table V.5.2.5.1. Relationships between EQAO scores and FS counts around schools within 500m, 1000m and 1500m in 2008 and 2010 after adjusting for school neighbourhood household income, parent education and students' competency in English

Year		2008									2010								
EQAO scores	Analysis method	Supermarkets			Convenience stores			Total stores			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I						-0.039[a]			-0.012 [a]									-0.012
	II											-0.509 [a]							
The overall EQAO scores from elementary schools	I						-0.043 [a]			-0.013 [a]	-0.560 [a]	-0.144 [a]					-0.091 [b]	-0.020 [b]	-0.016 [c]
	II										-0.990 [c]	-0.553 [a]							
The overall EQAO scores from secondary schools	I																		
	II																		
Grade 3 reading score	I																-0.012 [a]		-0.002 [a]
	II										-0.123 [a]								
Grade 3 writing score	I										-0.090 [c]	-0.014 [a]					-0.010 [a]		-0.001 [a]
	II										-0.139 [c]	-0.094 [b]	-0.091 [a]						
Grade 3 mathematic score	I								-0.194 [a]				-0.015 [a]						
	II										-0.189[b]	-0.139 [b]						-0.197 [a]	
Grade 6 reading score	I					-0.008 [a]	-0.008[c]			-0.002 [a]					-0.009 [a]			-0.002 [a]	-0.002 [a]
	II																		
Grade 6 writing score	I					-0.008 [a]	-0.009 [c]	-0.073 [a]	-0.002 [a]	-0.002 [c]				-0.036 [a]	-0.013 [c]	-0.009 [a]	-0.011 [a]	-0.004 [c]	-0.003 [c]
	II																		
Grade 6 mathematic score	I					-0.012 [a]	-0.012 [c]		-0.004 [a]	-0.004 [c]				-0.065 [a]	-0.015 [b]	-0.011 [a]		-0.005 [b]	-0.003
	II																		

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

I: Method I or when FSs was continuous variables, II: Method II or when FSs was binary variables

[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001

Coloured cells showed the significant associations before controlling for school neighbourhood **household income**, parent education and students' competency in English

VI. DISCUSSION

This is the first study to describe the food retailer environment around schools in the Region of Waterloo with regard to the change of FS counts around schools over time (2008 to 2010) and by elementary/middle versus secondary schools. The study also provides new information on food store counts around schools in relation to school neighbourhood income and school level academic performance results. The key findings were that FS counts around schools increased from 2008 to 2010 in general. In addition, the higher the school neighbourhood income, the lower the counts of FFRs, convenience stores and total stores around schools. Finally, the number of supermarkets, convenience stores and total stores were negatively associated with students' academic performance. Moreover, even after adjusting for school neighbourhood income, parent education and students' competency in English, there were still significant associations between FS counts (supermarkets, convenience stores and total stores) and students' academic performance. The discussion starts with the FS counts around schools in the Region of Waterloo from 2008 to 2010, and then the relationships between school neighbourhood income and FS counts will be discussed. Finally, the associations between students' academic performance and FS counts will be examined.

1. Exploring and comparing the FS counts around schools in the Region of Waterloo between 2008 and 2010

Hypothesis 1: There would be at least one FS within each buffer zone around schools.

Results from the current study supported the hypothesis that there would be at least one FS within walking distance from schools on average. In particular, there was at least one FFR within

500m and at least one FS of each store type within 1000m and 1500m around schools on average. These findings are in line with findings from previous research. For example, four studies conducted in the US found the presence of FFRs within 800m around most of the schools in the study sample (Harris et al., 2011; Simon et al., 2008; Austin et al., 2005; An & Sturm, 2012; Zenk & Powell, 2008; Day & Pearce, 2011). Similarly, other studies in US and New Zealand found at least one convenience store within 800m around most of the schools in the study sample (Gebauer & Laska, 2011; Zenk & Powell, 2008; Day & Pearce, 2011).

However, while the above studies only included FFRs or convenience stores, the current study, and three others conducted in Canada, also included other food store types in the analysis (Kestens & Daniel, 2010; Leatherdale et al., 2011; Seliske et al., 2009a). Findings from the current study strongly support those from a study conducted in Montreal, which found at least one full-service restaurant, FFR and supermarket within 750m from schools on average, and a study conducted in Ontario, which found an average of one FFR, supermarket and convenience store within 1000m from schools (Kestens & Daniel, 2010; Leatherdale et al., 2011). Similarly, Seliske and colleagues (2009a) also found that half of a 118 schools across Canada had at least one full-service restaurant, FFR and convenience store within 1000m from schools. However, none of the schools had supermarkets within 1000m.

All in all, even though different studies used different indicators for the number of food stores around schools (mean, median or percentage of schools within study samples) and buffer zones (400m, 500m, 800m or 1000m), the presence of FSs within walking distance around schools was consistently observed. Within the Canadian context, not only FFRs and convenience stores, but also full-service restaurants were found surrounding schools. In terms of the presence of supermarkets, studies conducted in either Montreal or Ontario found at least one supermarket

within either 750m or 1000m around each school, but the study conducted in schools across Canada did not find the presence of supermarket around schools. It is possible that a sample of 118 schools is a relatively small sample in generating a conclusion about the presence of supermarkets around schools across Canada. In addition, the study at 118 schools across Canada included schools in both urban and rural areas, while the current study and another were conducted in mostly urban schools (Kestens & Daniel, 2010). This could also be one of the reasons for the discrepancy in study findings. Therefore, future studies with sufficient sample including schools in both urban and rural areas are needed to verify the presence of supermarket around schools in the Canadian context. Nevertheless, it is clear that if students are able to purchase foods before, after, or during the school day (e.g., depending on the school policies, their transport patterns or personal finances), then the opportunities for them to do so are available within walking distance. Moreover, the opportunities to purchase less healthy foods seem to be more plentiful than the opportunities to purchase nutrient dense and low energy foods, like vegetables and fruit.

Hypothesis 2: There would be more FSs around schools in 2010 than in 2008.

In general, FS counts increased from 2008 to 2010, with some exceptions. For example, while the number of total stores, full-service restaurants and convenience stores increased from 2008 to 2010, FFR and supermarket counts at all buffer zones were not always higher in 2010 than in 2008. This trend was found around all schools combined, as well as around elementary schools and secondary schools separately. Findings of FS counts around schools from the current study partly support the hypothesis that there were more FSs around schools in 2010 than in 2008.

Even though summarized statistics about the growth of FSs over the years in Canada are unavailable, data about 'eating out' trends of Canadians partly explain the increase of restaurant

and FSs from 2008 to 2010. According to Statistic Canada, there has been a surge in the food service industry due to the increasing trend of eating out in Canada; Canadians have been eating out more often and spending more money on restaurant meals. For example, Canadian households spent an average of $1,487 on food purchased from restaurants in 2003, a 27% increase from 1997 (Statistics Canada, 2006). However, considering the increase of the population in the Region of Waterloo, the increase in FS counts might simply correspond with the increase in the population (Region of Waterloo, 2013).

Nevertheless, the number of specific store types within the three buffer zones studied did not always increase from 2008 to 2010; this was particularly true for FFRs and supermarkets. The decrease of supermarket counts at 500m could be partly explained by the slow growth and closing of supermarkets in Ontario in general due to the economic recession (Canadian Grocer, 2010). However, the increase of supermarket counts within 1000m and 1500m from schools, might also reflect a trend that supermarkets are closing in urban areas and opening in rural areas; it is more spacious and cheaper in terms of rent, labour and insurance to operate a supermarket in sub-urban areas (Pothukuchi, 2005; ICIC, n/d). However, the decrease of FFR counts from 2008 to 2010 within 1000m and 1500m around schools in the Region of Waterloo is hard to explain based on limited data available in the current study. Nevertheless, FFRs still had the highest counts around schools compared to other food types

Hypothesis 3: There would be more FSs around secondary schools compared to those around elementary/middle schools.

As hypothesized, the results showed that compared to elementary schools, secondary schools had higher FS counts at all buffer zones (500m, 1000m and 1500m) with the single exception that supermarket counts within 1500m were higher around elementary schools than secondary schools in either 2008 or 2010.

In general, secondary students are more mobile, have more freedom over food choices during the school day and have greater access to finances compared to elementary students. As a result, secondary students might be more likely than elementary students to serve as an important customer base for inexpensive and convenient food at FSs around schools. Therefore, the higher counts of FSs around secondary schools compared to elementary schools are reasonable.

Findings of FS counts around elementary and secondary schools might be affected by a school location factor. It was found that urban areas tend to have higher commercial density than rural areas (Zenk & Powell, 2008; Day & Pearce, 2011, Howard et al., 2011; Austin et al., 2005; Neckerman et al., 2009). However, while 19 out of 20 secondary schools in the current study were located in urban areas (Waterloo, Kitchener and Cambridge), 130 out of 147 elementary schools were also located in urban areas. Therefore, a school location factor might not explain the difference in FS counts between elementary and secondary schools in this study. The findings are in line with those from previous studies that were also conducted in urban areas, in which there were more convenience stores and FFRs around secondary schools than elementary schools (Gebauer & Laska, 2011; Simon et al., 2008; Day & Pearce, 2011).

2. Exploring the relationships between the FS counts around schools and school neighbourhood income

Hypothesis 4: There would be negative associations between the FS counts around schools and school neighbourhood household income.

Although there were significant negative associations between FS counts and school neighbourhood income as hypothesized, the associations were only found for FFRs and convenience stores. The myth that foods from FFRs and convenience stores are more affordable than those from full-service restaurants and supermarkets to low income families might not always be true since well-prepared homemade meals could be cheaper than meals purchased in FFRs or convenience stores (McDermott & Stephens, 2010). However, the fact that FFRs and convenience stores tended to cluster in low SES neighbourhood was proven through findings in several studies (Block, Scribner, & DeSalve, 2004; Pearce, Blakely, Witten, & Bartie, 2007; Cummis, McKay, & Maclntyre, 2005). It is plausible that FFRs and convenience stores may reflect urbanization. As the population in urban areas tend to be higher than those in rural areas, which draw more FSs to urban areas to meet the demand of the population. Nevertheless, the associations between FS counts and school neighbourhood income in the current all remained significant after correcting for population counts. Hence, urban versus rural location is not a matter in this case.

However, these findings were consistent with findings from several studies,in which negative associations between FFR and convenience store counts around schools to school neighbourhood SES were found (Simon et al., 2008; Zenk & Powell, 2008; Day & Pearce, 2011; Howard et al, 2011; Sturm, 2008; Kestens & Daniel, 2010). Also, most of the studies, including the current one, used median household income as a measurement for school income (Simon et al., 2008;

Zenk & Powell, 2008; Day & Pearce, 2011). Nevertheless, the findings were inconsistent with findings from a study conducted in 118 schools across Canada (Seliske et al., 2009b). Seliske and colleagues (2009b) did not find any association between FFR and convenience store counts to school neighbourhood SES. However, the classification of FFRs was slightly different between the current study and Seliske's study. For example, sub/sandwich shops and donut/coffee shops were two separate categories in Seliskes' study but were grouped under FFR category in the current study. The difference in FS classification might partly explain the difference in the findings between the two studies.

In contrast, the positive associations between full-service restaurant counts and school neighbourhood SES that were found in Seliske study were not found in the current study (Seliske et al., 2009b). However, the definition of school SES was different between two studies. Median household income was used a proxy for school neighbourhood SES in the current study, whereas a combination of average household income, unemployment rate and parent education was used as the proxy for school neighbourhood SES by Seliske and Colleagues (2009b). Differences in the definition of school neighbourhood SES might lead to difference in findings between two studies. Similarly, the associations between supermarket counts and school neighbourhood SES are also debatable. While Kestens & Daniel (2010) found the negative associations between supermarket counts and school neighbourhood SES, those associations were not found in the current study and another study conducted in the U.S. (Howard et al., 2011). Therefore, having a gold standard definition for school SES, such as the median household income at dissemination area or census tract level, and for FS classification such as the NAICS is significant in generating comparable study findings among studies. In addition, the finding that associations tended to be stronger within 500m compared to those at 1000m and 1500m when considering the same store

types is very interesting. This is the first study that found this trend. Hence, more studies are needed to re-test this trend before a conclusion can be generated.

3. Exploring the relationships between FS counts and students' academic performance (EQAO scores) without controlling for school neighbourhood income, parent education, physical activity and students' competency in English

Hypothesis 5: There would be negative associations between the FS counts around schools and students' academic performance.

All FS types were tested, but consistent associations were only found between the count of supermarkets, convenience stores and total stores to students' academic performance. Hence, without considering the count of full-service restaurants and FFRs, findings from the current study supported the hypothesis; there were negative correlations between FS counts around schools (supermarkets, convenience stores and total stores) and students' academic performance.

It was surprising that consistent associations between FFRs and EQAO scores were not found. Within the current study, FFRs were found to have the highest counts within 500m, 1000m and 1500m in either 2008 or 2010 compared to other FS types. FFRs were also found to be available within walking distance from schools in several other studies (Howard et al., 2011; Davis & Carpenter, 2009; Harrison et al., 2011; Leatherdale et al., 2011). In addition, the positive relationships between FFR counts and students' BMI were found in several studies (Davis & Carpenter, 2009; Harrison et al., 2011; Leatherdale et al., 2011; Seliske et al., 2009a; Howard et al., 2011). As discussed in the literature review section, obesity tended to be linked to poor performance of students at schools. Hence, it was expected that negative associations between FFR counts and EQAO scores would be found. Nevertheless, although most of foods at FFRs are

unhealthy in general, there are also some healthy food items at FFRs. Without individual information of students' food purchasing at FSs around schools and their food consumption, a rigid conclusion about the associations between FFRs around schools to student's academic performance is hard to establish.

In contrast, the negative relationships between supermarket and total store counts to Grade 3 EQAO scores and the negative relationships between convenience store and total store counts to Grade 6 EQAO scores were relatively consistent across buffer zones and years. Convenience stores within walking distance from schools were found in several studies as well as in the current study (Howard et al., 2011; Leatherdale et al., 2011; Seliske et al., 2009a), however, only one study found significant negative correlations between convenience store counts and students' BMI (Howard et al., 2011). Since unhealthy foods at convenience stores sometimes can be cheaper than those at some FFRs (e.g., Medill Reports Chicago, 2013). In addition, a study conducted in US found that students did shop at convenience stores around schools and most frequently purchased items were energy-dense and low-nutritive foods (Borradaile et al., 2009). Another study conducted in US found that even though some healthful items such as water or 100% fruit juice were also offered in some convenience stores, most of those items were not available in the single package. Also, most of the convenience stores in the sample advertised and promoted the purchasing of less healthful products (Gebauer & Laska, 2011). Perhaps, an association between FS counts and students' BMI is reasonable, but more explanation is needed to connect these with academic performance.

The consistent negative associations between supermarket counts and Grade 3 EQAO scores are also surprising. First of all, to date, only two studies conducted in Canada investigated the relationships between supermarket counts and students' BMI (Leatherdale et al., 2011; Seliske et

al., 2009a). Within those, Leatherdale and colleagues (2011) found negative associations, whereas Seliske and collogues (2009a) did not find any association between the presence of supermarket around schools and students' BMI. Furthermore, most Grade 3 students might not be allowed to leave schools during breaks and might not be as mobile as secondary students before and after schools to shop at FSs around schools. In addition, it seems unlikely that students, especially Grade 3 students, would choose to shop at grocery store when FFRs or convenience stores are around.

Nevertheless, due to the cross-sectional characteristic of the current study, the associations between supermarket counts and Grade 3 EQAO scores do not guarantee causal relationships. For example, the presence of supermarkets within walking distance around elementary schools might not necessarily serve the needs of Grade 3 students, but the population in those areas. Also, assuming that Grade 3 students did shop at supermarkets, they might choose unhealthy food items over healthy ones since plenty of unhealthy snacks such as pop and chips could be found at supermarkets. Finally, even if children do not shop for foods themselves, they seem to have pester power that influence their parents' food purchasing to some degrees (Turner, Kelly, & McKenna, 2006; Wimalasiri, 2004). Furthermore, a study conducted at supermarkets in Australia found that several products were marketed to children through product packaging, and most of those products were confectionary and chocolate (Mehta, Philips, Banytis, Ward, Coveney, Handsley, 2010). Besides that, unhealthy foods such as chocolate and confectionary dominate supermarket check-outs and are situated in the reach and sight of children (OPC, 2011). All in all, the supermarket environment seemed to foster pester power among children and most of the products advertised to children **were** unhealthy. Nevertheless, data within this study were insufficient to prove that parents shop for grocery at supermarkets close to schools.

Therefore, these explanations are all speculation and further research would be needed to see if these are spurious findings of if there are plausible explanations.

Since supermarket and total store counts were negatively associated with most of Grade 3 EQAO scores and convenience and total store counts similarly associated with most of Grade 6 EQAO scores, it follows that supermarket, convenience store and total store counts were all negative associated with the overall EQAO scores from all schools combined and from elementary schools only.

In summary, although the results of the associations between FS counts and EQAO scores were debatable, these findings are still valuable. As the first study examined the relationship between FS counts around schools and EQAO scores, findings from the current study can set out the foundation for future study in further investigating the hypothesized causal links in the path between FS counts and students' academic performance. Furthermore, regression plots suggested that although the associations seemed to be weak and there were some outliers, there were negatively association between FS counts and EQAO scores.

Although the slight difference in the associations across the buffer zones was documented among different analysis methods (method I and method II), this matter is not the main question within this study, and thus is not discussed. However, this could be an interesting topic for future study for further investigation.

Hypothesis 6: There would be more associations between FS counts and secondary students' academic performance than elementary students.

It was interesting that almost all of the associations between FS counts and EQAO scores were with EQAO scores from elementary schools. In other words, findings from the current study

failed to support the hypothesis that there would be more associations between FS counts and secondary students' academic performance than that of elementary students. Since secondary students are more mobile and have greater access to finances than elementary students, it was expected that secondary students would shop at FSs around their schools more frequently than elementary students. Plus, there were more FSs around secondary schools than elementary schools. Hence, secondary students were hypothesized to experience negative effects, e.g., unhealthy diets and obesity, to a greater extent than elementary students, which might contribute to poor academic performance as a result. However, findings from the current study did not support the hypothesis.

However, the number of secondary schools is relatively small in the current study (20 schools) although all secondary schools in the Region of Waterloo were included. It might be insufficient to generate the relationships between FS counts around schools and secondary students' EQAO scores. Thus, future studies might need to have a larger sample size of secondary schools to examine the above relationships. Furthermore, it is possible that students are more influenced to purchase foods at FSs in other places such as their home neighbourhood, recreation centres, movie theaters, location of part-time jobs or extended route to schools, rather than FSs around schools. As a result, the influence of FS counts around schools might be moderated for secondary students.

4. Exploring the relationships between FS counts and students' academic performance (EQAO scores) after controlling for school neighbourhood household income, parent education, physical activity and students' competency in English

Hypothesis 7: The associations between FS counts and students' academic performance would be weakened or become insignificant after controlling for school neighbourhood household income, parent education, and student physical activity and student competency in English.

Except for the interaction terms between school neighbourhood income and FS counts, school neighbourhood income, parent education, physical activity and students' competency in English all were found to influence the associations between FS counts and EQAO scores; many significant associations disappeared or were weakened after correcting for the above confounding factors separately or all together. However, different factors affected the associations between FS counts and EQAO scores at different levels. Within that, school neighbourhood household income had the most profound impact on the associations between FS counts and EQAO scores and parent education influence ranked second. Since positive associations between SES and parent education and students' academic performance were found in several studies (Sutton & Soderstrom, 1999; Toutkoushian & Curtis, 2005; Tomul & Celik, 2009; Thomas, 2006; Rindermann et al., 2011; Myrberg & Rosen, 2008; Davis & Kean, 2005), findings from the current study seem reasonable. It seems that income, parent education and students' academic performance are interrelated. According to Statistics Canada, "higher household income levels were associated with higher parent educations levels" and vice versa (Thomas, 2006). Studies also found that parents with high education or high annual income have higher expectations for their childrens' educational achievement than parents with low education

or annual income (Child Trends Databank, n/d). Parent expectations seem to positively associate with students' academic achievement (Entwisle, Alexander, & Olson, 2005; Fan, 2001; Jeynes, 2007). Therefore, students with higher education parents might also be from higher income families and had higher expectation from their parents, which might partly explain their better academic performance.

Although physical activities and students' competency in English also affected the associations between FS counts and EQAO scores, the influences were weaker than those of household income and parent education. Importantly, most of the associations between FS counts and EQAO scores remained significant after correcting for physical activity or students' competency. Due to the unavailability of PA data in 2008, only associations in 2010 were adjusted for physical activity and PA was not included in the final models, which corrects for all of the potential confounding factors.

When all potential confounding factors: school neighbourhood income, parent education and students' competency in English were adjusted for, many significant associations became insignificant or weaken. These results support the hypothesis that the associations between FS counts and EQAO scores would be weakened or become insignificant after correcting for potential confounding factors. However, even after several associations turned insignificant, there remained many significant associations that followed the trends; Grade 3 EQAO scores were negatively associated with supermarket counts, Grade 6 EQAO scores were negatively associated with convenience store counts and the overall EQAO scores from all schools combined and from elementary schools only were negatively associated with all FS counts (supermarket, convenience stores and total stores). This suggests that there is some true relationship between FS counts and academic performance.

In summary, school neighbourhood income and parent education are stronger confounding factors than PA and students' competency in English. Furthermore, the significant associations that remained after correcting for potential confounding factors indicate FS counts may be one of the many influences on students' academic performance. Therefore, it is justified for future studies to investigate the impact of FS counts around school on students' academic performance. It should be noted that not all potential confounders were tested in the current study. Hence, other potential confounding factors such as teaching quality, student learning strategy, parents' involvement, etc., should also be controlled for in future studies.

5. Comparing the associations between FS counts and EQAO scores between 2008 and 2010

Hypothesis 8: There would be more associations between FS counts and students' academic performance in 2010 compared to those in 2008.

Results from the current study support the hypothesis that there were more associations between FS counts and EQAO scores in 2010 compared to those in 2008 with or without adjusting for potential confounding factors. Even though supermarket, convenience store and total store counts all associated with EQAO scores in both 2008 and 2010, there were more significant associations between convenience store counts and EQAO scores in 2008 than those in 2010. In contrast, there were more associations between supermarket store counts and EQAO scores in 2010 than those in 2008. Also, the trends that Grade 3 EQAO scores were associated with supermarket and total store counts and Grade 6 EQAO scores were associated with convenience store and total stores were also more consistent in 2010 than those in 2008.

In general, FS counts increased from 2008 to 2010 in the Region of Waterloo for all store types

and within all three buffer zones measured around schools. The increase in FS counts might result in the increase of food purchasing at those store by students and more associations between FS counts and academic performance in 2010 as a result. However, the data of FS counts and EQAO scores were only collected for two years (2008 and 2010), which might not reflect the secular trend in FS counts and EQAO scores. In addition, it is a difficult task to fully explain the findings that supermarket counts tended to association with EQAO scores in 2010 and convenience store counts tended to associate with EQAO scores in 2008, explaining those associations within this study. Further investigation is needed for more reliable explanations.

VII. STUDY LIMITATIONS

1. Positional error in geocoding

Even though the geocoding process was done in a very careful manner, it is impossible to avoid positional errors. There are several possible sources of errors in the geocoding within this current study. First, reference files may contain errors such as missing, incomplete and incorrect street segment and address ranges (Cayo et al., 2003), which could lead to putting addresses to the wrong location. Second, if the postal code boundary information in the reference files is incorrect, addresses can be placed several kilometers from their true location (Cayo et al., 2003). Third, if address ranges are reversed in the reference files, houses will be geocoded to either the wrong side or wrong end of the street (Cayo et al., 2003). Finally, errors can come from the Address locator. For example, the Address locator uses interpolation algorithms to determine an address along a street centerline (Zimmerman et al., 2010). The software interpolated where to place an address based on the street number assigned to the ends of each street segment. Hence, when the street segments increase in length and have fewer intersection, the interpolate error will also be increased (Zimmerman et al., 2010). This error is more prevalent in the rural areas than urban areas (Zimmerman et al., 2010). Nevertheless, most of FSs in the current study sample are from urban areas (Waterloo, Kitchener and Cambridge). Therefore, the errors due to the interpolation algorithms should not be a concern.

In the current study, there were some discrepancies between the geocoding results from the current study. In particular, the number of total stores, full-service restaurants and convenience stores in the data from PH was higher than in the data from the current study; however, the number of FFRs and supermarkets was higher in data from the current study than that from PH even though both sets of data were drawn from the food inspection premises listing published by

the Region of Waterloo. The discrepancies might be due to the geocoding errors. However, since there is no gold standard to compared with, it is hard to justify the accuracy of the geocoding results either from the current study or from PH.

2. Using Euclidean buffer instead of the street network

The study used the Euclidean (straight-line, circular radius) buffers in calculating the buffers around schools. While it is a very useful tool in geocoding, in which thousands of addresses can be geocoded in a very short time, it also has a drawback. The Euclidean technique does not take into consider the street network, sidewalks, and other elements of the areas surrounding schools in the analysis (ESRI, n/d). As a result, the area covered by Euclidean buffers can be substantially larger than that covered by equivalent distance network buffers.

3. Misclassification of FSs

Classification of FSs based on site visits is highly accurate. However, it was not feasible to do so in the current study, especially given the FSs located in rural areas and the enormous amount of addresses. Therefore, classification of FSs was based on business websites as a reasonable substitute strategy. However, problems could have occurred in categorizing small local food stores. For example, for local FSs that did not have their own websites, the classification was based on general websites such as canpages.ca, Profilecanada.com, and Phonepages.ca or customer review websites such as Dinehere.ca, Restaurantica.ca, Yelp.ca. This could have lead to misclassification of FSs due to the insufficient information on those websites.

4. Accuracy of the FS source

The food premise inspection data from the Public Health unit in the Region of Waterloo would include most of the FSs in the Region of Waterloo and are expected to be fairly accurate.

However, it is still possible that some very small local FSs were not listed in the data. Also, data could contain some errors such as wrong store names or wrong addresses.

5. Proxy measurement of household income and students' academic performance

The median household income at dissemination area level was use as a proxy for students' families' incomes in the current study. However, students may travel to school from outside the neighbourhood, especially high school students, and there will be families in the neighbourhood with no students in a specific school. Therefore, it is plausible that a school population's household income is higher or lower than the average family income from the whole region. Moreover, there is a great variability from family to family within a region for any of the variables of interest (household income, parent education, etc.,), but we had only composite values.

Furthermore, the EQAO test is a one-day test, which might not accurately reflect students' competence and performance (EQAO, 2012). Also, the scores are the composite scores of all students in one grade (Grade 3, Grade 6 and Grade 9) in a school or of all students in one school. These composite scores would obscure the gaps in the test performance of different students and any associations between FS counts around schools and students' academic performance as a result.

6. Study design

This is a cross-sectional study only. Hence, a causal relationship cannot be established. Furthermore, without controlling for baseline measurement (students' academic achievement or BMI) or personal exposure to purchased foods, it is possible that the significant associations happened by chance.

7. Lacking individual information

The thesis is based on the assumption that unhealthy food counts around schools would affect student academic performance, perhaps with malnutrition or BMI as an intermediate. However, we have no data on individual food purchases, food intake, nutrition status or BMI. Proxy values by school will, recognizably, be very general. Lacking individual food habit information any association between the FS counts and students' performance could be due to the FS counts around schools or other locations where the student lives or plays. In addition, it is recognized that there are a range of choices (healthy or unhealthy) within any FS or retail category. Students might visit supermarkets but purchase pop and chips instead of fruits and vegetables, for example.

VIII. STUDY STRENGTHS

In spite of the above limitations, this study is still important with its several strengths. First, while many other factors such as family income and parent education have relationships with students' academic performance, the associations between FS counts around schools and students' academic performance have not been investigated elsewhere. Therefore, this is a first (pilot) study that investigated these relationships after consideration of income and parental education levels. In addition, the consistence in the associations even after correcting for several potential confounding factors in this study indicated that true relationship between FS counts and students' academic performance might exist. Therefore, it is worth further investigation of these relationships in future studies, given the importance of maximizing students' academic performance to students, parents, schools and the Ministry of Education.

Second, while previous studies mostly included FFRs and convenience stores in the analysis, this study also included full-service restaurants and supermarkets. In fact, findings from this study reveal very interesting information about the potential effects of supermarket on students. For example, while the presence of FFRs within walking distance around schools has been found in several studies and FFRs had the highest counts of all food outlet types around schools in the current study, the presence of supermarkets surrounding schools is controversial. In the literature, FFRs were more likely than supermarkets to associate with students' BMI. Hence, it would be expected that FFRs would have stronger associations with students' academic performance than supermarkets. However, relatively consistent relationships between supermarkets and EQAO scores were found and inconsistent relationships between FFRs and EQAO scores. The findings indicated that it is worth including FS types other than FFRs or convenience stores in the analysis.

Furthermore, while most studies only included franchised FSs and restaurants, this study also included local or non-franchised FSs or restaurants. If a non-franchised FS or restaurant is located within walking distance from schools students might visit it. Hence, it is also important to include local FSs and restaurants besides just the branded ones.

Third, although the EQAO test is the one-day-exam, it is a provincially standardized exam in which students from same Grade in Ontario take the same test at roughly the same time of year. Therefore, it eliminates discrepancies and sources of bias that might affect less standardized means of assessing academic performance.

Fourth, the current study included all schools (elementary/middle and secondary schools) in the Region of Waterloo. Hence, the selection bias in choosing participants (schools) for this study would be eliminated. This study sample might not be a representative sample for all schools in Canada, but it is a comprehensive sample reflecting characteristics of schools in the Region of Waterloo. Therefore, findings from the current study are highly applicable for schools within the Region of Waterloo

Fifth, although this is a cross-sectional study, the data on FS counts and EQAO scores, were collected in 2008 and 2010 retrospectively. The relatively consistent trends in the associations between FS counts and EQAO scores across the years (2008 and 2010) might indicate this is a secular trend. In other words, the two years of data collection helped to diminish some weaknesses of the cross-sectional study design.

Finally, FSs were classified using the NAICS, a standardized FS classification that was developed by the U.S. federal government in cooperation with Canadian and Mexican statistical agencies and applicable for categorizing FSs in Canada. Different definitions of FS categories could lead to difficulty in comparing findings among studies. Therefore, it is important to use the

standardized measurement so that the classification can be repeated in other studies and the findings are comparable among studies.

IX. IMPLICATIONS FOR PRACTICE

The totality of the evidence from the current study suggests that the counts of food stores around a school has a relationship to academic performance even when key factors such as neighbourhood income and parental education are considered. If the associations or causal relationships could be confirmed, this would have policy implications, for example, zoning of FSs around schools and school practices.

According to the current study, the opening of FSs within walking distance from schools, especially at 500m, should be restricted, including supermarkets and convenience stores. Furthermore, the food neighbourhood environment should be considered when new schools or new communities are going to be built. As the social environment could influence people eating behaviour and BMI as a result (Story et al., 2008), if schools are located in high FS counts areas, and if those FSs can be accessible by students during beaks, students' academic performance might be affected. Furthermore, having a school policy that restricts students from leaving school property during breaks might also help to enhance students' performance.

X. SUGGESTIONS FOR FUTURE STUDIES

In order to overcome the limitations of the current study described above, yet explore the suggestion within the data or a relationship between FS counts and academic performance, future studies should be longitudinal data including individual data on academic performance; BMI; accurate assessment of food intake; food purchasing behaviour and determinants, own family income; own family parental education; accurate assessment of physical activity. Identification of all outlets visited in all relevant geographical locations is also suggested.

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APPENDIX

Appendix A: The Education Quality and Accountability Office (EQAO,n/d)

EQAO's tests measure student achievement in reading, writing and mathematics in relation to Ontario Curriculum expectations. The resulting data provide accountability and a gauge of quality in Ontario's publicly funded education system. By providing this important evidence about learning, EQAO acts as a catalyst for increasing the success of Ontario students

The Provincial Standard
The four levels of achievement that EQAO uses to report student results are aligned with the four levels of achievement used by the Ministry of Education. The Ministry of Education has established Level 3 as the provincial standard. Level 3 represents a range from B– to B+ for students in elementary school and a range from 70% to 79% for students in secondary school.

Meeting the standard means a student has a solid grasp of the required knowledge and skills, which is a good indication that he or she will be ready for work in the next Grade. The standard is rigorously maintained from year to year, and EQAO assessments are developed and scored in a way that ensures the results can be compared appropriately from one year to the next.

Testing the Curriculum
The provincial tests given at the end of the primary division (Grade 3) and the junior division (Grade 6) assess students relative to the expectations in *The Ontario Curriculum, Grades 1–8: Language* (revised 2006) and *The Ontario Curriculum, Grades 1–8: Mathematics* (revised 2005), which outline the knowledge and skills students should have acquired by the corresponding stages of their schooling.

EQAO assessments measure how well students have met the provincial curriculum expectations. For example, Grade 3 and Grade 6 students are assessed in

- **reading**—using a variety of reading strategies and conventions, understanding concepts, making inferences and connecting ideas;
- **writing**—using writing strategies and language conventions, understanding assigned tasks, organizing ideas and communicating with the reader and
- **mathematics**—demonstrating knowledge and skills in the five strands of mathematics: number sense and numeration, geometry and spatial sense, measurement, patterning and algebra, and data management and probability.

The Grade 9 mathematics test is based on the expectations for student knowledge and performance up to the end of Grade 9 in *The Ontario Curriculum, Grades 9 and 10: Mathematics* (revised 2005). The purpose of the Grade 9 Assessment of Mathematics is to assess the level at which students in the applied and academic mathematics courses are meeting Grade 9 curriculum expectations. Students enrolled in Grade 9 academic and applied mathematics must demonstrate knowledge and skills in the same three areas number sense and algebra, linear relations, measurement and geometry and for the academic course, they must also do so in analytic geometry.

Appendix B: Overall rating out of 10 for elementary schools (Fraser Institute, n/d)

Grade-6 enrollment: The number of students eligible to participate in the Grade-6 tests. Indicator results for schools with small enrollments tend to be more variable than do those for larger schools. For this reason it is particularly important to consider previous results as well as those for the most recent year.

Gr 3 avg level and Gr 6 avg level: The average level achieved by the students on the Grade-3 and Grade-6 EQAO tests. The EQAO assigns a level of achievement to each completed test. Achievement at Levels 1 and 2 suggest that the student has not yet met the provincial standard. Level 3 is considered the provincial standard and Level 4 represents achievement well above the expected level. Thus, achievement at Level 3 or 4 suggests that students are well prepared for work at the next Grade. In order to calculate the average level, a numerical value was given to each level of achievement. Thus, Level 1 was given a value of 1 for purposes of determining the average; Level 2, a value of 2; Level 3, a value of 3; and Level 4, a value of 4. In those cases where a student completed the test but did not demonstrate sufficient understanding to be assigned achievement Level 1, the test was given a value of 0.

Gender gap The difference (in average level of achievement) between girls and boys in the Grade-6 reading and mathematics tests. Where the difference favours the girls, the value is preceded by an F. Where boys are favoured, the value is preceded by an M. An E means that there is no difference between the girls and the boys on this measure. Smaller differences indicate that the school is doing a good job for all its students.

Tests below standard (%): The percentage of all the completed tests written by students at the school that were judged to be below Level 3. A low percentage of Tests below standard (%) indicates that the school is successful in ensuring that most of its students are meeting or exceeding the provincial standard of performance for the Grade.

Overall rating out of 10: The Overall rating out of 10 takes into account the nine indicators described in Gr 3 avg level and Gr 6 avg level, Gender gap and Tests below standard (%) above to answer the question, “In general, how is the school doing academically compared to other schools in the Report Card?”

Appendix C: Overall rating out of 10 for secondary schools (Fraser Institute, n/d)

Avg. level Gr 9 Math: The average level achieved by the students on the Grade-9 academic (Acad) and applied (Apld) mathematics tests. The EQAO assigns a level of achievement to each completed test. Achievement at Levels 1 and 2 suggest that the student has not yet met the provincial standard. Level 3 is considered the provincial standard and Level 4 represents achievement well above the expected level. Thus, achievement at Level 3 or 4 suggests that students are well prepared for work at the next Grade. In order to calculate the average level, a numerical value was given to each level of achievement. Thus, Level 1 was given a value of 1 for purposes of determining the average; Level 2, a value of 2; Level 3, a value of 3; and Level 4, a value of 4. In those cases where a student completed the test but did not demonstrate sufficient understanding to be assigned achievement Level 1, the test was given a value of 0.

OSSLT passed (%): The percentage of eligible OSSLT writers who successfully completed the test, either on their first attempt (FTE) or on a subsequent attempt (PE).

Tests below standard (%): The percentage of all the completed tests written by students at the school that were judged to be either unsuccessful (OSSLT) or below Level 3 (Grade-9 math tests). A low percentage of Tests below standard (%) indicates that the school is successful in ensuring that most of its students are meeting or exceeding the provincial standard of performance.

Gender gap: The difference (in average level of achievement) between girls and boys in the Grade-9 academic mathematics test and the OSSLT (FTE students). Where the difference favours the girls, the value is preceded by an F. Where boys are favoured, the value is preceded by an M. An E means that there is no difference between the girls and the boys on this measure. Smaller differences indicate that the school is doing a good job for all its students.

Gr 9 tests not written (%): The percentage of the Grade-9 mathematics tests that could have been completed by the school's students but which were not assigned an overall score. The percentage, Gr 9 tests not written (%), takes into account the total number of students for whom no test data were submitted or who were exempt from testing. Important note: Schools that administer these tests are expected to ensure that all their students participate. For this reason, you should take note of the Tests not written percentage when you consider each school's results in the Report Card. The principal of a school with a high Tests not written percentage should be able to provide good reasons for the students' failure to complete the tests.

Overall rating out of 10: The Overall rating out of 10 takes into account the indicators Avg. level Gr 9 Math, OSSLT passed (%),Tests below standard (%) and Gender gap described above to answer the question, "In general, how is the school doing academically compared to other schools in the report card?" Important note: The Overall rating out of 10, based as it is on standardized scores, is a relative rating. That is, in order for a school to show improvement in its Overall rating out of 10, it must improve more rapidly than the average. If it improves, but at a

rate less than the average, it will show a decline in its rating.

Appendix D: Definition of Dissemination Area (DA) (Statistics Canada, 2009)

Part A - Plain language definition:

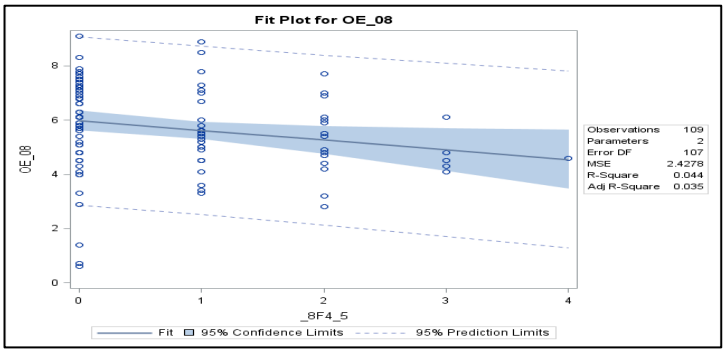
Small area composed of one or more neighbouring dissemination blocks, with a population of 400 to 700 persons. All of Canada is divided into dissemination areas.

Part B - Detailed definition:

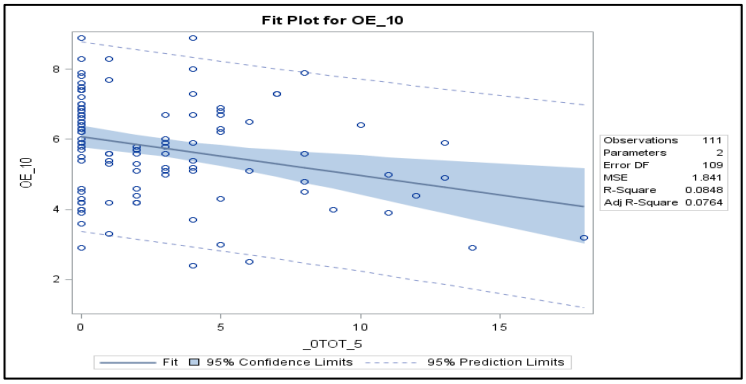
A dissemination area (DA) is a small, relatively stable geographic unit composed of one or more adjacent dissemination blocks. It is the smallest standard geographic area for which all census data are disseminated. DAs cover all the territory of Canada.

Appendix E: Regression plots of the association between FS counts within 500m and

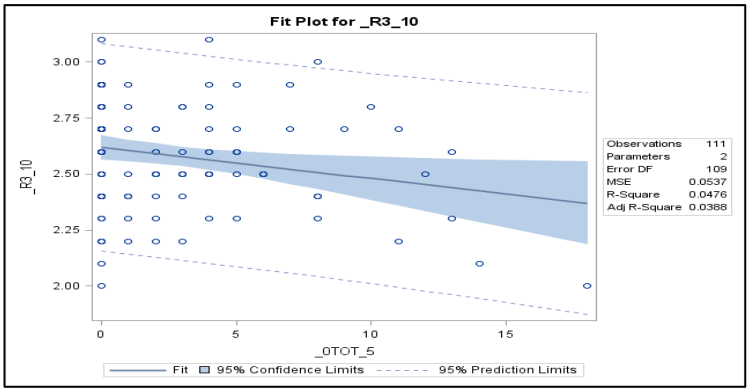
EQAO scores when both EQAO scores and FS counts were treated as continuous variables



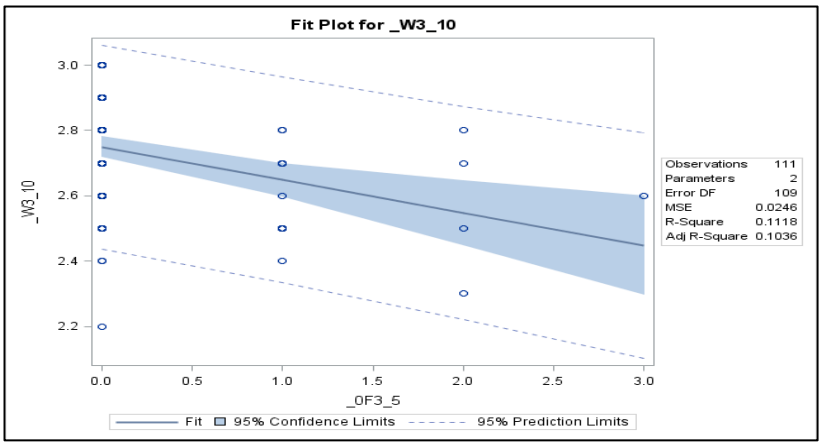
Linear regression between the overall EQAO scores from elementary schools and continuous data on convenience store counts within 500m around schools in 2008



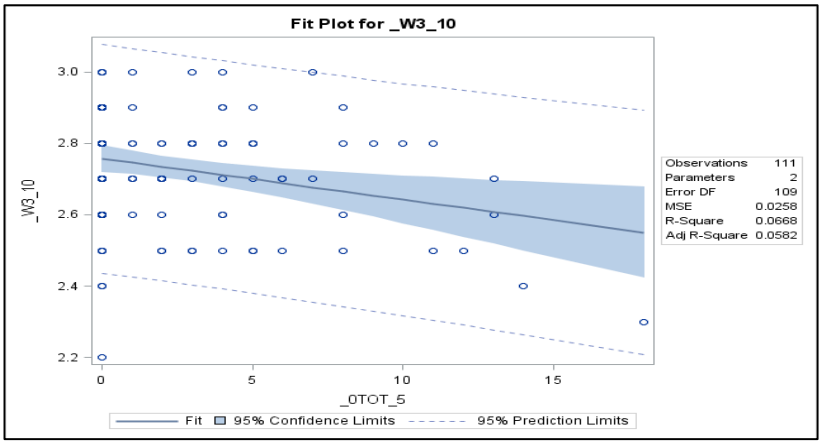
Linear regression between the overall EQAO scores from elementary schools and continuous data on total store counts within 500m of schools in 2010



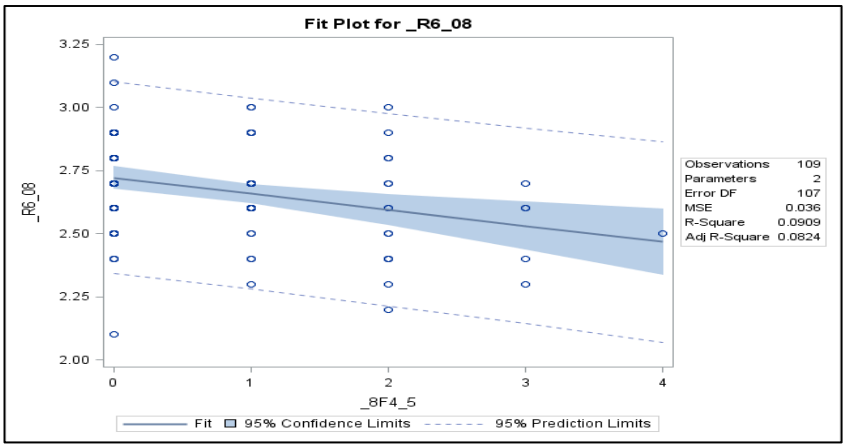
Linear regression plot the relationship between Grade 3 reading score and continuous data on total store counts within 500m of schools in 2010



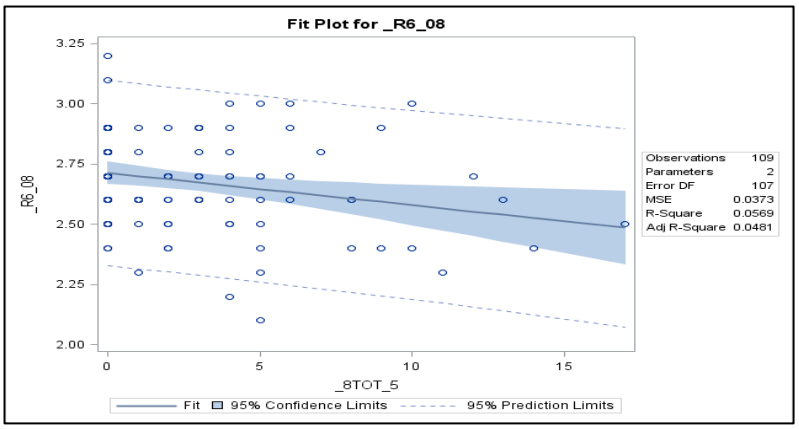
Linear regression plot the relationship between Grade 3 writing score and continuous data on supermarket counts within 500m of schools in 2010



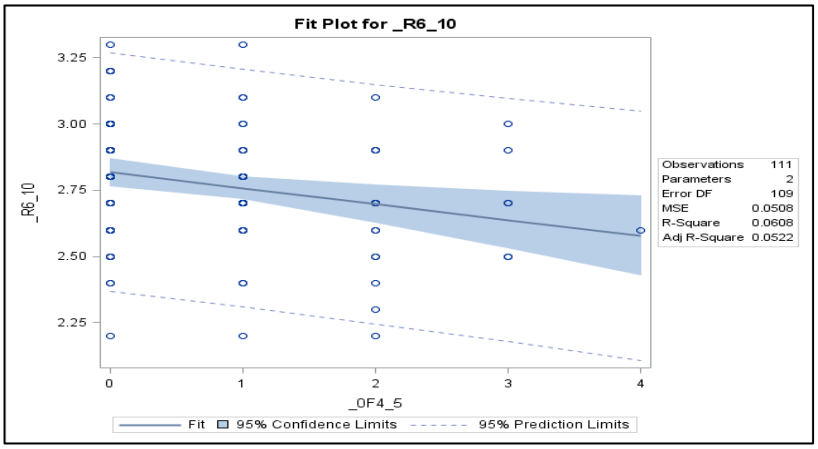
Linear regression plot the relationship between Grade 3 writing score and continuous data on total store counts within 500m of schools in 201



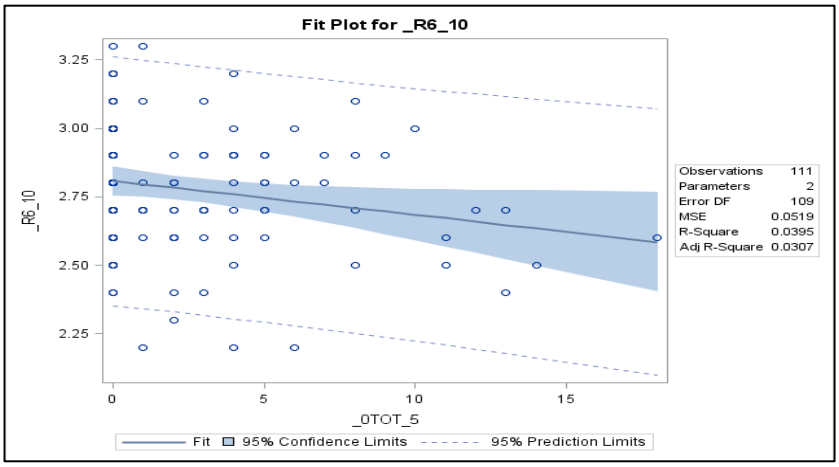
Linear regression plot of the relationship between Grade 6 reading score and continuous data on convenience store counts within 500m of schools in 2008



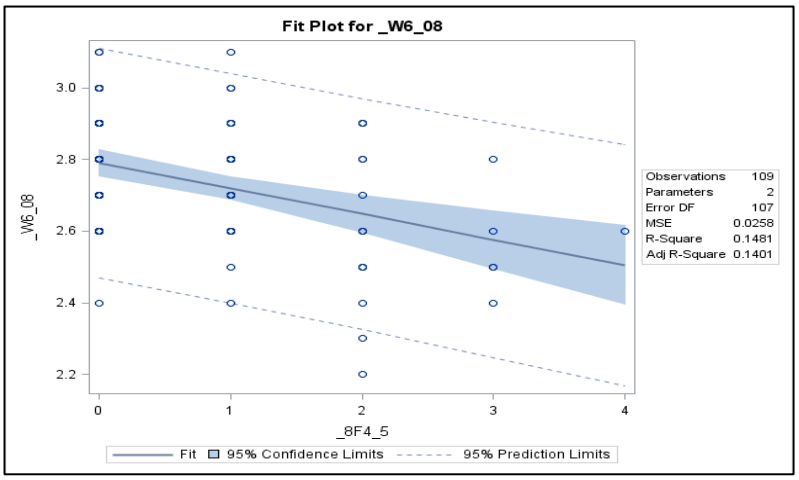
Linear regression plot of the relationship between Grade 6 reading score and continuous total store counts data at 500m in 2008



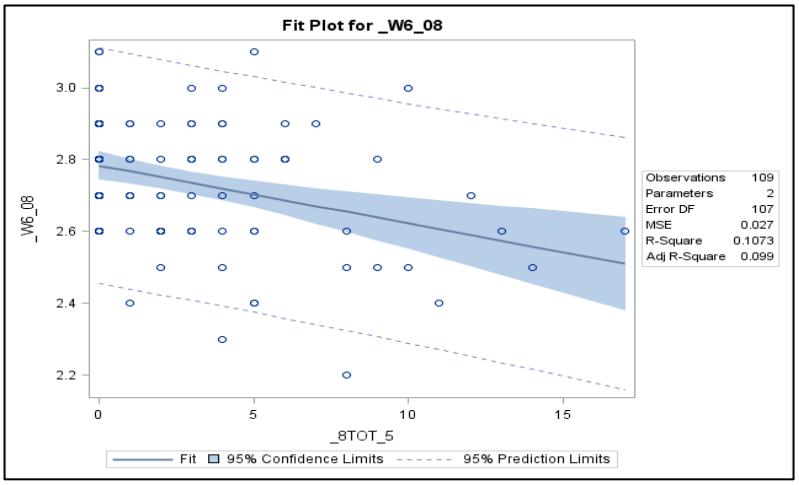
Linear regression plot of the relationship between Grade 6 reading score and continuous convenience store counts data at 500m in 2010



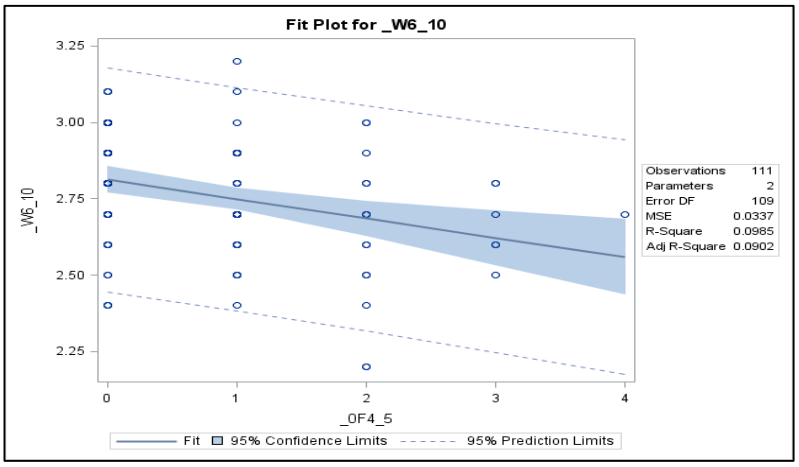
Linear regression plot of the relationship between Grade 6 reading score and continuous total store counts data at 500m in 2010



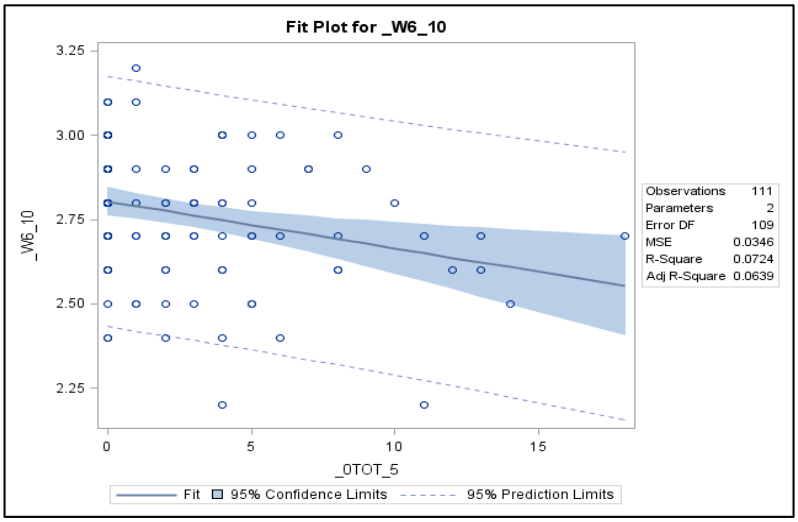
Linear regression plot of the relationship between Grade 6 writing score and continuous convenience store counts data at 500m in 2008



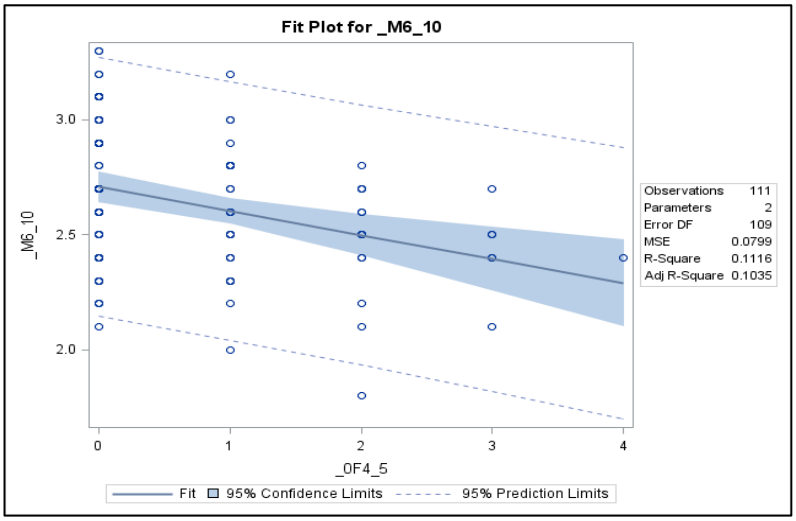
Linear regression plot of the relationship between Grade 6 writing score and continuous total store counts data at 500m in 2008



Linear regression plot of the relationship between Grade 6 writing score and continuous convenience store counts data at 500m in 2010



Linear regression plot of the relationship between Grade 6 writing score and continuous total store counts data at 500m in 2010



Linear regression plot of the relationship between Grade 6 mathematic score and continuous convenience store counts data at 500m in 2010

Appendix F: Outlines all of forward selection/regression analyses performed

Table of analysis
Abbreviation for students' academic performance 08_R3 and 10_R3: EQAO reading score for Grade 3 in 2008 and 2010 respectively 08_W3 and 10_R3: EQAO writing score for Grade 3 in 2008 and 2010 respectively 08_M3 and 10_M3: EQAO mathematics score for Grade 3 in 2008 and 2010 respectively 08_R6 and 10_R6: EQAO reading score for Grade 6 in 2008 and 2010 respectively 08_M6 and 10_M6: EQAO mathematics score for Grade 6 in 2008 and 2010 respectively 08_W6 and 10_W6: EQAO writing score for Grade 6 in 2008 and 2010 respectively 08_A9 and 10_A9: EQAO academic mathematic score for Grade 9 in 2008 and 2010 respectively 08_P9 and 10_P9: EQAO applied mathematic score for Grade 9 in 2008 and 2010 respectively 08_L10 and 10_L10: Percentage of Grade 10 students who passes the literacy test in 2008 and 2010 respectively 08_OE and 10_OE: Overall scores for elementary schools in 2008 and 2010 respectively 08_OS and 10_OS: Overall score for secondary schools in 2008 and 2010 respectively 08_OES and 10_OES: Overall score for all schools in 2008 and 2010 respectively **Abbreviation for school neighbourhood income** SES: 2006 school neighbourhood income **Abbreviation for FS counts around schools** ***FS counts around all schools*** 08_F1_{500}, 08_F1_{1000} and 08_F1_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around schools in 2008 10_F1_{500}, 10_F1_{1000} and 10_F1_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around schools in 2010 08_F2_{500}, 08_F2_{1000} and 08_F2_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around schools in 2008 10_F2_{500}, 10_F2_{1000} and 10_F2_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around schools in 2010 08_F3_{500}, 08_F3_{1000} and 08_F3_{1500}: counts of supermarket within 500m, 1000m and 1500m around schools in 2008 10_F3_{500}, 10_F3_{1000} and 10_F3_{1500}: counts of supermarket within 500m, 1000m and 1500m around schools in 2010 08_F4_{500}, 08_F4_{1000} and 08_F4_{1500}: counts of convenience stores within 500m, 1000m and 1500m around schools in 2008 10_F4_{500}, 10_F4_{1000} and 10_F4_{1500}: counts of convenience stores within 500m, 1000m and 1500m around schools in 2010

08_TOT_{500}, 08_TOT_{1000} and 08_TOT_{1500}: Total FS counts within 500m, 1000m and 1500m around schools in 2008
10_TOT_{500}, 10_TOT_{1000} and 10_TOT_{1500}: Total FS counts within 500m, 1000m and 1500m around schools in 2010

FS counts around elementary schools
08_F1e_{500}, 08_F1e_{1000} and 08_F1e_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around elementary schools in 2008
10_F1e_{500}, 10_F1e_{1000} and 08_F1e_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around elementary schools in 2010
08_F2e_{500}, 08_F2e_{1000} and 08_F2e_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around elementary schools in 2008
10_F2e_{500}, 10_F2e_{1000} and 10_F2e_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around elementary schools in 2010
08_F3e_{500}, 08_F3e_{1000} and 08_F3e_{1500}: counts of supermarket within 500m, 1000m and 1500m around elementary schools in 2008
10_F3e_{500}, 10_F3e_{1000} and 10_F3e_{1500}: counts of supermarket within 500m, 1000m and 1500m around elementary schools in 2010
08_F4e_{500}, 08_F4e_{1000} and 08_F4e_{1500}: counts of convenience stores within 500m, 1000m and 1500m around elementary schools in 2008
10_F4e_{500}, 10_F4e_{1000} and 10_F4e_{1500}: counts of convenience stores within 500m, 1000m and 1500m around elementary schools in 2010
08_TOTe_{500}, 08_TOTe_{1000} and 08_TOTe_{1500}: Total FS counts within 500m, 1000m and 1500m around elementary schools in 2008
10_TOTe_{500}, 10_TOTe_{1000} and 10_TOTe_{1500}: Total FS counts within 500m, 1000m and 1500m around elementary schools in 2010

FS counts around secondary schools
08_F1s_{500}, 08_F1s_{1000} and 08_F1s_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around secondary schools in 2008
10_F1s_{500}, 10_F1s_{1000} and 10_F1s_{1500}: counts of full-serviced restaurants within 500m, 1000m and 1500m around secondary schools in 2010
08_F2s_{500}, 08_F2s_{1000} and 08_F2s_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around secondary schools in 2008
10_F2s_{500}, 10_F2s_{1000} and 10_F2s_{1500}: counts of limited-serviced restaurants within 500m, 1000m and 1500m around secondary schools in 2010
08_F3s_{500}, 08_F3s_{1000} and 08_F3s_{1500}: counts of supermarket within 500m, 1000m and 1500m around secondary schools in 2008
10_F3s_{500}, 10_F3s_{1000} and 10_F3s_{1500}: counts of supermarket within 500m, 1000m and 1500m around secondary schools in 2010
08_F4s_{500}, 08_F4s_{1000} and 08_F4s_{1500}: counts of specialty stores within 500m, 1000m and 1500m around secondary schools in 2008
10_F4s_{500}, 10_F4s_{1000} and 10_F4s_{1500}: counts of specialty stores within 500m, 1000m and 1500m around secondary schools in 2010

08_TOTs_{500}, 08_TOTs_{1000} and 08_TOTs_{1500}: Total FS counts within 500m, 1000m and 1500m around secondary schools in 2008 10_TOTs_{500}, 10_TOTs_{1000} and 10_TOTs_{1500}: Total FS counts within 500m, 1000m and 1500m around secondary schools in 2010		
Significance level to entry for forward selection models: slentry=0.2 Power: 80% Significance level: 5%		
Objective II: Exploring the relationship between the school FS counts in 2008 and 2010 to 2006 school neighbourhood income		
Multiple linear regression	**Response variables**	**Explanatory variables** (Continuous variables/Binary variables)
Forward stepwise regressions between the school FS counts within 500m in 2008 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{500}$ $X_2 = 08\_F2_{500}$ $X_3 = 08\_F3_{500}$ $X_4 = 08\_F4_{500}$ $X_T = 08\_TOT_{500}$
Forward stepwise regressions between the school FS counts within 500m in 2010 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = SES	$X_1 = 10\_F1_{500}$ $X_2 = 10\_F2_{500}$ $X_3 = 10\_F3_{500}$ $X_4 = 10\_F4_{500}$ $X_T = 10\_TOT_{500}$
Forward stepwise regressions between the school FS counts within 1000m in 2008 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{1000}$ $X_2 = 08\_F2_{1000}$ $X_3 = 08\_F3_{1000}$ $X_4 = 08\_F4_{1000}$ $X_T = 08\_TOT_{1000}$
Forward stepwise regressions between the school FS counts within 1000m in 2010	Y_1 = SES	$X_1 = 10\_F1_{1000}$

and school region income $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regresion models for each Y variable		$X_2 = 10\_F2_{1000}$ $X_3 = 10\_F3_{1000}$ $X_4 = 10\_F4_{1000}$ $X_T = 10\_TOT_{1000}$
Forward stepwise regressions between the school FS counts within 1500m in 2008 and school region income $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{1500}$ $X_2 = 08\_F2_{1500}$ $X_3 = 08\_F3_{1500}$ $X_4 = 08\_F4_{1500}$ $X_T = 08\_TOT_{1500}$
Forward stepwise regressions between the school FS counts within 1500m in 2010 and school region income $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 10\_F1_{1500}$ $X_2 = 10\_F2_{1500}$ $X_3 = 10\_F3_{1500}$ $X_4 = 10\_F4_{1500}$ $X_T = 10\_TOT_{1500}$
2. Logistic regression If SES ≥ 75,000, it was coded as 1 If SES < 75,000, it was coded as 0	**Response variables**	**Explanatory variables** (Continuous variables/Binary variables)
Forward stepwise regressions between the school FS counts within 500m in 2008 and school region income $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{500}$ $X_2 = 08\_F2_{500}$ $X_3 = 08\_F3_{500}$ $X_4 = 08\_F4_{500}$ $X_T = 08\_TOT_{500}$
Forward stepwise regressions between the school FS counts within 500m in 2010 and school region income $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$	Y_1 = SES	$X_1 = 10\_F1_{500}$ $X_2 = 10\_F2_{500}$ $X_3 = 10\_F3_{500}$ $X_4 = 10\_F4_{500}$

$Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable		$X_T = 10\_TOT_{500}$
Forward stepwise regressions between the school FS counts within 1000m in 2008 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{1000}$ $X_2 = 08\_F2_{1000}$ $X_3 = 08\_F3_{1000}$ $X_4 = 08\_F4_{1000}$ $X_T = 08\_TOT_{1000}$
Forward stepwise regressions between the school FS counts within 1000m in 2010 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 10\_F1_{1000}$ $X_2 = 10\_F2_{1000}$ $X_3 = 10\_F3_{1000}$ $X_4 = 10\_F4_{1000}$ $X_T = 10\_TOT_{1000}$
Forward stepwise regressions between the school FS counts within 1500m in 2008 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 08\_F1_{1500}$ $X_2 = 08\_F2_{1500}$ $X_3 = 08\_F3_{1500}$ $X_4 = 08\_F4_{1500}$ $X_T = 08\_TOT_{1500}$
Forward stepwise regressions between the school FS counts within 1500m in 2010 and school region income $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regresion models for each Y variable	Y_1 = SES	$X_1 = 10\_F1_{1500}$ $X_2 = 10\_F2_{1500}$ $X_3 = 10\_F3_{1500}$ $X_4 = 10\_F4_{1500}$ $X_T = 10\_TOT_{1500}$
Exploring the relationship between the school FS counts and students' academic performance		
Objective III: Exploring the relationships between the school FS counts around schools within 500m, 1000m and 1500m and students' academic performance using the EQAO scores from all schools combined		

Multiple linear regression/Logistic regression	**Response variables** (Continuous variables/Binary variables)	**Explanatory variables** (Continuous variables/Binary variables)
Forward stepwise regressions between students' academic performance and FS counts around schools at 500m in 2008 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 08_OES	X_1 = 08_F1$_{500}$ X_2 = 08_F2$_{500}$ X_3 = 08_F3$_{500}$ X_4 = 08_F4$_{500}$ X_T = 08_TOT$_{500}$
Forward stepwise regressions between students' academic performance and FS counts around schools at 500m in 2010 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 10_OES	X_1 = 10_F1$_{500}$ X_2 = 10_F2$_{500}$ X_3 = 10_F3$_{500}$ X_4 = 10_F4$_{500}$ X_T = 10_TOT$_{500}$
Forward stepwise regressions between students' academic performance and FS counts around schools at 1000m in 2008 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_8)$ 2 forward stepwise regression models for each Y variable	Y_1 = 08_OES	X_1 = 08_F1$_{1000}$ X_2 = 08_F2$_{1000}$ X_3 = 08_F3$_{1000}$ X_4 = 08_F4$_{1000}$ X_T = 08_TOT$_{1000}$
Forward stepwise regressions between students' academic performance and FS counts around schools at 1000m in 2010 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_8)$	Y_1 = 10_OES	X_1 = 10_F1$_{1000}$ X_2 = 10_F2$_{1000}$ X_3 = 10_F3$_{1000}$ X_4 = 10_F4$_{1000}$ X_T = 10_TOT$_{1000}$

2 forward stepwise regression models for each Y variable		
Forward stepwise regressions between students' academic performance and FS counts around schools at 1500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 08_OES	X_1 = 08_F1$_{1500}$ X_2 = 08_F2$_{1500}$ X_3 = 08_F3$_{1500}$ X_4 = 08_F4$_{1500}$ X_T = 08_TOT$_{1500}$
Forward stepwise regressions between students' academic performance and FS counts around schools at 1500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 10_OES	X_1 = 10_F1$_{1500}$ X_2 = 10_F2$_{1500}$ X_3 = 10_F3$_{1500}$ X_4 = 10_F4$_{1500}$ X_T = 10_TOT$_{1500}$
Exploring the associations between the school FS counts around schools within 500m, 1000m and 1500m and students' academic performance by school levels		
Multiple linear regression/Logistic regression	**Response variables** (Continuous variables/Binary variables)	**Explanatory variables** (Continuous variables/Binary variables)
Forward/stepwise models between students' academic performance and FS counts around elementary at 500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 08_OE	X_1 = 08_F1e$_{500}$ X_2 = 08_F2e$_{500}$ X_3 = 08_F5e$_{500}$ X_4 = 08_F6e$_{500}$ X_T = 08_TOTe$_{500}$
Forward/stepwise models between students' academic performance and FS counts around elementary at 500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$	Y_1 = 10_OE	X_1 = 10_F1e$_{500}$ X_2 = 10_F2e$_{500}$ X_3 = 10_F5e$_{500}$ X_4 = 10_F6e$_{500}$

$Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable		$X_T = 10\_TOTe_{500}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_OS$	$X_1 = 08\_F1s_{500}$ $X_2 = 08\_F2s_{500}$ $X_3 = 08\_F5s_{500}$ $X_4 = 08\_F6s_{500}$ $X_T = 08\_TOTs_{500}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_OS$	$X_1 = 10\_F1s_{500}$ $X_2 = 10\_F2s_{500}$ $X_3 = 10\_F5s_{500}$ $X_4 = 10\_F6s_{500}$ $X_T = 10\_TOTs_{500}$
Forward stepwise regressions between students' academic performance and FS counts around elementary schools at 1000m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_OE$	$X_1 = 08\_F1e_{1000}$ $X_2 = 08\_F2e_{1000}$ $X_3 = 08\_F3e_{1000}$ $X_4 = 08\_F4e_{1000}$ $X_T = 08\_TOTe_{1000}$
Forward stepwise regressions between students' academic performance and FS counts around elementary schools at 1000m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_OE$	$X_1 = 10\_F1e_{1000}$ $X_2 = 10\_F2e_{1000}$ $X_3 = 10\_F3e_{1000}$ $X_4 = 10\_F4e_{1000}$ $X_T = 10\_TOTe_{1000}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 1000m in 2008	$Y_1 = 08\_OS$	$X_1 = 08\_F1s_{1000}$ $X_2 = 08\_F2s_{1000}$ $X_3 = 08\_F3s_{1000}$

$Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable		$X_4 = 08\_F4s_{1000}$ $X_T = 08\_TOTs_{1000}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 1000m in 2010 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_OS$	$X_1 = 10\_F1s_{1000}$ $X_2 = 10\_F2s_{1000}$ $X_3 = 10\_F3s_{1000}$ $X_4 = 10\_F4s_{1000}$ $X_T = 10\_TOTs_{1000}$
Forward stepwise regressions between students' academic performance and FS counts around elementary schools at 1500m in 2008 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_OE$	$X_1 = 08\_F1e_{1500}$ $X_2 = 08\_F2e_{1500}$ $X_3 = 08\_F3e_{1500}$ $X_4 = 08\_F4e_{1500}$ $X_T = 08\_TOTe_{1500}$
Forward stepwise regressions between students' academic performance and FS counts around elementary schools at 1500m in 2010 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_OE$	$X_1 = 10\_F1e_{1500}$ $X_2 = 10\_F2e_{1500}$ $X_3 = 10\_F3e_{1500}$ $X_4 = 10\_F4e_{1500}$ $X_T = 10\_TOTe_{1500}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 1500m in 2008 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i$ $(i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_OS$	$X_1 = 08\_F1s_{1500}$ $X_2 = 08\_F2s_{1500}$ $X_3 = 08\_F3s_{1500}$ $X_4 = 08\_F4s_{1500}$ $X_T = 08\_TOTs_{1500}$
Forward stepwise regressions between students' academic performance and FS counts around secondary schools at 1500m in 2010 $Y_i = a + B_iX_i$ $(i = X_1, X_2, X_3, X_4)$	$Y_1 = 10\_OS$	$X_1 = 10\_F1s_{1500}$ $X_2 = 10\_F2s_{1500}$ $X_3 = 10\_F3s_{1500}$

$Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable		$X_4 = 10\_F4s_{1500}$ $X_T = 10\_TOTs_{1500}$
Exploring the relationship between the school FS counts within 500m, 1000m and 1500m around schools and students' academic performance on specific subjects		
Multiple linear regression/Logistic regression	**Response variables** (Continuous variables/Binary variables)	**Explanatory variables** (Continuous variables/Binary variables)
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around elementary schools at 500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_R3$ $Y_2 = 08\_W3$ $Y_3 = 08\_M3$ $Y_4 = 08\_R6$ $Y_5 = 08\_W6$ $Y_6 = 08\_M6$	$X_1 = 08\_F1e_{500}$ $X_2 = 08\_F2e_{500}$ $X_3 = 08\_F3e_{500}$ $X_4 = 08\_F4e_{500}$ $X_T = 08\_TOTe_{500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around elementary schools at 500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_R3$ $Y_2 = 10\_W3$ $Y_3 = 10\_M3$ $Y_4 = 10\_R6$ $Y_5 = 10\_W6$ $Y_6 = 10\_M6$	$X_1 = 10\_F1e_{500}$ $X_2 = 10\_F2e_{500}$ $X_3 = 10\_F3e_{500}$ $X_4 = 10\_F4e_{500}$ $X_T = 10\_TOTe_{500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_P9$ $Y_2 = 08\_A9$ $Y_3 = 08\_L10$	$X_1 = 08\_F1s_{500}$ $X_2 = 08\_F2s_{500}$ $X_3 = 08\_F3s_{500}$ $X_4 = 08\_F4s_{500}$ $X_T = 08\_TOTs_{500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 500m in 2010	$Y_1 = 10\_P9$ $Y_2 = 10\_A9$ $Y_3 = 10\_L10$	$X_1 = 10\_F1s_{500}$ $X_2 = 10\_F2s_{500}$ $X_3 = 10\_F3s_{500}$

$Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable		$X_4 = 10\_F4s_{500}$ $X_T = 10\_TOTs_{500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around elementary schools at 1000m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_R3$ $Y_2 = 08\_W3$ $Y_3 = 08\_M3$ $Y_4 = 08\_R6$ $Y_5 = 08\_W6$ $Y_6 = 08\_M6$	$X_1 = 08\_F1e_{1000}$ $X_2 = 08\_F2e_{1000}$ $X_3 = 08\_F3e_{1000}$ $X_4 = 08\_F4e_{1000}$ $X_T = 08\_TOTe_{1000}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around elementary schools at 1000m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_R3$ $Y_2 = 10\_W3$ $Y_3 = 10\_M3$ $Y_4 = 10\_R6$ $Y_5 = 10\_W6$ $Y_6 = 10\_M6$	$X_1 = 10\_F1e_{1000}$ $X_2 = 10\_F2e_{1000}$ $X_3 = 10\_F3e_{1000}$ $X_4 = 10\_F4e_{1000}$ $X_T = 10\_TOTe_{1000}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 1000m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 08\_P9$ $Y_2 = 08\_A9$ $Y_3 = 08\_L10$	$X_1 = 08\_F1s_{1000}$ $X_2 = 08\_F2s_{1000}$ $X_3 = 08\_F3s_{1000}$ $X_4 = 08\_F4s_{1000}$ $X_T = 08\_TOTs_{1000}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 1000m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	$Y_1 = 10\_P9$ $Y_2 = 10\_A9$ $Y_3 = 10\_L10$	$X_1 = 10\_F1s_{1000}$ $X_2 = 10\_F2s_{1000}$ $X_3 = 10\_F3s_{1000}$ $X_4 = 10\_F4s_{1000}$ $X_T = 10\_TOTs_{1000}$
Forward stepwise regressions between students' academic performance (on specific	$Y_1 = 08\_R3$	$X_1 = 08\_F1e_{1500}$

subjects) and FS counts around elementary schools at 1500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_2 = 08_W3 Y_3 = 08_M3 Y_4 = 08_R6 Y_5 = 08_W6 Y_6 = 08_M6	X_2 = 08_F2e$_{1500}$ X_3 = 08_F3e$_{1500}$ X_4 = 08_F4e$_{1500}$ X_T = 08_TOTe$_{1500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around elementary schools at 1500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 10_R3 Y_2 = 10_W3 Y_3 = 10_M3 Y_4 = 10_R6 Y_5 = 10_W6 Y_6 = 10_M6	X_1 = 10_F1e$_{1500}$ X_2 = 10_F2e$_{1500}$ X_3 = 10_F3e$_{1500}$ X_4 = 10_F4e$_{1500}$ X_T = 10_TOTe$_{1500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 1500m in 2008 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 08_P9 Y_2 = 08_A9 Y_3 = 08_L10	X_1 = 08_F1s$_{1500}$ X_2 = 08_F2s$_{1500}$ X_3 = 08_F3s$_{1500}$ X_4 = 08_F4s$_{1500}$ X_T = 08_TOTs$_{1500}$
Forward stepwise regressions between students' academic performance (on specific subjects) and FS counts around secondary schools at 1500m in 2010 $Y_i = a + B_iX_i \quad (i = X_1, X_2, X_3, X_4)$ $Y_i = a + B_iX_i \quad (i = X_T)$ 2 forward stepwise regression models for each Y variable	Y_1 = 10_P9 Y_2 = 10_A9 Y_3 = 10_L10	X_1 = 10_F1s$_{1500}$ X_2 = 10_F2s$_{1500}$ X_3 = 10_F3s$_{1500}$ X_4 = 10_F4s$_{1500}$ X_T = 10_TOTs$_{1500}$

Appendix G: Associations between school neighbourhood household income and FS counts after adjusting for population counts

Relationships between school neighbourhood income and the FS counts within 500m, 1000m and 1500m around schools after controlling for population counts

	Year	Full-service restaurants			FFRs			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
School neighbourhood median family income	2008					-0.778					-2.54		-0.745	-0.848	-0.307	-0.223
						<.0001					0.0016		<.0001	0.002	<.001	<.0001
	2010				-2.138	-0.741	-0.568							-0.886	-0.278	-0.223
					0.0013	<.0001	<.0001							0.0006	<.0001	<.0001

All four explanatory variables (Full-service restaurants, fast-food restaurants, supermarkets and convenience stores) were run in one model and the total store was run in a separate model
Based on 2006 medium family income for the census neighbourhood of the schools
500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
[a] p≤ 0.05, [b] p≤ 0.005, [c] p≤ 0.001

Relationships between school neighbourhood income and the FS counts within 500m, 1000m and 1500m around schools after controlling population counts

	Year	Full-service restaurants			FFRs			Supermarkets			Convenience stores			Total stores		
		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
School neighbourhood median family income	2008					0.941	0.925				0.3786			0.903	0.972	0.979
						0.892-0.993	0.954-0.984				0.492-0.953			0.826-986	0.949-0.996	0.965-0.992
	2010				0.796	0.933	0.943							0.897	0.975	0.977
					0.663-0.956	0.980-0.989	0.911-0.976							0.923-0.977	0.954-0.997	0.964-0.991

As a dichotomous variable, above and below the median.
Yes: Income ≥ 75,500 was coded as 1; * No: Income < 75,500 was coded as 0
All four explanatory variables (Full-service restaurants, fast-food restaurants, supermarkets and convenience stores) were run in one model and the total stores was run in a separate model
500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

Appendix H: Summaries the significant relationships between FS counts and EQAO scores using multiple linear regression and logistic regression modeling

Year	EQAO score	Analysis method		Full-service restaurants			FFRs			Supermarkets			Convenience stores			Total stores		
				500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
2008	The overall EQAO scores from all schools combined	I	β		0.102									-0.123	-0.047			-0.012
			p		0.028									0.003	0.005			0.023
		II	β															
			p															
		III	β									0.811		0.890				0.985
			p									0.7-0.939		0.807-0.981				0.973-0.998
		IV	β										0.409			0.471		
			p										0.213-0.786			0.25-0.887		
	The overall EQAO scores from elementary schools	I	β										-0.327	-0.069	-0.062		-0.021	-0.017
			p										0.029	0.018	0.001		0.036	0.003
		II	β		-0.779											-0.683		
			p		0.026											0.026		
		III	β									0.675	-0.539	0.755		0.846	0.930	0.967
			p									0.554-0.823	0.387-0.878	0.644-0.884		0.762-0.94	0.89-0.973	0.949-0.986
		IV	β								0.414	0.262	0.327			0.371		
			p								0.204-0.843	0.092-0.745	0.16-0.665			0.187-0.737		
	The overall EQAO scores from secondary schools	I	β															
			p															
		II	β															
			p															
		III	β															
			p															
		IV	β															
			p															
	Grade 3 reading score	I	β										-0.070	-0.011	-0.011		-0.003	-0.003
			p										0.010	0.024	0.001		0.042	0.002
		II	β		-0.137							-0.173	-0.130			-0.151	-0.236	
			p		0.021							0.030	0.012			0.003	0.036	
		III	β															
			p															
		IV	β															
			p															
		I	β								-0.022	-0.019	-0.039					-0.002

	writing score		p									0.022	0.004	0.041					0.007
			β					-0.145					-0.112	-0.082				-0.106	-0.177	
		II	p					0.012					0.040	0.019				0.003	0.021	
			β																	
		III	p																	
			β																	
		IV	p																	
	Grade 3 mathematic score		β									-0.027	-0.024						-0.030	-0.002
		I	p									0.038	0.008						0.050	0.016
			β		-0.166								-0.155						-0.295	
		II	p		0.002								0.033						0.004	
			β											0.444	0.707	0.835		0.837	0.904	0.961
		III	p											0.232-0.852	0.554-0.903	0.734-0.949		0.711-0.985	0.841-0.972	0.934-0.989
			β		0.293									0.277				0.210	0.160	
		IV	p		0.125-0.691									0.105-0.733				0.085-0.519	0.04-0.642	
	Grade 6 reading score		β											-0.064	-0.011	-0.010		-0.013	-0.003	-0.002
		I	p											0.001	0.002	<.0001		0.013	0.006	0.001
			β											-0.096	-0.162	-0.223		-0.103	-0.183	
		II	p											0.012	0.001	0.004		0.007	-0.183	
			β																	
		III	p																	
			β												0.107	0.136				
		IV	p												0.019-0.591	0.022-0.847				
	Grade 6 writing score		β											-0.071	-0.011	-0.010		-0.016	-0.003	-0.002
		I	p											<.0001	0.001	<.0001		0.001	0.003	<.0001
			β		-0.100									-0.098				-0.111	-0.188	
		II	p		0.009									0.003				0.001	0.009	
			β																	
		III	p																	
			β												0.171					
		IV	p												0.045-0.645					
	Grade 6 mathematic score		β												-0.016	-0.013		-0.005	-0.004	
		I	p												0.001	<.0001		0.002	0.000	
			β		-0.174											-0.258		-0.256		
		II	p		0.003											0.013		0.023		
			β											0.254	0.694	0.808		0.905	0.962	
		III	p											0.084-0.766	0.512-0.941	0.681-0.957		0.831-0.986	0.93-0.995	
			β			0.154									0.211	0.105				
		IV	p			0.026-0.918									0.074-0.598	0.02-0.541				
	Grade 9 applied		β			-0.018	-0.049											-0.011		
		I	p			0.008	0.016											-0.011		

	mathematic score		β															
		II	p															
			β															
		III	p															
			β															
		IV	p															
2010	The overall EQAO scores from all schools combined		β				-0.126											-0.012
		I	p				0.039											0.002
			β								-0.734	-1.036	-0.755	-0.693		-0.574	-1.578	
		II	p								0.004	0.002	0.002	0.036		0.017	0.001	
			β											0.863	0.930			0.986
		III	p											0.771-0.965	0.884-0.979			0.974-0.998
			β								0.502		0.326	0.394		0.308	0.065	
		IV	p								0.253-0.997		0.167-0.635	0.156-0.993		0.161-0.588	0.008-0.527	
	The overall EQAO scores from elementary schools		β							-0.551	-1.020		0.146			-0.111	-0.026	-0.018
		I	p							0.032	0.000		0.043			0.002	0.001	0.000
			β							-1.242	-1.020	-1.079				-0.734	-1.682	
		II	p							0.000	0.000	0.004				0.006	0.001	
			β											0.717	0.876		0.910	0.970
		III	p											0.608-0.847	0.815-0.941		0.867-0.956	0.954-0.987
			β							0.278		0.269	0.292			0.248	0.083	
		IV	p							0.096-0.808		0.097-0.747	0.141-0.605			0.124-0.498	0.01-0.681	
	The overall EQAO scores from secondary schools		β															
		I	p															
			β											-1.606	-1.606			
		II	p											0.042	0.042			
			β															
		III	p															
			β															
		IV	p															
	Grade 3 reading score		β						-0.006		-0.142					-0.014	-0.003	-0.002
		I	p						0.004		0.002					0.022	0.035	0.010
			β							-0.174	-0.142	-0.190					-0.222	
		II	p							0.003	0.002	0.003					0.010	
			β															
		III	p															
			β															
		IV	p															
	Grade 3 writing		β						-0.005	-0.100	-0.129					-0.012		-0.002
		I	p						0.001	0.000	<.0001					0.006		0.003
		II	β							-0.159	-0.129	-0.137						

	score		p							<.0001	<.0001	0.002						
			β															
		III	p															
			β								0.171	0.100						
		IV	p								0.032-0.919	0.019-0.517						
	Grade 3 mathematic score		β								-0.172	-0.020						-0.002
		I	p								0.000	0.008						0.030
			β							-0.204	-0.172	-0.148					-0.251	
		II	p							0.001	0.000	0.027					0.005	
			β					0.600				0.773					0.921	
		III	p					0.443-0.813				0.61-0.98					0.857-0.989	
			β								0.366							
		IV	p								0.148-0.907							
	Grade 6 reading score		β										-0.060	-0.157		-0.012	-0.004	-0.003
		I	p										0.009	0.006		0.037	0.001	0.001
			β										-0.104	-0.157	-0.220	-0.102	-0.244	-0.332
		II	p										0.018	0.006	0.009	0.020	0.004	0.044
			β					0.798				0.727					0.916	0.971
		III	p					0.673-0.947				0.567-0.933					0.853-0.983	0.947-0.996
			β				0.227	0.205								0.265	0.080	
		IV	p				0.08-0.643	0.068-0.619								0.106-0.665	0.018-0.347	
	Grade 6 writing score		β			0.009							-0.063	-0.115	-0.017	-0.014	-0.005	-0.003
		I	p			0.035							0.001	0.031	<.0001	0.004	<.0001	<.0001
			β				-0.114				-0.085			-0.113		-0.102	-0.185	-0.289
		II	p				0.002				0.026			0.021		0.005	0.008	0.034
			β								0.428	0.633						
		III	p								0.225-0.814	0.455-0.881						
			β											0.184	0.172		0.090	0.067
		IV	p											0.064-0.531	0.043-0.685		0.022-0.376	0.006-0.778
	Grade 6 mathematic score		β										-0.105	-0.208	-0.013	-0.019	-0.006	-0.004
		I	p										0.000	0.005	<.0001	0.015	0.000	0.000
			β		-0.199								-0.178			-0.150	0.002	-0.426
		II	p		0.002								0.002			0.008	0.008	0.045
			β											0.627	0.682			
		III	p											0.441-0.893	0.53-0.878			
			β			0.171							0.179	0.148		0.306	0.083	0.063
		IV	p			0.043-0.679							0.05-0.65	0.05-0.442		0.108-0.869	0.02-0.349	0.005-0.729

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer

I: when EQAO scores were treated as continuous variables and FSs were continuous variables,.

II: when EQAO scores were treated as continuous variables and FSs were binary variables

III: when EQAO scores were treated as binary variables and FSs were continuous variables
IV: when EQAO scores were treated as binary variables and FSs were binary variables
B: parameter estimate; P: 5% significance level

Appendix I: Associations between FS counts within 500m, 1000m and 1500m and EQAO scores in 2008 and 2010 after controlling for school neighbourhood household income and the interactions

2008											
EQAO scores	Methods		Supermarkets			Convenience stores			Total stores		
			500	1000	1500	500	1000	1500	500	1000	1500
The overall EQAO scores from all schools combined	I	β					0.167				
		p					0.253				
	II	β									
		p									
The overall EQAO scores from elementary schools	I	β						-0.075			
		p						0.425			
	II	β									
		p									
The overall EQAO scores from secondary schools	I	β									
		p									
	II	β									
		p									
Grade 3 reading score	I	β						-0.010			
		p						0.477			
	II	β				-0.156			-0.126		
		p				0.106			0.049		
Grade 3 writing score	I	β			-0.031						
		p			0.334						
	II	β				-0.172			-0.124		
		p				0.013			0.007		
Grade 3 mathematic score	I	β			-0.069						
		p			0.118						
	II	β									
		p									
Grade 6 reading score	I	β					-0.002				
		p					0.929				
	II	β							-0.071	-0.028	

		p							0.137	0.720	
Grade 6 writing score	I	β				-0.080	-0.006	-0.009	-0.029		-0.001
		p				0.248	0.790	0.358	0.097		0.612
	II	β				-0.001			-0.073		
		p				0.994			0.090		
Grade 6 mathematic score	I	β					0.012	-0.001			0.000
		p					0.742	0.936			0.978
	II	β									
		p									
2010											
The overall EQAO scores from all schools combined	I	β									
		p									
	II	β		-0.611	-0.430					0.000	
		p		0.024	0.221					0.031	
The overall EQAO scores from elementary schools	I	β	1.361	-0.470					-0.075	-0.063	-0.038
		p	0.163	0.291					-0.075	0.192	0.101
	II	β	-0.960	-0.604					-0.344	-0.891	
		p	0.853	0.040					0.333	0.073	
The overall EQAO scores from secondary schools	I	β									
		p									
	II	β									
		p									
Grade 3 reading score	I	β							-0.026	-0.020	
		p							0.279	0.154	
	II	β	-0.143	-0.109							
		p	0.276	0.030							
Grade 3 writing score	I	β	-0.137	-0.096					-0.032		
		p	0.260	0.086					0.080		
	II	β	-0.220	-0.105	-0.073						
		p	0.020	0.004	0.140						
Grade 3 mathematic score	I	β			-0.028						
		p			0.063						
	II	β	-0.332	-0.166							
		p	0.021	0.003							
Grade 6 reading score	I	β								-0.005	
		p								0.490	
	II	β									
		p									
Grade 6 writing	I	β				-0.084	-0.022	-0.009	-0.005	0.004	-0.002

score		p				0.336	0.418	0.418	0.822	0.512	0.486
	II	β					-0.003		-0.065		
		p					0.156		0.217		
Grade 6 mathematic score	I	β				-0.134	-0.082	-0.031			-0.009
		p				0.308	0.051	-0.031			0.077
	II	β				-0.080					
		p				0.443					

500: 500m buffer, 1000: 1000m buffer, 1500: 1500m buffer
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II: when EQAO scores were treated as continuous variables and FSs were binary variables
B: parameter estimate; P: 5% significance level