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Environmental Influences on E-cigarette Use Among Young People

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Abstract

E-cigarette use is a recent phenomenon that is growing in prevalence among young people. The devices often contain various substances, such as nicotine, tobacco, cannabis, and/or flavouring and other chemicals, which may lead to addiction, respiratory issues, and impact brain development. Recent studies have identified various features of neighbourhood environments that may be associated with e-cigarette use. This thesis explores elements of the neighbourhood environment that may be influential in e-cigarette use. It includes a systematic review that examines how neighbourhood environments influence e-cigarette use among young people. It also includes a geospatial analysis of how e-cigarette retailers are distributed throughout Middlesex, Oxford, and Elgin counties, in relation to school locations and neighbourhood characteristics and the potential impact of future policies restricting e-cigarette retailers. Findings from this thesis may be useful for informing effective and equitable policies to protect young people from e-cigarette use and the potential associated health risks.

Keywords

E-cigarette, vaping, neighbourhood, environment, young people

Summary for Lay Audience

E-cigarettes are electronic devices that contain chemicals, such as nicotine, tobacco, cannabis, and/or flavouring. The devices heat a liquid into a vapour, which is then inhaled by the user. E-cigarettes have become popular with people trying to quit smoking as well as people who do not smoke and young people. However, e-cigarette use can impact brain development and lead to addiction and breathing issues. Recent studies have found features of neighbourhood environments that may be linked to e-cigarette use. This thesis explores elements of the neighbourhood environment that may impact e-cigarette use. It includes a systematic review that studies how neighbourhood environments affect e-cigarette use among young people. This thesis then studies how e-cigarette retailers are located in Middlesex, Oxford, and Elgin counties, in relation to school locations and neighbourhood characteristics. It also studies the potential impact of future policies limiting e-cigarette retailers. Findings from this thesis may be useful for informing effective and fair policies to protect young people from e-cigarette use and the potential related health risks.

Co-Authorship Statement

This thesis consists of two integrated articles, which will be submitted for publication in peer-reviewed journals.

Chapter 2 was written by Zoe Askwith with Dr. Gina Martin, Dr. Jamie Seabrook, Dr. Mariam Ismail, and Dr. Jason Gilliland as co-authors. Zoe Askwith performed the literature search and screening, data extraction, data analysis, and is the primary author. Dr. Mariam Ismail assisted with full-text screening and data extraction. Dr. Gina Martin, Dr. Jamie Seabrook, and Dr. Jason Gilliland contributed to editing the paper.

Chapter 3 was written by Zoe Askwith with Dr. Gina Martin, Dr. Jamie Seabrook, and Dr. Jason Gilliland as co-authors. Dr. Andrew Clark and Xiaoxuan Sun conducted GIS analysis. Zoe Askwith conducted data analysis and is the primary author. Dr. Gina Martin provided overall guidance and assistance with data analysis and editing of drafts. Dr. Jamie Seabrook assisted with data analysis and Dr. Jason Gilliland provided overall guidance and editing of drafts.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1 Introduction

1.1 Research Context

1.1.1 Youth Vaping: A Growing Health Concern

In the *Chief Public Health Officer's Report on the State of Public Health in Canada in 2019*, Dr. Theresa Tam identified increasing youth vaping rates as a major health concern for the nation (Public Health Agency of Canada, 2019). Vaping is a recent phenomenon that is growing in prevalence among youth. Vaping consists of inhaling and exhaling an aerosol that is produced by a vaporized product, such as an electronic cigarette (e-cigarette) (Health Canada, 2019a). The device heats a liquid that is often flavoured and can contain nicotine or tetrahydrocannabinol (THC) into a vapour, which is then inhaled. E-cigarettes have been popularized under the notion that they can aid current tobacco smokers in smoking cessation. However, the devices have become popular not only with those attempting to quit smoking, but also among non-smokers, especially non-smoking youth (Hammond, Rynard, & Reid, 2020). Youth vaping is a health concern as it can increase the risk of nicotine addiction, which may impact brain development (Tobore, 2019). E-cigarettes that contain THC often contain high-potency cannabis concentrates, which has been associated with mental and physical health issues, such as paranoia, psychosis, and cannabis hyperemesis syndrome (Chadi, Minato, & Stanwick, 2020; Prince & Conner, 2019). In addition, recent evidence has highlighted an increased risk of respiratory disease among e-cigarette users, however, the long-term health effects of vaping due to exposure to the devices' chemical ingredients is unknown (Public Health Agency of Canada, 2019). The prevalence of past month e-cigarette use, among Canadian students in grades 7 to 12 increased between 2016-2017 and 2018-2019 from 10% to 20% (Health Canada, 2019). More research is needed to understand what is driving the rapid uptake of vaping among Canadian youth. This thesis attempts to gain a better understanding of the environmental determinants of youth vaping. Specifically, this research explores how e-cigarette retail locations are (in)equitably distributed in communities and how e-cigarette policy interventions may be used to reduce the impact of e-cigarette retail on youth vaping behaviours.

1.1.2 The Role of the Retail Environment on Youth Vaping

The increased use of e-cigarettes by youth has been associated with various individual, environmental, and policy determinants, such as geographical accessibility to e-cigarette retailers (Robitaille, Bergeron, & Houde, 2019). This could be because the presence of retailers increases both visibility and accessibility of e-cigarettes, which potentially increases the awareness and accepting opinions on e-cigarette use (Bostean et al., 2016). Our understanding of the role of e-cigarette retailer distribution on e-cigarette use is in its infancy; however, lessons can be learned from previous studies on traditional tobacco retail. Such studies have demonstrated that geographic retail locations matter as they represent availability of a highly addictive product that carries significant health risks. The greater availability of tobacco retailers promotes the normalization of tobacco use and increases the chance underage youth may obtain tobacco cigarettes (Chaiton, Mecredy, Cohen, & Tilson, 2013). Various studies have demonstrated a relationship between the density of tobacco retailers and increased smoking rates (Valiente, et al., 2021; Shortt, Tisch, Pearce, Richardson, & Mitchell, 2016). Additionally, many tobacco retailers are located within walking distance of schools and in socioeconomically disadvantaged neighbourhoods leading to a disproportionate exposure to potentially vulnerable populations (Chaiton, Mecredy, Cohen, & Tilson, 2013). Given this, it is critical to advance such research regarding e-cigarette retail.

1.1.3 Inequalities in E-Cigarette Retailer Distribution

Several studies have identified various socioeconomic and sociodemographic inequalities in the distribution of e-cigarette retailers, indicating inequalities in environmental influences on vaping for different neighbourhoods. Venugopal, Morse, Tworek, and Chang (2020) identified that e-cigarette retailers in the United States were located farther distances from schools in districts with higher poverty rates. They also found that in school districts with higher proportions of racial minorities, the distribution of e-cigarette retailers is denser and located closer to schools (Venugopal et al., 2020). Moreover, another United States study found that e-cigarette retailers were less likely to be concentrated in census tracts of higher education levels (Dai, Hao, & Catley, 2017). As such, it is important to understand potential socioeconomic and sociodemographic disparities in the distribution of e-cigarette retailers to inform equitable policies that limit potential exposure.

1.1.4 Policy Restrictions on Retailers

With restrictive policies on traditional tobacco cigarettes, governments have seen success in reducing smoking rates. In Ontario, the government has imposed restrictions on where tobacco can be sold (Government of Ontario, 2017). While there are licensing regulations for e-cigarette retailers, the province was late to regulate e-cigarette retail and thus left a window of opportunity for companies to open specialty retailers in addition to selling the devices where tobacco is already sold. Minority groups have historically been targeted by tobacco companies, and as such any policies restricting e-cigarette retail should be sensitive to any social inequalities. Ribisl et al. (2017) conducted an analysis of the distribution of tobacco retailers in relation to school locations and neighbourhood socioeconomic and sociodemographic characteristics in New York and Missouri. They found that there was a greater density of tobacco retailers in neighbourhoods of lower income and greater racial diversity. They then conducted a policy simulation restricting tobacco retailers within certain distances of schools to examine equity impacts across different socioeconomic and sociodemographic groups. They found that such policies would eliminate the identified disparities and had a strong pro-equity impact (Ribisl, Luke, Bohannon, Sorg, & Moreland-Russell, 2017). There is a need for similar policies to be investigated for e-cigarette retailers.

1.1.5 Challenges to Research

Despite the potential links between e-cigarette retail locations and use, as well as evidence of inequalities in e-cigarette retail locations, there are still multiple complications when researching this evolving issue that limits the comparability of results. A key challenge in understanding such relationships is that due to the recency of e-cigarettes, the comparison of findings may be complicated by different definitions of e-cigarette retailer employed by various researchers. This is likely because studies are limited by a lack of regulatory databases of e-cigarette retailers and thus must obtain retailer locations using unofficial sources, often through other piecemeal methods (e.g., Yelp, YellowPages.com, ReferenceUSA, and GoogleMaps). There is a need to analyze the distribution of e-cigarette retailers while distinguishing between the variation in retailer types and ensuring that location data is complete and accurate with a comprehensive list of licensed retailers.

1.2 Theoretical Framework

This thesis is guided by the socioecological model (Figure 1). This model evolved out of the ecological systems theory first developed by Bronfenbrenner (1977), which included a conceptual model for understanding human development. It considers the interaction of changing environments in influencing one's behaviour. It includes not only the immediate environment of an individual, but also both the formal and informal larger social contexts (such as physical settings, relationships, and major institutions). Bronfenbrenner's ecological model consists of concentric circles, each representing a different social context, with the individual at the center. The first circle, the microsystem, is the relationship between the person and their immediate environment (e.g., home, school, workplace, etc.) where the person has a particular role (e.g., mother, student, employee, etc.). The next circle, the mesosystem, represents the interactions between the major settings in which the person is a part of, or a system of microsystems. The next circle, the exosystem, includes specific formal and informal social structures that affect or determine what occurs in the immediate settings that surrounds an individual. The final circle is the macrosystem, which represents the overarching institutional structures of the culture, such as economic, social, legal, and political systems, which are explicitly and implicitly demonstrated within the micro-, meso-, and exosystems (Bronfenbrenner, 1977). Bronfenbrenner's ecological model has since been adapted for various uses, using different terminology for each system, however, the main idea of the framework remains. The United States Centers for Disease Control and Prevention (CDC) (2021) have adapted the concentric circles in Bronfenbrenner's systems model for various health promotion programs to include individual, relationship, community, and societal levels. Given this, the socioecological model is an important model that can be applied to various public health issues.

Stokols (1992) also adapted Bronfenbrenner's ecological model to apply it to health-promoting environments, leading to the socioecological model of health as seen in Figure 1. It recognizes the influence that interactions among physical-material and social-symbolic features of the environment have on the emotional, physical, and social well-being of both individuals and groups. Recent literature has identified various features of the neighbourhood environment that may be associated with e-cigarette use, such as presence of retailers (Bostean, Sanchez, & Lippert, 2018; Giovenco, Duncan, Coups, Lewis, & Delnevo, 2016a; Cole, Aleyan, & Leatherdale, 2019), advertisements (Giovenco, et al., 2016b), and sociodemographic disparities. According to Stokols, understanding such features are critical to creating health-promoting environments.

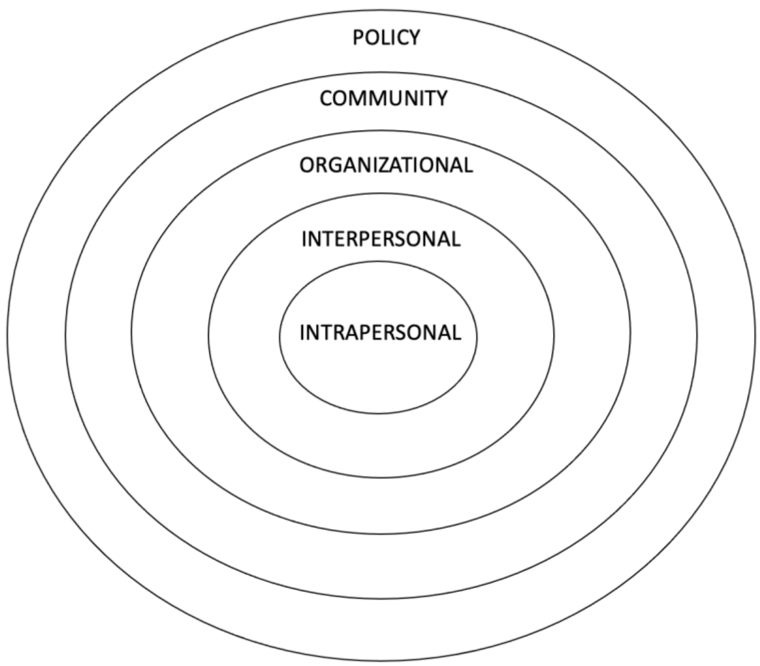

Figure 1: Socioecological model

Socioecological models have been previously used to understand vaping behaviour. For example, to understand influences on vaping among college students, Cheney et al. (2018) found that college students that use e-cigarettes reported various influences on their vaping beyond individual-level beliefs and behaviours. The model that Cheney et al. employed uses intrapersonal, interpersonal, organizational, community, and policy levels as concentric circles. At the intrapersonal level, characteristics of the individual included college students reporting their vaping behaviour enhancing or diminishing their self-image and as part of establishing an adult identity. At the interpersonal level, social networks and support systems included response of family, friends, and fellow students on campus as well as a vaping and smoking “community” on campus. At the organizational level, social institutions’ regulations, such as knowledge of policy, vaping regulations on campus, and rules about vaping in dorms, reportedly impacted vaping behaviour. At the community level, relationships among organizations and institutions, included where and when the college students vape in the community and the response from community members, such as around people, public spaces, or where “no vaping” signs were posted. Finally, at the policy level, state and national laws that included a ban of tobacco products from all government buildings including college campuses were reported to impact vaping behaviour. Cheney et al. (2018) conclude that the socioecological model is a useful tool for health promotion and research with colleges and community groups to reduce student vaping and improve compliance to tobacco control policies.

1.3 Research Questions and Objectives

The purpose of this research is to examine the environmental determinants of youth vaping. It will focus on the neighbourhood environment and specifically the distribution of e-cigarette retailers surrounding schools. To achieve this objective, this thesis is comprised of a systematic review of existing literature and a geospatial analysis of the distribution of retailers in a case study area within Southwestern Ontario. This thesis aims to address the gaps in the literature by obtaining comprehensive data on e-cigarette retailer locations from licensing registries and examining the distribution of specialty retailers separately from other e-cigarette retailers to gain a fuller understanding of e-cigarette retail locations.

The systematic review is guided by the following research question:

1) How do neighbourhood e-cigarette advertisements, retailers, local policies, and neighbourhood social characteristics influence ever and current e-cigarette use among young people?

The geospatial analysis seeks to answer two questions:

2) How are e-cigarette retailers geographically distributed throughout Middlesex, Oxford, and Elgin counties, in relation to school locations and neighbourhood characteristics; and
3) How might policies restricting the locations of e-cigarette retailers around schools reduce potential youth access and make the distribution of e-cigarette retailers between neighbourhoods more equitable?

To answer the first research question, the systematic review draws from a range of existing literature relating to neighbourhood environment influences on youth vaping. Four elements of the neighbourhood were examined: advertisements, retail, local policies, and social characteristics. This review aims to identify the potential role that the neighbourhood environment plays in youth vaping.

To answer the second and third questions, a geospatial analysis was conducted. The first objective was to assess the locations of e-cigarette retailers obtained from local public health units in relation to school locations and neighbourhood sociodemographic and socioeconomic measures. The second objective was to assess the impacts of policy scenarios on accessibility of e-cigarette retailers within certain distances of schools in relation to neighbourhood sociodemographic and socioeconomic measures.

This research is crucial and timely due to the recent popularization of e-cigarettes among young people, the uncertainty around their potential benefits and harms, and the current need for evidence to support informed regulations. This research provides an overview of neighbourhood environment influences on youth vaping. Moreover, socioeconomic and sociodemographic disparities in the distribution of e-cigarette retailers were examined in relation to school locations. Potential policy interventions were simulated to assess how these disparities can be reduced. As e-cigarettes can increase the risk of nicotine addiction and respiratory disease and are increasing in popularity, understanding the influences of their use, and imposing appropriate regulations is necessary to protect young people.

1.4 Outline of Thesis

The remainder of this thesis is organized into 3 chapters. The following chapter (Chapter 2) presents a systematic review of existing peer-reviewed literature on the environmental determinants of youth vaping. Chapter 3 presents a geospatial analysis of the distribution of e-cigarette retailers in relation to schools and neighbourhood characteristics. Finally, Chapter 4 offers a discussion of the key findings and implications of the research, as well as a conclusion to the thesis. This thesis is presented in an integrated article format with two separate but connected studies. Each article will be submitted for publication in a peer-reviewed journal.

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Chapter 2

2 Environmental Influences on E-Cigarette Use Among Young People: A Systematic Review

2.1 Abstract

E-cigarettes, electronic devices that deliver various substances such as nicotine, tobacco, cannabis, and/or flavouring and other chemicals, have become increasingly popular but carry a variety of health risks. E-cigarette use among young people, in particular, has increased in recent years. This can have harmful effects on brain development leading to long-term complications, such as impaired memory, cognition, and learning, increased depression, and behavioural issues. The objectives of this study are to identify how neighbourhood advertisements, retailers, local policies, and social characteristics influence ever and current e-cigarette use among young people. Eight databases (PubMed, SCOPUS, Web of Science, Sociological Abstracts, Nursing and Allied Health, PsychInfo, EMBASE, and CINAHL) were searched to obtain literature published globally, in English, after 2006. The inclusion criteria used in this review included quantitative results relating to elements of the neighbourhood environment and current and/or ever use of e-cigarettes among young people (aged 10-24). A total of 43 studies were included in this review. Overall, studies examined the impact of neighbourhood advertising, policy, retail, and social characteristics on current and ever e-cigarette use and demonstrated mixed results. However, advertising was associated with significantly greater current and ever use. Most policies were not significantly associated with current or ever e-cigarette use among young people. Of the policies that were significantly associated with e-cigarette use, many demonstrated a significant decrease in e-cigarette use after the policy was initiated, or significantly lower odds of e-cigarette use in jurisdictions that implemented policies. The impact of retail and neighbourhood social characteristics on current or ever e-cigarette use also demonstrated mixed results. More research using objective measures of interactions in the neighbourhood environment that could be predisposing young people to use e-cigarettes is imperative. Identifying such elements of the neighbourhood environment will aid in formulating policies to intervene, potentially reducing e-cigarette use among young people and thus promoting health.

2.2 Introduction

E-cigarettes (also known as electronic cigarettes, electronic nicotine delivery systems, and vapes) are an increasingly popular mode of delivery for nicotine, tobacco, cannabis, and/or flavouring and other chemicals and represent a health concern (World Health Organization, 2021). The devices electronically heat a liquid into aerosols, which are then inhaled by the user (World Health Organization, 2021). E-cigarettes were originally marketed as a less harmful alternative to traditional cigarettes and a method of smoking cessation. However, e-cigarettes that contain nicotine and cannabis can be addictive, especially among never-smokers, children, and adolescents (US Department of Health and Human Services, 2012). Youth vaping increased in England, Canada, and the United States between 2018 and 2019, and more substantially in Canada and the United States (Hammond, Rynard, & Reid, 2020). The number of youths (aged 16 to 19) who reported using e-cigarettes 'at least once in the past week' more than doubled in Canada and the United States between 2017 and 2019 (Hammond, Rynard, & Reid, 2020). E-cigarette use may have harmful effects on brain development in children and adolescents, which could potentially lead to long-term complications such as impaired memory and cognition, difficulties in learning and academic performance, increased depression, and aggressive and impulsive behaviour (Tobore, 2019). Adolescent e-cigarette users are also more likely to subsequently initiate traditional cigarette smoking (O'Brien, et al., 2021), putting them at risk of the additional associated health effects such as cancer, heart disease, stroke, and lung diseases (Centers for Disease Control and Prevention, 2010). The increase in e-cigarette use among young people is therefore a public health concern and understanding the predictors of e-cigarette use among young people is an important area of inquiry.

According to a report from the World Health Organization (WHO) (2021), e-cigarette and tobacco companies use marketing strategies and product designs aimed at attracting new users, especially young people. E-cigarettes contain liquids which come in many flavours (e.g., candies, desserts, and fruit) that can be more enjoyable and appealing to young people (Krüsemann, Boesveldt, de Graaf, & Talhout, 2019). E-cigarette devices appear as small, sleek, modern technology that are easily concealed or disguised as a

USB key, and as a result can easily be hidden at home and school (Centers for Disease Control and Prevention, 2020). Likewise, e-cigarette products are often sold in specialty retailers which are designed to appear glamorous and/or hyper modern, making the devices more appealing to young people (World Health Organization, 2021; Cantrell, et al., 2017). Since e-cigarettes have the potential to reduce traditional smoking rates as a method of smoking cessation for current smokers (Rahman, Hann, Wilson, Mnatzaganian, & Worrall-Carter, 2015), while also posing potential harm from use among young people and never smokers, regulating these products is complicated. Therefore, it is critical to understand the geographic factors that may be associated with use among young people, to inform policies aiming to reduce potential health risks.

2.2.1 Neighbourhood Environment

Stokols' (1992) socioecological notion of health-promoting environments recognizes the influence of interactions among physical-material and social-symbolic features of the environment and the impact they may have on the emotional, physical, and social well-being of individuals and groups. Elements of the built environment have been identified as meaningful in shaping health outcomes, particularly those within one's neighbourhood (Renalds, Smith, & Hale, 2010; Jackson & Kochtitzky, 2001). Further, the neighbourhood environment has been identified as an important factor in tobacco smoking rates (Ellaway & Macintyre, 2009; Cano & Wettner, 2014). For example, density and proximity of tobacco retailers in the built environment have been found to be associated with adolescent smoking and susceptibility to smoking (Gwon, DeGuzman, Kulbok, & Jeong, 2017; Chan & Leatherdale, 2011; Lipperman-Kreda, Grube, & Friend, 2012). In addition, social characteristics of the neighbourhood environment such as social capital (Åslund & Nilsson, 2013) and neighbourhood socioeconomic disadvantage (Cambron, et al., 2020) have been identified as predictors of traditional smoking among young people. As e-cigarettes can contain an addictive substance, like traditional cigarettes, the role of the neighbourhood environment in use among young people may also be similar. Recent studies have identified various features of neighbourhood environments that may be associated with e-cigarette use, such as presence of retailers (Bostean, Sanchez, & Lippert, 2018; Giovenco, et al., 2016; Cole, Aleyan, &

Leatherdale, 2019), advertisements (Giovenco, et al., 2016), social characteristics (Shih, et al., 2017), and local policies (Martin, et al., 2021; Azagba, Shan, & Latham, 2019). Understanding such features is critical to informing policies and processes that support health-promoting environments. The overarching purpose of this study is to conduct a systematic review of existing literature to identify neighbourhood environmental influences on youth vaping. Specifically, the objectives are to identify how neighbourhood advertisements, retailers, local policies, and social characteristics influence ever and current e-cigarette use among young people.

2.3 Methods

2.3.1 Context

This systematic review will assess the existing literature on neighbourhood environments and e-cigarette use among young people. The exposure of interest is the neighbourhood environment. In this review, the neighbourhood environment is defined as areas that young people may frequent, such as around their home or school, and includes elements of the built and social environment, as well as the overarching forces that shape such elements. Specifically, this includes retailers, such as specialty shops, convenience stores, or gas stations, and advertisements, such as billboards, urbanicity (i.e., urban vs. rural), neighbourhood social characteristics (e.g., income, socioeconomic disadvantage, social capital), and government policies (i.e., municipal, regional, provincial/state) restricting the sale or use of e-cigarettes. The definition of neighbourhood was applied broadly, and thus, studies were not required to explicitly use the term neighbourhood. In addition, the elements of the neighbourhood environment were not required to be within a defined boundary of the home or school area.

2.3.2 Inclusion/Exclusion Criteria

Studies were included if they were quantitative in design (e.g., cross-sectional, longitudinal, intervention studies) and published in academic journals in English after 2006. The year 2006 was chosen as a cut-off because this was when the first successful e-cigarette was imported to the United States from China (U.S. Customs and Border Protection Securing America's Borders, n.d.). Studies were included if they incorporated a component of the neighbourhood environment (i.e., e-cigarette retailers or advertisements in the neighbourhood environment, regional policies restricting the sale or use of e-cigarettes, urbanicity, and neighbourhood social characteristics). In addition, studies were included if they assessed ever or current use of e-cigarettes as the outcome. Ever use was defined as ever having used an e-cigarette and current use was defined as having used an e-cigarette in the past 30 days. Studies that measured past year or past 6-month use were considered in this review as ever use. Studies were excluded if they did not assess ever or current e-cigarette use as the outcome, or these measures could not be determined from other measures provided. The study population was children and youth 10-24 years of age. This age range was chosen as it fits the World Health Organization's (n.d.) definition of young people (10-24 years), comprising adolescents (10-19 years) and youth (15-24 years). Studies that were conducted on a different age group that overlapped with the age group of interest were included if the results were reported separately for those 10-24 years of age (e.g., a study conducted on children under the age of 18 and can be separated into those aged 10-18 years). Studies were excluded if they assessed retail sales volume only, as it is a component of retail activity, but not the built environment of a neighbourhood.

2.3.3 Search Strategy

This review followed the systematic review methods for a narrative synthesis outlined by Petticrew and Roberts (2006). First, a preliminary review was conducted to identify existing literature and systematic reviews, refine the research question, and determine relevant search terms related to youth, neighbourhood environments, and e-cigarette use. A final list of search terms was established by the authors (see Table 1). Searches were conducted on January 13th, 2021, in 8 databases: PubMed, SCOPUS, Web of Science, Sociological Abstracts, Nursing and Allied Health, PsychInfo, EMBASE, and CINAHL. The review protocol was registered with PROSPERO (ID: 243287).

Table 1: Search Terms

Search Terms	
Population	Youth OR Adolescen* OR Teen* OR "Young adult" OR "High school student" OR "Middle school student" OR "Junior high school student"

	OR “Secondary school student” OR “Young person*” OR “Young people”
Exposure	Environment* OR School OR “School-based” OR Neighbourhood OR Neighborhood OR Communit* OR “Census tract” OR Geograph* OR Retail
Outcome	E-cig* OR “Electronic cigarette” OR “Electronic nicotine delivery system” OR Vape* OR Vaping OR Vapour OR Vapor OR JUUL

2.3.4 Study Selection Process

Results from 2006 – January 13th, 2021, from each database were uploaded to Covidence where duplicates were removed. As per Petticrew and Roberts (2006), the screening process followed two stages: title and abstract screening, and full article screening (see Figure 2). Documents were assessed based on their fit to the predetermined inclusion criteria: quantitative design, participants aged 10-24 years, a component of the neighbourhood environment, and ever or current e-cigarette use as the outcome. Initial title and abstract screening of studies was conducted by one researcher [ZA], then all studies that appeared to fit the inclusion criteria were maintained for full article screening, which was conducted independently by two researchers [ZA & MI]. Any initial disagreements between the two reviewers were resolved through discussion.

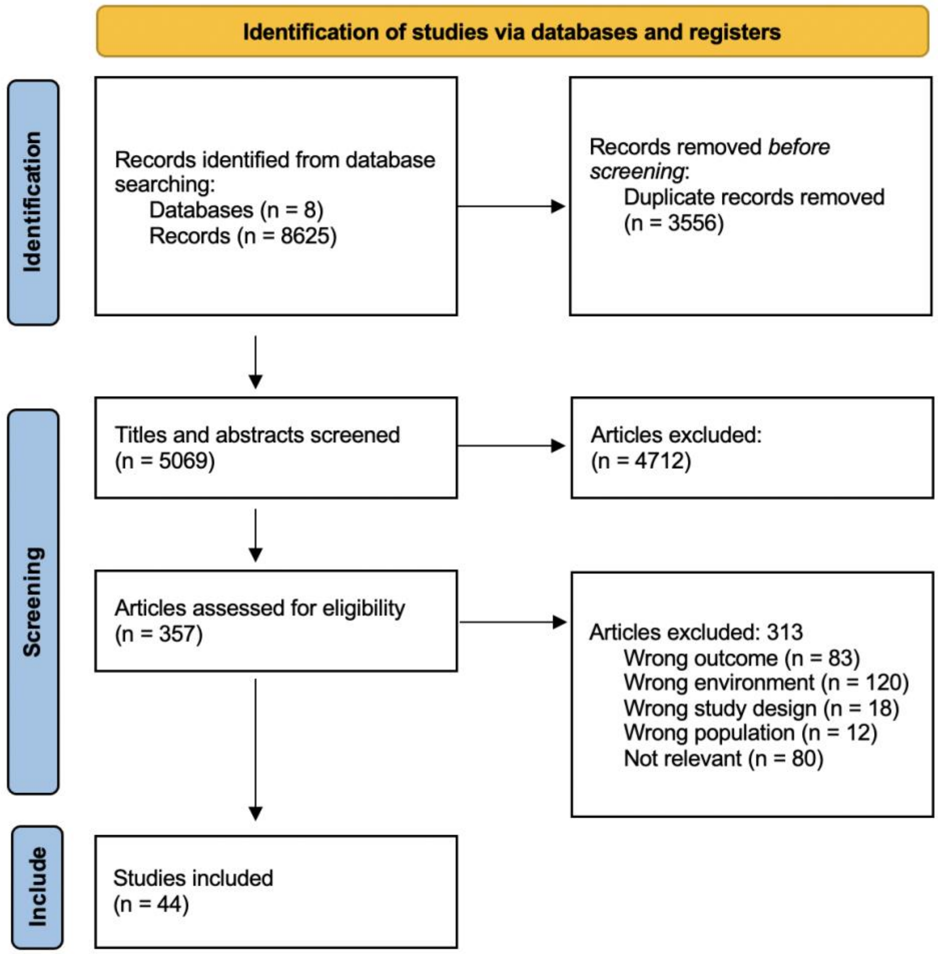

Figure 2: PRISMA Flow Chart

2.3.5 Data Extraction

Relevant data were extracted independently by two researchers, compared, and compiled into an Excel spreadsheet. The information was used to summarize key characteristics, findings, and limitations. Findings were organized by outcome (i.e., ever use or current use), neighbourhood characteristic (i.e., retail, advertisement, policy, and social characteristics), and interaction (i.e., exposure, accessibility, density, proximity, availability). Studies that had findings pertaining to multiple outcomes, neighbourhood characteristics, or interactions were listed multiple times. In most cases, studies were organized into different types of interactions based on the terminology used by the authors. In terms of interactions with advertisements, "exposure" was typically measured through self-reported exposure to an e-cigarette advertisement, where participants were asked whether, where, or how often they have seen things that promote e-cigarettes or vaping. One study examined “volume”, which was defined as the number of vaping advertisements within a half-mile (805 meters) of schools (Giovenco et al., 2016). In terms of interactions with retailers, accessibility was defined as the ease at which a retailer can be reached from one’s home or school. Sometimes this was measured by frequency of visits to a retailer (Trapl et al., 2020) or whether e-cigarettes were obtained from a particular retailer (Mantey et al., 2019). Although some studies may have defined accessibility differently, in general the term “access” was used within the study to describe the interaction. Density was defined as the number of retailers within a specified distance. The specified distance was not consistent between studies. Proximity was defined as a measure of a particular distance from one’s home or school to a retailer. Again, the specified distance was not consistent between studies. Availability was defined as presence of a retailer within various distances of the home or school environment. One study examined retail exposure and defined it as self-reported recent visits to convenience stores, drug stores, corner stores, or food retailers, such as grocery stores. To assess interactions with policies, availability was used which was defined as a jurisdiction having a policy implemented. Social characteristics included various neighbourhood level social characteristics as well as urbanicity.

2.3.6 Quality Assessment

A quality assessment of the studies was not conducted for this review. Environmental influences of e-cigarettes are an emerging area of study, and as such the purpose of this review was to synthesize the relevant research. Excluding studies for poor quality would limit the review but could be carried out in future work.

2.4 Results

The characteristics of each study reviewed are presented in Table 2 and the findings of studies considering elements of the neighbourhood environments and e-cigarette use are presented in Table 3. Of the forty-three papers included in the review, thirty-eight were conducted in the United States, four in Canada, two in the United Kingdom, and one in

Indonesia. A total of thirty-three papers considered current use of e-cigarettes as an outcome and twenty papers considered ever use. The number of studies by the four categories of neighbourhood characteristics and two outcome categories were as follows: advertising (current use: 15 papers; ever use: 10 papers), policy (current use: 9 papers; ever use: 3 papers), retail (current use: 5 papers; ever use: 7 papers), and social characteristics (current use: 4 papers; ever use: 1 paper).

The forty-three papers reported 113 total findings on the relationship between elements of the neighbourhood environment and e-cigarette use. Of the findings related to current use, 52.2% (35/67) were statistically significant and 58.7% (27/46) of the findings related to ever use were statistically significant.

2.4.1 Findings Related to Current Use of E-Cigarettes

2.4.1.1 Advertising and Current Use

Seventeen papers examined associations between advertisements and current e-cigarette use, among which there were twenty-seven findings. All findings were measured through self-reported exposure to advertisements, except one, which measured volume of advertisements around schools. Most advertisements were in retail settings, while two findings were related to outdoor advertisements, and six did not specify the type or location of advertisements. Among the twenty-seven findings, seventeen were associated with statistically higher e-cigarette use, and ten were not significant.

2.4.1.1.1 Any Retail

There were eleven findings that examined advertisements in any retail setting as the independent variable. Eight of the findings were associated with higher odds of e-cigarette use. Nicksic et al. (2017) found that current e-cigarette use was higher at baseline for students who recalled advertisements in retail stores (OR 2.21, 95% CI: 1.17-4.19; $p<0.05$). Additionally, current e-cigarette use was higher at follow-up for those that recalled advertisements at baseline (OR 2.03, 95% CI=1.11-3.72; $p<0.05$). Cho et al. (2019) found that both current dual users (those who both smoke traditional cigarettes and use e-cigarettes) (AOR = 1.83, 95% CI: 1.43, 2.35) and those who exclusively use e-cigarettes (AOR = 1.89, 95% CI: 1.48, 2.41) were more likely than never users to report exposure to retail e-cigarette advertisements. Furthermore, both Pu et al. (2017) (AOR = 1.75, $p < .05$) and Pasch et al. (2018) (AOR=2.02, 95% CI: 1.07, 3.83) found that retail advertising exposure was associated with current e-cigarette use. Marynak et al. (2018) found that exposure to advertising in retail stores was higher for current e-cigarette users than non-users in 2014, 2015, and 2016 (2014: 70.5%, 95% CI: 67.3-73.6; 2015: 68.4%, 95% CI: 64.8-71.8; 2016: 74.3, 95% CI: 70.7-77.6; $p<0.05$). Similarly, Dai et al. (2016) found that greater self-reported exposure to e-cigarette advertisements was associated with current e-cigarette use (aOR = 1.9, $p < 0.0001$). Cruz et al. (2019) also found that e-cigarette initiation is associated with exposure to retail e-cigarette marketing (OR 1.86, 95% CI: 1.19, 2.92; $p < 0.05$). It should be noted that the authors defined e-cigarette initiators as having never used e-cigarettes at baseline and subsequently reporting ever use or past 30-day use (current use) at follow up.

Conversely, exposure to retail marketing for a combination of 6 different tobacco products was not associated with e-cigarette use (Cruz et al., 2019). Lee et al. (2017) found that retail advertising exposure was not associated with current use of e-cigarettes or with transitioning from ever use to current use. Peiper et al. (2020) also found that environmental marketing exposure, defined as seeing e-cigarette advertisements in stores/billboards near one's neighbourhood or school, was not associated with current e-cigarette use.

2.4.1.1.2 Any Retail

There were eleven findings that examined advertisements in any retail setting as the independent variable. Eight of the findings were associated with higher odds of e-cigarette use. Nicksic et al. (2017) found that current e-cigarette use was higher at baseline for students who recalled advertisements in retail stores (OR 2.21, 95% CI: 1.17-4.19; $p<0.05$). Additionally, current e-cigarette use was higher at follow-up for those that recalled advertisements at baseline (OR 2.03, 95% CI=1.11-3.72; $p<0.05$). Cho et al. (2019) found that both current dual users (those who both smoke traditional cigarettes and use e-cigarettes) (AOR = 1.83, 95% CI: 1.43, 2.35) and those who exclusively use e-cigarettes (AOR = 1.89, 95% CI: 1.48, 2.41) were more likely than never users to report exposure to retail e-cigarette advertisements. Furthermore, both Pu et al. (2017) (AOR = 1.75, $p < .05$) and Pasch et al. (2018) (AOR=2.02, 95% CI: 1.07, 3.83) found that retail advertising exposure was associated with current e-cigarette use. Marynak et al. (2018) found that exposure to advertising in retail stores was higher for current e-cigarette users than non-users in 2014, 2015, and 2016 (2014: 70.5%, 95% CI: 67.3-73.6; 2015: 68.4%, 95% CI: 64.8-71.8; 2016: 74.3, 95% CI: 70.7-77.6; $p<0.05$). Similarly, Dai et al. (2016) found that greater self-reported exposure to e-cigarette advertisements was associated with current e-cigarette use (aOR = 1.9, $p < 0.0001$). Cruz et al. (2019) also found that e-cigarette initiation is associated with exposure to retail e-cigarette marketing (OR 1.86, 95% CI: 1.19, 2.92; $p < 0.05$). It should be noted that the authors defined e-cigarette initiators as having never used e-cigarettes at baseline and subsequently reporting ever use or past 30-day use (current use) at follow up.

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2.4.1.1.3 Specific Retail Locations

Two papers investigated associations between advertisements in specific retail locations, such as kiosks, convenience stores, drug stores, and grocery stores, and current e-cigarette use. From the two studies, there were four findings, and only one demonstrated increased odds of e-cigarette use. Cho et al. (2019) found that current dual users (those who smoke and vape) were more likely to report exposure to e-cigarette advertisements at kiosks or temporary sales outlets (AOR=1.88, 95% CI =1.47, 2.40). Conversely, Pasch et al. (2018) found that exposure to e-cigarette marketing in convenience stores, drug stores, and grocery stores were not associated with current e-cigarette use.

2.4.1.1.4 School Neighbourhood

Two studies examined exposure to retail e-cigarette advertising surrounding schools and current e-cigarette use. Among the two papers, there were four findings, two of which demonstrated statistically greater e-cigarette use, while two were not significant. Perez et al. (2017) found that recall of e-cigarette retail marketing around schools was associated with current e-cigarette use in Harris (1.72, 95% CI:1.11-2.68; $p<0.01$) and Travis (2.35, 95% CI: 1.22-4.55; $p<0.01$) counties, but not in Dallas/Tarrant County, Texas, USA. Giovenco et al. (2016) found that self-reported exposure to e-cigarette advertising in stores around schools in New Jersey, USA was not associated with current e-cigarette use. The same study (Giovenco et al. 2016) also assessed the volume of e-cigarette retail advertising around schools (# of total e-cigarette ads x the proportion of all tobacco ads that were for e-cigarettes within a half mile [805 meters] of school) and found that it was associated with current e-cigarette use (aPR=1.03 95% CI: 1.00,1.07; $p=0.031$).

2.4.1.1.5 Outdoor Advertisements

One study investigated outdoor e-cigarette marketing and current e-cigarette use. Cruz et al. (2019) found that exposure to outdoor e-cigarette marketing was associated with e-cigarette initiation (OR 1.92, 95% CI: 1.27, 2.90; $p < 0.05$). However, when considering outdoor advertisements for a combination of six different tobacco products, it was not associated with current e-cigarette use.

2.4.1.1.6 Not Stratified by Location/Type

Six studies asked participants about the location or type of advertisements they were exposed to including neighbourhood locations, such as specific retailers and billboards among others. However, such studies also included advertisements outside the neighbourhood environment in their assessment, such as social media and television. Four results were associated with statistically greater current e-cigarette use, and two were not statistically significant. Kreitzberg et al. (2019b) found that a one unit increase in e-cigarette advertising exposure resulted in an increase in current marijuana e-cigarette use (OR 1.08, 95% CI: 1.01-1.14). Simon et al. (2018) examined exposure to advertisements as a mediating factor of the relationship between socioeconomic status and adolescent e-cigarette use. They found that higher socioeconomic status was associated with greater exposure to e-cigarette advertising, and subsequently with a higher frequency of current use (**β** = 0.01, SE = 0, 95% CI: 0.001, 0.010, p=0.02; B = 0.01, SE = 0.01, 95% CI: 0.003, 0.022, p=0.01). Additionally, Papaleontiou et al. (2020) found that exposure to both traditional tobacco and e-cigarette advertising was associated with higher odds of current e-cigarette use (aOR 1.56, 95% CI: 1.28-1.92). Although they did not stratify the results by advertising type or location, they reported that exposure was highest for retail stores, when compared to TV/movies, internet, and magazines/newspapers (Papaleontiou et al., 2020). Moreover, Hammond et al., (2020) found that those who reported marketing exposure often or very often were more likely to report current e-cigarette use (AOR = 1.41, 95% CI: 1.23-1.62, p < 0.001), past week use (AOR = 1.44, 95% CI: 1.22-1.70; p < 0.001), and on >/= 20 days in the past month (AOR = 1.42, 95% CI: 1.11-1.81; p=0.005). Kreitzberg et al. (2019a) found that exposure to e-cigarette marketing was not associated with current e-cigarette use at wave 1 or wave 3 of the survey. Yet, self-reported exposure in a previous survey wave predicted current e-cigarette use at each subsequent wave (***β*** ranges = 0.07-0.10; p < 0.01). Finally, Pesko et al. (2017) found that a one unit increase in e-cigarette advertising exposure was not associated with statistically significant e-cigarette use.

2.4.1.2 Policy and Current Use

Ten studies examined the relationship between policy and current use. These papers examined a variety of policies, including retail licensing, taxation, minimum sale age, packaging, and product displays, as well as tobacco policies such as taxing traditional cigarettes or implementing smoke-free environments and minimum sale age. Within the ten papers, there were twenty-three findings, six of which demonstrated that the presence or implementation of policies was associated with statistically lower current e-cigarette use, three findings demonstrated statistically greater use – one of which being a restrictive policy that had the opposite impact than intended –and fourteen were not significant (Table 3).

Table 2: Study Characteristics (n=43)

Author(s)	Year	Location (Country)	Ages (Years)	N (M/F)	Element of Neighbourhood	Interaction(s)	Outcome(s)	Study Design
Beleva et al	2019	Southern California (USA)	high school students (14-18 years)*	746 (47.6% M; 51.7% F)	Advertising	Exposure	Ever use	Longitudinal survey and observational data
Camenga et al	2018	Connecticut (USA)	middle and high school students (Gr.6-12 aged 10 to 18 years)*	1,742 (45.9% M; 54.1% F)	Advertising	Exposure	Ever use	Longitudinal cohort
Chen-Sankey et al	2019	USA	12-24 years	9,804 (49.6% M; 50.4% F)	Advertising	Exposure	Ever use	Prospective longitudinal cohort study
Cho et al	2019	USA, UK, and Canada	16-19 years	12,064 (53.3% M; 46.6% F)	Advertising	Exposure	Ever use, Current use	Cross-sectional
Cruz et al	2019	California (USA)	grades 11-12 (17-18 years)*	1,553 (48.4% M; 51.6% F)	Advertising	Exposure	Current use	Cross-sectional (Prospective cohort study)
Dai et al	2016	USA	grades 6-12 (11-18 years)*	21,491 (50.5% M; 48.8 F)	Advertising	Exposure	Ever use, Current use	Cross-sectional
Giovenco et al	2016	New Jersey (USA)	high school students (14-18 years)*	3,909 (50.5% M; 49.5% F)	Advertising	Exposure	Ever use, Current use	Cross-sectional
Hammond et al	2020	Canada	16-19 years	12,004 (51.4% M; 48.6% F)	Advertising	Exposure	Current use	Repeated cross-sections

Kreitzberg et al	2019b	USA	College students (19-24 years)*	3,720 (35.7% M)	Advertising	Exposure	Current use	Longitudinal
Kreitzberg et al	2019a	Texas (USA)	undergraduate college students (18-24 years)*	4,327 (64% F)	Advertising	Exposure	Current use	Longitudinal
Lee et al	2017	Midwest (USA)	18-25 years	1,185 (33.3% M)	Advertising	Exposure	Ever use, Current use	Cross-sectional**
Loukas et al	2019	Texas (USA)	12-29 years	4,711 (youth: 49.4% F; young adults: 66.7% F)	Advertising	Exposure	Ever use	Longitudinal surveillance system
Marynak et al	2018	USA	grades 6-12 (11-18 years)*	2014: 22,007, 2015: 17,711 and 2016: 20,675	Advertising	Exposure	Current use	Longitudinal
Nicksic et al 2017	2017	USA	12-17 years	baseline: 3,907 (49% F), follow up: 2,488	Advertising	Exposure	Ever use, Current use	Longitudinal
Papaleontiou et al	2020	USA	grades 9-12 (13-18 years)*	17,711 (51.2% M, 48.8% F)	Advertising	Exposure	Current use	Cross-sectional
Pasch et al	2018	Texas (USA)	grades 6-10 (11-17 years)*	baseline: 3,907 (49% F), follow up: 2,483	Advertising	Exposure	Ever use, Current use	Longitudinal
Peiper et al	2020	USA	11-18 years	2,058 (48.8% M; 51.2% F)	Advertising	Exposure	Current use	Cross-sectional
Pu et al	2017	USA	11-18 years	21,595	Advertising	Exposure	Current use	Cross-sectional
Simon et al	2018	Connecticut (USA)	Grades 9-12 (13-18 years old)*	3,473 (50.7% F)	Advertising	Exposure	Current use	Cross-sectional

Astor et al	2019	Southern California (USA)	grades 11-12 (17-18 years)*	baseline: 2,097 (50.5% M; 49.5% F) follow up: 1,553	Policy	Availability	Ever use, Current use	Prospective cohort study
Azagba et al	2020	Pennsylvania (USA)	grades 9-12 (13-18 years)*	PA: 6,660 (49% M; 51% F), NY: 2,2245 (48.6% M; 51.4% F), VA: 8,892 (49.2% M; 50.8% F)	Policy	Availability	Current use	Longitudinal**
Du et al	2020	USA	18+ (18-24 years)	894,997 (51.3% F)	Policy	Availability	Current use	Cross-sectional
Hawkins et al	2019	USA	grades 9-12 (>14 years)	Aim 2: 155,131 (49.9% M; 50.1% F)	Policy	Availability	Current use	Repeated cross-sections
Jun et al	2020	USA	18-34 years (18-24 years)	444,023 (ages 18-24: 24 380)	Policy	Availability	Ever use, Current use	Cross-sectional
Lee et al	2019	USA	18-59 years **(18-24 years)**	**25,068 (ages 18-24 years)** (240 849 ages 18-59 years; 46% M; 54% F)	Policy	Availability	Current use	Cross-sectional
Macinko et al	2018	New York City (USA)	grades 7-12 (11-18 years)*	Not reported	Policy	Availability	Current use	Pre-post (Difference-in-differences with repeated cross-sections)

Nguyen et al	2020	Canada	15-25 years	8,212 (age 15-18 difference-in-differences analysis), 20,934 (age 15-25 in triple-differences analysis)	Policy	Availability	Current use	Pre-post (Difference-in-differences with repeated cross-sections)
Valentine et al	2019	Mississippi (USA)	grades 9-12 (13-18 years)*	1,923 (967 M; 934 F)	Policy	Availability	Current use	Cross-sectional**
Borodovsky et al	2017	USA	14-18 years	2,630 (45.7% M; 50.8% F; 1.9% trans; 1.6% other)	Policy/Retail	Availability/Density	Ever use	Cross-sectional**
Best et al	2016	Scotland (UK)	10-18 years	3,808 (49.7% F)	Retail	Availability	Ever use	Cross-sectional
Bigwanto et al	2019	Indonesia	high school students (Junior secondary: Gr. 7-9 aged 12-15/ Senior Secondary: 10-12 aged 15-18)*	767 (54.1% M; 45.9% F)	Retail	Accessibility	Ever use	Cross-sectional
Bostean et al	2016	Orange County (USA)	grades 7,9,11 (11-13/13-15/15-17 years)*	67,701 (middle school: 51% F; high school: 51.4% F)	Retail	Availability	Ever use, Current use	Cross-sectional

Cole et al	2019	Ontario, Alberta, Quebec, BC (Canada)	grades 7-12 (12-18 years)*	63,400 (50.5% F)	Retail	Availability/ Density	Ever use, Current use	Cross-sectional**
King et al	2020	North Carolina and Virginia (USA)	College students (18-24 years)*	1,099 (47.8% M)	Retail	Density/ Proximity	Ever use	Cohort study
Mantey et al	2019	USA	Grades 9-12, under the age of 18 (13-17 years)*	1217	Retail	Accessibility	Current use	Cross-sectional
Perez et al	2017	USA	grades 6,8,10 (ages 10-12/ 12-14/ 15-17 years)*	3,765 (49% F)	Retail	Availability	Current use	Cross-sectional**
Trapl et al	2020	Cleveland (USA)	grades 7&8 (12-14 years)*	3,778 (47.7% M; 52.3% F)	Retail	Density/ Proximity/ Accessibility/ Exposure	Current use	Cross-sectional**
D'Angelo et al	2021	USA	12-17 years	6,470 (50.5% M; 49.5% F)	Retail/ Advertising	Accessibility/ Exposure	Ever use	Longitudinal
Gewirtz O'Brien et al	2020	Minnesota (USA)	grades 8,9,11 (aged 12-14/13-15/14-16)*	10,757 (47.5% M; 52.3% F)	Social characteristics	N/A	Current use	Cross-sectional
Noland et al	2018	USA	grades 9-12 (13-18 years old)*	11,053 (49.4% M; 50.6% F)	Social characteristics	N/A	Current use	Cross-sectional
Pesko et al	2017	USA	11-17 years	71,012 (49.68% M; 50.1% F)	Social characteristics	N/A	Current use	Repeated cross-sections

Shih et al	2017	USA	grades 10-12 (aged 15-18 years)*	2,539 (53.7% F)	Social characteristics	N/A	Ever use	Longitudinal
Wiggins et al	2020	USA	grades 6-12 (10-18 years old)*	121,443 (50% M)	Social characteristics	N/A	Current use	Cross-sectional cohort study

* age range determined by reviewer
** study design determined by reviewer
N/A: not applicable
M: male
F: female

2.4.1.2.1 Age Restrictions

Five papers examined the relationship between age restrictions on purchase of e-cigarettes and current use; among these papers were a total of 8 findings. The findings of one paper from the U.S. demonstrated statistically lower current e-cigarette use in states that had age restrictions (3/53 states) compared to those that did not (Du et al., 2020). Two papers demonstrated a significant increase when comparing current e-cigarette use before and after changes in minimum sale age in New York City (Macinko et al., 2018) and Canada (Nguyen et al., 2020). The rest of the findings were not significant. Hawkins et al. (2019) did not find an association between e-cigarette age restrictions and current e-cigarette use, even when they were adopted early (in 2010). Jun and Kim (2021) also found that restricting general youth access through various means was not associated with current e-cigarette use. Additionally, they did not find a significant association in states with a minimum sale age of 21 years (vs 18 years) or 19 years (vs 18 years) (Jun & Kim, 2021). However, Du et al. (2020) found that policies mandating a minimum sale age of 21 years were associated with a 20% lower current e-cigarette use (OR 0.80, 95% CI: 0.59-1.07).

Two papers examined the change in e-cigarette use before and after policy changes to minimum sale age. Both studies found that, despite increasing the minimum sale age, current e-cigarette use continued to increase (Macinko et al., 2018; Nguyen et al., 2020). In one Canadian study, Nguyen et al. (2020) found that even after provinces prohibited e-cigarette sales to minors, youth e-cigarette use still increased in all provinces between 2013 and 2017. However, this increase was 79% lower (95% CI, 0.2-6.0; p=0.04) in provinces that adopted this policy than those that did not (Nguyen et al., 2020). Likewise, Macinko et al. (2018) found that after New York City increased the minimum legal purchase age for tobacco and e-cigarette products from 18 to 21 years, e-cigarette use increased significantly between 2014 (6.85%, 95% CI:5.70, 8.22) and 2016 (14.9%, 95% CI:11.61, 18.92). However, this increase also occurred in the control group (New York State) (2014: 8.1%, 95% CI: 5.82, 11.17; 2016: 14.06%, 95% CI: 10.01, 19.40) (Macinko et al., 2018).

2.4.1.2.2 Tobacco Policy

Four studies assessed the relationship between traditional tobacco policies and current e-cigarette use. Among the four studies, one finding was significant, while 3 were not significant. A United States study found that in states with smoke-free policies for traditional tobacco products, e-cigarette use was higher (marginal effects 0.038, p<0.001) (Hawkins et al., 2019). Conversely, a Mississippi study of high school students found that smoke-free municipal policies were not associated with any differences in current e-cigarette use. Examining taxation in the United States on traditional tobacco cigarettes, Hawkins et al. (2019) and Pesko et al. (2017) did not find a significant association with current e-cigarette use. When state laws in the United States defined e-cigarettes as tobacco products, thus including them in tobacco policy, Jun and Kim (2021) found that the policies were not significantly associated with current e-cigarette use in 18–24-year-olds.

2.4.1.2.3 E-Cigarette Taxation

Two studies examined e-cigarette taxation in the United States. Du et al. (2020) found that state laws applying taxation to e-cigarettes were associated with statistically lower current e-cigarette use among 18-24-year-olds (OR 0.81 95% CI: 0.68-0.97; p=0.02), while Jun and Kim (2021) found no association with states applying a special non-sales tax on e-cigarettes.

2.4.1.2.4 Retail Licensing

Four studies investigated the impact of retail licensing policies in the United States, three of which found statistically lower current e-cigarette use, while one had null findings. Astor et al. (2019) found that those in grades 11 and 12, living in jurisdictions of Southern California in the United States with the most restrictive retail licensing policies had lower odds of current e-cigarette use at baseline (OR 0.51, 95% CI: 0.29–0.89) and follow-up (OR 0.45, 95% CI: 0.23-0.90) than those living in less restrictive jurisdictions. In addition, Du et al. (2020) found retail licensing policies in the United States to be associated with statistically lower current e-cigarette use among 18-24-year-olds (OR 0.90, 95% CI: 0.80-1.01), yet Jun and Kim (2021) did not find a significant association between current e-cigarette use and state laws mandating retail licenses in the United States. Azagba et al. (2020) examined the association between an e-cigarette licensing policy in Pennsylvania and current e-cigarette use and compared this to current e-cigarette use in New York and Virginia, where no policy was implemented. The policy was associated with a decrease in the probability of e-cigarette use in Pennsylvania. Nonetheless, all 3 states demonstrated a decline in the prevalence of e-cigarette use. Pennsylvania had a 12.8 percent decrease (from 24.14% in 2015 to 11.34% in 2017), while the prevalence in New York decreased by 7.2% (Pennsylvania vs NY: **β** -0.052, SE (**β**) 0.020, p=0.01) and the prevalence in Virginia decreased by 5% (Pennsylvania vs Virginia: **β** -0.074, SE (**β**) 0.018, p<0.0001).

2.4.1.2.5 Use Restrictions

Two studies investigated the association between use restrictions and current use of e-cigarettes among 18-24-year-olds in the United States. Lee et al. (2019) and Du et al. (2020) found that state aerosol-free policies and policies prohibiting e-cigarette use in indoor areas, such as private workplaces, restaurants, and bars, were not associated with current e-cigarette use.

2.4.1.2.6 Packaging and Display

One paper examined packaging restrictions and e-cigarette use and one paper studied self-services display restrictions and e-cigarette use among 18-24-year-olds in the United States. Neither study demonstrated a significant association (Jun & Kim, 2021; Du et al., 2020).

2.4.1.3 Retail and Current Use

Seven studies examined the relationship between retail interactions in the neighbourhood environment and current e-cigarette use. Of the seven papers there were twelve findings, half demonstrated that retail environment interactions were associated with statistically higher current e-cigarette use, while the other half were not significant. This relationship was measured through accessibility, exposure, availability, density, and proximity to retailers. Again, while the findings are organized by these different types of interactions with the retailers, not all papers define the interactions the same way.

2.4.1.3.1 Accessibility

There were four findings related to accessibility to retailers in a United States study, two of which demonstrated that increased accessibility was associated with an increase in current e-cigarette use, while one found that lower accessibility was associated with statistically lower e-cigarette use. Mantey et al. (2019) considered participants to have retail access if they reported that they purchase e-cigarette products from a convenience store, supermarket, discount store, gas station, vape shop, or online (Mantey et al., 2019). Given that online retailers are not part of the neighbourhood environment, this may complicate the findings. Regardless, the United States study found that retail access to e-cigarettes was associated with "moderate" (10-29 days per month) (RRR: 2.11, 95% CI: 1.11-4.03) or "daily" (30 days per month) (RRR: 5.81, 95% CI: 2.88-11.69) e-cigarette use compared to "infrequent use" (1-2 days per month). However, retail access was not associated with any change in relative risk of light e-cigarette use (3-9 days per month) relative to infrequent use (Mantey et al., 2019).

2.4.1.3.2 Exposure

One study investigated exposure to retailers and current e-cigarette use in Cleveland, Ohio, USA. Trapl et al. (2020) defined exposure as students in grades 7 and 8 who self-reported visiting retailers before/after school. This was associated with significantly greater odds of current e-cigarettes use (visiting 1-2 times per week: 1.42, 95% CI: 0.98-2.06; 3-4 times: 2.66, 95% CI: 1.79-3.96, $p<0.05$; everyday: 3.54, 95% CI: 2.32-5.41, $p<0.05$).

2.4.1.3.3 Availability

Two papers examined the availability of e-cigarette retailers and current e-cigarette use. A study of students in grades 7, 9, and 11 in Orange County, California, USA found that presence of an e-cigarette retailer within a quarter mile (402 meters) of a middle school (OR = 1.42, 95% CI = 0.82-2.46) and high school (OR = 0.96, 95% CI = 0.71-1.28) was not associated with current e-cigarette use among students (Bostean et al., 2016). A study in Ontario, Alberta, Quebec, and British Colombia, Canada found that e-cigarette retailer availability around schools was not associated with current e-cigarette use among students aged 12 to 18 years (Cole et al., 2019).

2.4.1.3.4 Density

Three papers examined density of retailers and current e-cigarette use. One demonstrated statistically higher e-cigarette use, while the remaining two were not significant. A study of high school students in New Jersey, USA calculated e-cigarette retailer density by the number of retailers within a half mile (805 meters) radius of the high school. They found that density was associated with current e-cigarette use (aPR = 1.06, 95 CI: 1.02,1.10; p=0.002) (Giovenco, et al., 2016). Trapl et al. (2020) calculated tobacco retailer density in Cleveland, Ohio, USA as the number of retailers per square mile (1609 meters) and found that it was not associated with current e-cigarette use. Likewise, Perez et al. (2017) did not find an association between students attending schools in tobacco retail hotspot areas of Travis County in Texas and e-cigarette use. However, there was a higher relative risk of current e-cigarette use in Dallas/Tarrant and Harris counties (no value reported) (Perez et al., 2017). In addition, Cole et al. (2019) found that e-cigarette retailer density around schools was not significantly associated with current e-cigarette use among students.

2.4.1.3.5 Proximity

Two papers investigated proximity to e-cigarettes within the retail environment surrounding schools in Cleveland, Ohio (Trapl et al., 2020) and e-cigarette retailers within 500m, 1000m, and 1500m of schools in Canada (Cole et al., 2019) and current e-cigarette use, neither of which demonstrated significant findings.

2.4.1.4 Neighbourhood Social Characteristics and Current Use

Four studies examined the relationship of living/going to school in areas of varying levels of urbanicity and current e-cigarette use. Among the four articles, there were six findings, two of which found urban environments were associated with greater odds of e-cigarette use, two found they were associated with lower odds, and two were not significant. A study in the United States found that, regardless of place of residence, e-cigarette use increased over time among middle and high school students and there was no difference in rate of change. Although e-cigarette use was low in urban and rural areas among middle school students, the rural students were 1.3 times more likely to report current e-cigarette use than urban students (aRR=1.26, CI:1.04-1.54) (Wiggins, et al., 2020). Among high school students, there was no difference in current e-cigarette use associated with place of residence. Similarly, a study in Minnesota, USA found that among youth experiencing homelessness, e-cigarette use was lower among those attending urban schools in Minnesota, USA (37.7%; p=0.002) compared to suburban (39.5%; p=0.002), town (43.3%; p=0.002), and rural (40.7%; p=0.002) schools (Gewirtz O'Brien et al., 2020). Conversely, a study in the United States found that youth attending urban schools who smoke cigarettes were 86% more likely to also use e-cigarettes than youth attending rural schools who smoke (95% CI: 1.02-3.40; p=0.043) (Noland, et al., 2018). However, when examining youth who do not smoke, there was no difference in the likelihood of urban and rural students to use e-cigarettes (Noland et al., 2018). Pesko et al. (2017) found that between 2011 and 2014, e-cigarette use increased more among youth living in urban areas (2011: 0.92%, CI: 0.65-1.18; 2014: 8.62% CI: 7.30-9.94; p<0.001) in the United States than rural (2011: 2.13%, CI: 1.15-3.11; 2014: 4.26%, CI: 1.80-6.71; p=0.05). In addition, current e-cigarette use among urban youth increased significantly between 2013 (2.42%, CI: 1.92-2.92; p<0.001) and 2014 (8.62%, CI: 7.30-9.94; p<0.001); however, rural residency was not associated with e-cigarette use (Pesko et al., 2017).

2.4.2 Findings Related to Ever Use of E-Cigarettes

2.4.2.1 Advertising and Ever Use

Eleven studies assessed the relationship between advertising and ever use. Among the eleven studies, there were twenty-three findings, with fourteen demonstrating a statistically higher e-cigarette use, and seven finding no relationship. Twenty-two findings measured self-reported exposure to advertising, and one used an objective measure of volume of advertisements to assess exposure (Giovenco et al., 2016).

2.4.2.1.1 Retail Advertising

There were eighteen findings that examined exposure to retail advertisements, thirteen of which found increased exposure to be associated with statistically higher ever e-cigarette use, while the remaining five were not significant. The types of retailers examined included any retailer type, stores that sell traditional cigarettes, kiosks, malls, drug stores, grocery stores, convenience stores, and tobacco stores.

2.4.2.1.1.1 Any Retail Type

A study in Texas, USA found that for students who reported visiting gas stations, convenience, grocery, and drug stores in the last 30 days, recall of retail e-cigarette marketing was associated with higher odds of subsequent ever e-cigarette use among youth (aOR = 1.99; 95% CI: 1.25-3.17; p<0.05) and young adults (aOR = 1.30; 95% CI: 1.05-1.61; p<0.05) (Loukas, et al., 2019). A United States study also found that the odds of ever e-cigarette use was higher at baseline for students who recalled advertisements when visiting gas stations, convenience, and grocery stores compared to those who did not (OR 1.51, 95% CI=1.07-2.15; p<0.05) (Nicksic et al., 2017). There was also an increase in odds at baseline for each recall of an advertisement (OR 1.14 95% CI=1.04-1.25; p<0.05). Students who recalled retail store advertisements at baseline were also more likely to report ever e-cigarette use at follow-up (OR 2.99, 95% CI=1.50-5.97; p<0.05) (Nicksic et al., 2017). Dai et al. (2016) found that greater exposure to e-cigarette advertisements in retail stores in the United States was significantly associated with increased odds of former e-cigarette use (aOR = 1.4; p<0.01). Similarly, Lee et al. (2017) found that retail advertising exposure in the United States was associated with increased risk (RRR 1.24, 95% CI= 1.03, 1.50; p < 0.05) of ever using e-cigarettes among college students. Retail advertising exposure was associated with higher odds (OR 1.12, 95% CI=0.90, 1.40) of transitioning from intending to try e-cigarettes to ever using (Lee et al., 2017). Additionally, another study in Texas, USA found that students who recalled e-cigarette marketing in gas stations, convenience, grocery, and drug stores near their schools had higher odds of e-cigarette use (AOR = 2.71, CI = 95%; 1.36, 5.4; p<0.05) (Pasch, et al., 2018). However, Giovenco et al. (2016) found that both exposure to e-cigarette advertisements and the volume of e-cigarette advertisements around schools (#

of total e-cigarette ads x the proportion of all tobacco ads that were for e-cigarettes within a half mile [805 m] of school) were not associated with the probability of ever use. Self-reported exposure to e-cigarette advertisements was measured to account for students visiting tobacco retail locations and potentially being exposed to advertisements outside of their school area, which would not otherwise be captured through advertisement volume within a half mile (805 meters) of the school (Giovenco et al., 2016).

2.4.2.1.1.2 Tobacco Retail Advertisements

A study in Southern California, USA found that exposure to point-of-sale tobacco advertising was significantly associated with use of e-cigarettes (Beleva, et al., 2019). Share of advertising voice – the percentage of point-of-sale advertising for a particular product – demonstrated a significant moderating effect, where an increased proportion of point-of-sale advertising for e-cigarettes increased the effect of point-of-sale exposure on the use of e-cigarettes ($B = 0.27$, SE = 0.07, $p < .001$) (Beleva et al., 2019). Giovenco et al. (2016) also found that exposure to tobacco advertisements in retailers within a half mile (805 meters) of school was associated with the probability of e-cigarette use (aPR 1.25 95% CI: 1.14, 1.36; $p<0.001$).

2.4.2.1.1.3 Specific Retail Locations

D'Angelo et al (2021) found that self-reporting an e-cigarette advertisement in a convenience store, small market, or liquor store was not associated with e-cigarette initiation. Cho et al. (2019) found that ever users of both traditional tobacco cigarettes and e-cigarettes were more likely to self-report exposure to e-cigarette advertisements in stores that sell cigarettes (AOR = 1.53, 95% CI =1.37, 1.70) and kiosks or temporary sales locations (AOR = 1.33, 95% CI = 1.19, 1.49). Similarly, at study in Texas, USA found that e-cigarette marketing exposure in drug stores (OR 3.31, 95% CI: 1.36, 8.03; $p<0.05$), grocery stores (OR 3.95, 95% CI: 1.65, 9.46; $p<0.05$), and convenience stores (OR 2.82, 95% CI: 1.4, 5.66; $p<0.05$) was associated with greater odds of e-cigarette ever use (Pasch et al., 2018). However, a study in Connecticut, USA did not find a significant association with convenience stores, malls, or tobacco shops (Camenga, et al., 2018).

2.4.2.1.1.3.1 Billboards and Posters

Three studies assessed self-reported exposure to e-cigarette advertisements on billboards or posters and ever e-cigarette use. The findings of one demonstrated statistically greater use, while the other 2 demonstrated no significance. A study in the United States found that exposure to e-cigarette advertisements on billboards or posters was associated with higher e-cigarette use (aOR 1.65, 95% CI: 1.14-2.40) (Chen-Sankey, et al., 2019). However, a study in the United States, Canada, and the United Kingdom (Cho et al., 2019) and another study in the United States (Camenga et al., 2018) found that the association was not significant.

2.4.2.2 Policy and Ever Use

Three studies examined a specific policy dimension as the independent variable and ever use as the dependent variable (Astor et al., 2019; Jun & Kim, 2021; Borodovsky et al., 2017). Within these three studies, there were nine findings for restrictive regulative policies and one finding for legalization policies.

Of the nine findings of restrictive policies, five were not significantly associated with ever e-cigarette use and four findings demonstrated that policies were linked to lower odds of ever e-cigarette use. The existence of a legalization policy was associated with increased ever e-cigarette use. Jun and Kim (2021) found that state laws in the United States defining e-cigarettes as tobacco products and including them in existing tobacco policies, restricting youth access through various means, packaging regulations, non-sales taxation, and minimum sale age of 21 years (vs 18) were not significantly associated with ever e-cigarette use. However, the study also found that retail licensing (OR 0.942, 95% CI:0.898-0.994; $p<0.05$), minimum sale age of 19 years (vs 18) (OR 0.715, 95% CI:0.637-0.802; $p<0.001$), and all 5 e-cigarette regulations (defining e-cigarettes, non-sales tax, packaging regulation, restricting youth access, retail licensing) (the initiation rate in states with all five regulations was 42.1%, statistically significant in χ^2 analyses $p<0.001$, while in those with no regulations it was 42.6%) were associated with a significant decrease in ever e-cigarette use (Jun & Kim, 2021). It should be noted that only one state in the study had all five e-cigarette regulations (Jun & Kim, 2021).

Additionally, Astor et al. (2019) found that living in jurisdictions in California with the most restrictive retail policies (vs less restrictive) was also associated with lower odds of ever e-cigarette use (OR 0.74, 95% CI: 0.55-0.99). The finding for legalization policies demonstrated that longer duration of legal cannabis laws in the United States was associated with greater odds of ever cannabis e-cigarette use (OR 2.82, 95% CI: 2.24, 3.55) (Borodovsky et al., 2017).

2.4.2.3 Retail and Ever Use

Eight studies examined the relationship between retail and ever use, within which there were ten findings. This relationship was measured through accessibility, availability, density, and proximity to retailers. While the subsequent findings are organized by these different types of interactions with the retailers, some studies defined the interactions differently from one another. Five findings were associated with a statistically greater ever use (D'Angelo et al., 2021; Best et al., 2016; Bostean et al., 2016; Borodovsky et al., 2017; Giovenco et al., 2016), while five findings were not significant (Bigwanto et al., 2019; Bostean et al., 2016; Cole et al., 2019; King et al., 2020).

2.4.2.3.1 Accessibility

Two studies examined accessibility to retailers. One demonstrated statistically higher ever use, while the other was not significant. D'Angelo et al. (2021) defined accessibility as frequency of convenience store visits and found that those who visited a convenience store in the United States 1-3 times in 30 days compared to never had higher odds of e-cigarette use (OR 1.48 95% CI: 1.03-2.12). A study in Indonesia found that high school students' perceived accessibility to a vape shop was not independently associated with higher odds of e-cigarette use (Bigwanto et al., 2019).

2.4.2.3.2 Availability

Three studies examined availability of retailers and e-cigarette use. Two studies found that availability of e-cigarette retailers, defined as seeing e-cigarettes in small shops and supermarkets and presence of a retailer within a quarter mile (402 meters) was associated with a statistically significant increase in e-cigarette use, while one did not have significant findings. A study in Scotland, UK found that adolescents who recalled seeing e-cigarettes in small shops (OR 2.89, 99% CI:2.36-3.54) and supermarkets (OR 2.56, 99% CI:1.89-3.47) were over two times more likely to have ever used e-cigarettes (Best, et al., 2016). A study in Orange County, California, USA found that presence of e-cigarette specialty retailers within a quarter mile (402 meters) of a middle school was associated with increased odds of e-cigarette use (OR = 1.70, 95% CI:1.02-2.83) (Bostean et al., 2016). However, the association for high schools was not significant (Bostean et al., 2016). A study in Ontario, Alberta, Quebec, and British Colombia, Canada found that the number of e-cigarette retailers within 500m, 1000m, and 1500m buffers was not associated with ever e-cigarette use among students (Cole et al., 2019).

2.4.2.3.3 Density

Four studies examined density of retailers and ever e-cigarette use, two of which demonstrated statistically greater use, while the remaining two were not significant. Increased density of cannabis dispensaries (<1 dispensary per 100k people, >/= 1 dispensary per 100k people) (OR: 2.68, 95% CI: 2.12, 3.38) in the United States (Borodovsky et al., 2017) and e-cigarette retailer density (# of retailers within a half mile radius [805 m]) around schools (aPR=1.04 95% CI: 1.02, 1.07; p=0.001) in New Jersey, USA (Giovenco et al., 2016) were associated with statistically higher e-cigarette use. A study in Canada found that retailer density around schools was not significantly associated with ever e-cigarette use (Cole et al., 2019). Similarly, a study in North Carolina and Virginia, USA found that density of waterpipe cafés, vape shops, and traditional tobacco retailers (per 1000 pop tract level) were not associated with e-cigarette use (King, et al., 2020). However, this was measured with past 6-month e-cigarette use.

2.4.2.3.4 Proximity

One study in North Carolina and Virginia, USA found that proximity of retailers and ever e-cigarette use were not significantly associated. King et al. (2020) found that proximity (in miles driving) from participants’ homes to the nearest waterpipe café, vape shop, and traditional retailer were not associated with e-cigarette use.

2.4.2.4 Neighbourhood Social Environment and Ever Use

One study in the United States examined the relationship between neighbourhood social characteristics and ever use (Shih, et al., 2017). Neighbourhood problems with alcohol/drugs (OR 1.25, 95% CI: 1.13, 1.38; $p<0.001$) and disorganization (OR 1.59, 95% CI: 1.29, 1.96; $p<0.001$) were associated with higher odds of e-cigarette use, whereas neighbourhood socioeconomic disadvantage was not significantly associated with e-cigarette use. Increased neighbourhood cohesion was associated with lower odds of e-cigarette use (OR 0.83, 95% CI: 0.7, 0.97; $p<0.05$).

Table 3: Findings of papers considering elements of the neighbourhood environment and e-cigarette use (n=43)

Author	Interaction(s)	Outcome(s)	Results	Association
Current use (past 30-day) findings				
Advertising				
Cho et al 2019	Exposure	Current use	Current dual users, those that smoke and vape, were more likely than never users to report exposure to advertisements at stores that sell cigarettes (AOR = 1.83, 95% CI: 1.43, 2.35).	↑
	Exposure	Current use	Current dual users, those that smoke and vape, were more likely than never users to report exposure to advertisements at kiosks or temporary sales locations (AOR = 1.88, 95% CI: 1.47, 2.40).	↑
	Exposure	Current use	Those who currently exclusively use e-cigarettes, were more likely than never users to self-report exposure to e-cigarette ads through stores that sell cigarettes in the last 30 days (AOR = 1.89, 95% CI: 1.48, 2.41).	↑
Cruz et al 2019	Exposure	Current use	E-cigarette initiation is more likely following self-reported exposure to e-cigarette marketing in stores (OR 1.86, 95% CI:1.19, 2.92; p < 0.05).	↑
	Exposure	Current use	Self-reported exposure to marketing in stores for six combined tobacco products was not associated with e-cigarette use (OR 1.91, 95% CI: 0.95, 3.85).	–
	Exposure	Current use	E-cigarette initiation is more likely following self-reported exposure to e-cigarette marketing outdoors (OR 1.92, 95% CI:1.27, 2.90; p < 0.05).	↑
	Exposure	Current use	Self-reported exposure to outdoor marketing for six combined tobacco products was not associated (OR 1.45, 95% CI:0.73, 2.88) current e-cigarette use.	–
Dai et al 2016	Exposure	Current use	Greater self-reported exposure to e-cigarette advertisements in retail stores was significantly associated with increased odds of current e-cigarette use (aOR = 1.9, p < 0.0001).	↑
Giovenco et al 2016	Exposure	Current use	The total number of e-cigarette advertisements within and half-mile of school was not associated with past month use of e-cigarettes (aPR=1.01, 95% CI:1.00,1.03; p=0.033.	–

	Exposure	Current use	E-cigarette advertising volume (# of total e-cig ads x the proportion of all tobacco ads that were for e-cigs within 1/2 mile of school) increased the probability of past-month use of e-cigarettes (aPR=1.03, 95% CI: 1.00,1.07; p=0.031).	↑
Hammond et al 2020	Exposure	Current use	Respondents who self-reported marketing exposure often or very often were more likely to report current use of e-cigarettes (AOR = 1.41, 95% CI: 1.23-1.62, p < 0.001), past week use (AOR = 1.44, 95% CI: 1.22-1.70, p < 0.001), and on >/= 20 days in the past month (AOR = 1.42, 95% CI: 1.11-1.81, p=0.005) **(not stratified by ad type/location)**.	↑
Kreitzberg et al 2019a	Exposure	Current use	Self-reported exposure to ENDS marketing had a small but significant association with current ENDS use at wave 1 (r = 0.08, p < 0.001) and wave 3 (r = -0.09, p < 0.05). Reported ENDS marketing exposure in the previous survey wave predicted current ENDS use at each subsequent survey wave ($\boldsymbol{\beta}$ ranges = 0.07-0.10, p < 0.01) **(not stratified by ad type/location)**.	↑
Kreitzberg et al 2019b	Exposure	Current use	At wave 2, for every one-unit increase in self-reported e-cigarette advertising exposure, there was a 1.08 increase (95% CI: 1.01-1.14) in the odds of a participant subsequently using marijuana e-cigarettes. **(not stratified by ad type/location)**.	↑
Lee et al 2017	Exposure	Current use	Self-reported retail advertising exposure was associated with 0.97 RRR (95% CI: 0.72, 1.30) of being at "adopter" (current use) level of e-cigarette use acceptability.	–
	Exposure	Current use	Self-reported retail advertising exposure was associated with 0.78 (95% CI: 0.59, 1.03) times the odds of transitioning from "early majority" (ever use/trying e-cigarettes, but not within past 30 days) to "adopter" (past 30-day use).	–
Marynak et al 2018	Exposure	Current use	Current users of e-cigarettes self-report a high prevalence of exposure to e-cigarette advertising in each year from 2014-2016 (2014: 70.5%, 95% CI:67.3-73.6; 2015: 68.4%, 95% CI:64.8-71.8; 2016: 74.3%, 95% CI:70.7-77.6; p<0.05) than non-users.	↑
Nicksic et al 2017	Exposure	Current use	The odds of current e-cigarette use was 2.21 times higher at baseline for students who recalled advertisements in retail stores compared to those who did not (95% CI: 1.17-4.19; p<0.05). At follow-up, the odds of current e-cigarette use was 2.03 times higher compared to those who did not recall the advertisements (95% CI: 1.11-3.72; p<0.05).	↑

Papaleontiou et al 2020	Exposure	Current use	Self-reported exposure to both traditional tobacco and e-cigarette advertising was associated with significantly increased odds of current e-cigarette use (aOR 1.56, 95% CI: 1.28-1.92) **(not stratified by ad type/location)**.	↑
Pasch et al 2018	Exposure	Current use	Recall of e-cigarette marketing in any type of retail store at baseline predicted current e-cigarette use (AOR=2.02, 95% CI: 1.07, 3.83).	↑
	Exposure	Current use	Self-reported exposure to point-of-sale e-cigarette marketing in convenience stores is associated with 1.88 odds (95% CI: 0.99, 3.56) of current e-cigarette use.	–
	Exposure	Current use	Self-reported exposure to marketing in drug stores is associated with 1.81 odds (95% CI: 0.8, 4.1) of current e-cigarette use.	–
	Exposure	Current use	Self-reported exposure to marketing in grocery stores is associated with 1.85 odds (95% CI: 0.89, 3.85) of ever e-cigarette use.	–
Peiper et al 2020	Exposure	Current use	Self-reported environmental marketing exposure, defined as e-cigarette advertisements in stores/billboards near home or school, was not associated with current e-cigarette use (aOR 0.98, 95% CI: 0.47-2.04).	–
Perez et al 2017	Exposure	Current use	Recall of any signs marketing e-cigarettes in stores was associated with current e-cigarette use in Harris (1.72, 95% CI:1.11-2.68; p<0.01) and Travis (2.35, 95% CI:1.22-4.55; p<0.01) counties.	↑
	Exposure	Current use	Recall any signs marketing e-cigarettes in stores was not associated with current e-cigarette use in Dallas/Tarrant county (1.31, 95% CI: 0.88-1.96).	–
Pesko et al 2017	Exposure	Current use	Any one-interval increase in self-reported exposure to tobacco advertisement (e.g., from "rarely see tobacco advertisements" to "sometimes" or "sometimes" to "most of the time") was not associated current e-cigarette use (OR 6.42, 95% CI: 2.28-18.11, p < 0.001; fixed effects model: OR 2.15, 95% CI:0.85-5.42) **(not stratified by ad type/location)**.	–
Pu et al 2017	Exposure	Current use	Self-reported exposure to e-cigarette advertisements in retail stores was associated with current use of e-cigarettes (AOR = 1.75, p < .05).	↑
Simon et al 2018	Exposure	Current use	Higher socioeconomic status was associated with greater exposure to e-cigarette advertising, and subsequently with a higher frequency of past-month use (**β** = 0.01, SE = 0, 95% CI:0.001, 0.010, p=0.02; B = 0.01, SE = 0.01, 95% CI:0.003, 0.022, p=0.01). **(not stratified by ad type/location)**.	↑

Policy				
Astor et al 2019	Availability	Current use	Those living in jurisdictions with the most restrictive tobacco retail policies had lower odds of past 30-day e-cigarette use between (OR 0.51; 95% CI 0.29–0.89) and follow-up (OR 0.45; 95% CI: 0.23-0.90) than those living in less restrictive jurisdictions.	↓
Azagba et al 2020	Availability	Current use	E-cigarette retail licensing policy in Pennsylvania was associated with a decrease in probability of e-cigarette use among adolescents, when compared to New York and Virginia (control states). PA, NY, and VA demonstrated a decline in the prevalence of e-cigarette use; however, PA had a greater decrease at 12.8 percent (from 24.14% in 2015 to 11.34% in 2017), while the prevalence in NY decreased by 7.2% (PA vs NY: **β** -0.052, SE(**β**) 0.020, p=0.01 and the prevalence in VA decreased by 5% (PA vs VA: **β** -0.074, SE(**β**) 0.018, p<0.0001).	↓
Du et al 2020	Availability	Current use	Policies prohibiting e-cigarette use in indoor areas (OR 0.95, 95% CI: 0.81-1.12; p < 0.001) were associated with a lower prevalence of current e-cigarette use for those age 18-24 years.	↓
	Availability	Current use	Policies requiring a license to sell e-cigarettes (OR 0.90, 95% CI: 0.80-1.01) were associated with a lower prevalence of current e-cigarette use.	↓
	Availability	Current use	Policies prohibiting the sale of tobacco-related products to those under age 21 (OR 0.80 95% CI: 0.59-1.07) were associated with a lower prevalence of current e-cigarette use.	↓
	Availability	Current use	Applying taxes to e-cigarettes (0.81, 95% CI: 0.68-0.97; p=0.02) was associated with a lower prevalence of e-cigarette use.	↓
	Availability	Current use	There was no association with prohibiting self-service displays of e-cigarettes (OR 1.00, 95% CI: 0.90-1.11; p=0.08) and current e-cigarette use.	–
Hawkins et al 2019	Availability	Current use	There were no associations between ENDS age restrictions (marginal effects -0.006, p=0.4) and e-cigarette use.	–
	Availability	Current use	There were no associations between early adoption (in 2010) of ENDS age restrictions (-0.011, p=0.5) and e-cigarette use.	–
	Availability	Current use	There were no associations between cigarette taxes (-0.013, p=0.1) and e-cigarette use.	–

	Availability	Current use	In states with smoke-free policies for traditional tobacco products, e-cigarette use was 3.8 percent higher (0.038, p < 0.001).	↑
Jun et al 2020	Availability	Current use	State laws defining e-cigarettes as tobacco products (OR 1.027 95% CI: 0.939-1.124) were not associated with current e-cigarette use.	–
	Availability	Current use	State laws restricting packaging (OR 1.015 95% CI: 0.933-1.104) were not associated with current e-cigarette use.	–
	Availability	Current use	State laws mandating a minimum sale age of 19+ (vs 18+) (OR 1.081, 95% CI:0.909-1.285) were not associated with current e-cigarette use.	–
	Availability	Current use	Restricted youth access (OR 0.930, 95% CI: 0.773-1.118) was not associated current e-cigarette use.	–
	Availability	Current use	State laws mandating retail licenses (OR 0.979, 95% CI: 0.897-1.068) were not associated with current e-cigarette use.	–
	Availability	Current use	Applying taxes to e-cigarettes (OR 0.964, 95% CI: 0.829-1.121) was not associated with current e-cigarette use.	–
	Availability	Current use	State laws mandating a minimum sale age of 21+ (vs 18+) (OR 0.986, 95% CI: 0.870-1.118) were not associated with current e-cigarette use.	–
Lee et al 2019	Availability	Current use	State aerosol-free policies were not associated with e-cigarette use (AOR = 1.00, 95% CI = 0.82, 1.21).	–
Macinko et al 2018	Availability	Current use	After New York City increased the minimum legal purchase age for tobacco and e-cigarette products, current e-cigarette use increased significantly in both New York City (2014: 6.85%, 95% CI: 5.70, 8.22; 2016: 14.9%, 95% CI:11.61, 18.92) and New York State (control) (2014: 8.1%, 95% CI: 5.82, 11.17; 2016: 14.06%, 95% CI: 10.01, 19.40) from 2014-2016.	↑*
Nguyen et al 2020	Availability	Current use	After provincial bans on e-cigarette sales to minors, youth e-cigarette use increased in all provinces in Canada between 2013 and 2017, however the increase was 3.1 percentage points (95% CI, 0.2-6.0; p=0.04) or 79% lower in provinces with a ban than those without.	↑
Pesko et al 2017	Availability	Current use	Cigarette taxes were negatively associated with e-cigarette use; however, this was not significant (aOR 0.94, 95% CI: 0.87-1.02).	–

Valentine et al 2019	Availability	Current use	Smoke-free municipal ordinances were not associated with any differences in current e-cigarette use (11.2% smoke-free ordinance vs 12.1% no ordinance, p = NS).	–
Retail				
Perez et al 2017	Density	Current use	Students attending schools in tobacco retailer hot spots of Dallas/Tarrant and Harris counties had a higher relative risk of current e-cigarette use **(no measure of association reported)**.	↑
	Density	Current use	There is not a clear pattern of associations of attending school in a tobacco retailer hotspot and current e-cigarette use in Travis County **(no measure of association reported)**.	–
Mantey et al 2019	Accessibility	Current use	Retail access (primarily acquiring e-cigarettes from in-person or online retailers) to e-cigarettes was statistically associated with moderate (10-29 days per month) (RRR: 2.11, 95% CI:1.11-4.03) or daily (30 days per month) (RRR: 5.81, 95% CI: 2.88-11.69) e-cigarette use compared to infrequent use (1-2 days per month). Retail access was not statistically associated with a change in RR of light e-cigarette use (3-9 days per month) (RRR 1.27, 95% CI: 0.86-1.87) relative to infrequent use.	↑
Bostean et al 2016	Availability	Current use	Presence of an e-cigarette retailer within 1/4 mile of a middle school (OR = 1.42, 95% CI: 0.82-2.46) and high school (OR = 0.96, 95% CI: 0.71-1.28) was not associated with current e-cigarette use among students.	–
Cole et al 2019	Availability	Current use	E-cigarette retailer availability (any within 500m: AOR 1.29, 95% CI: 0.71, 2.33; 1000m: AOR 1.01, 95% CI: 0.76, 1.34, 1500m: AOR 1.12, 95% CI:0.88, 1.42) around schools was not significantly associated with current e-cigarette use among students.	–
	Density	Current use	E-cigarette retailer density (each additional retailer within 500m: AOR 1.29, 95% CI:0.71, 2.33; 1000m: AOR 1.04, 0.89, 1.21; 1500m: AOR 1.03, 95% CI: 0.96, 1.10) around schools was not significantly associated with current e-cigarette use among students.	–
Giovenco et al 2016	Density	Current use	E-cigarette retailer density around schools was also positively associated with past month use of e-cigarettes (aPR = 1.06, 95% CI: 1.02, 1.10, p= 0.002).	↑
Trapl et al 2020	Density	Current use	Tobacco retail density was not associated with current e-cigarette use (1.00, 95% CI: 0.98-1.02).	–

	Exposure	Current use	Students who reported visiting retailers before/after school (1-2 times: 1.42, 95% CI 0.98-2.06; 3-4 times: 2.66, 95% CI: 1.79-3.96, p<0.05; everyday: 3.54, 95% CI: 2.32-5.41, p<0.05) had significantly greater odds of current e-cigarette use.	↑
	Proximity	Current use	Tobacco retail proximity (OR 0.84, 95% CI: 0.11-6.45) was not associated with current e-cigarette use.	–
Neighbourhood Social Characteristics				
Gewirtz O'Brien et al 2020	N/A	Current use	Prevalence of e-cigarette use was lowest among homeless youth attending city schools (37.7%; p=0.002) compared to suburban (39.5%; p=0.002), town (43.3%; p=0.002), and rural (40.7%; p=0.002) schools. E-cigarette use was higher for homeless youth attending town schools compared to suburban schools.	↓*
Noland et al 2018	N/A	Current use	Urban youth who currently smoke cigarettes were almost twice as likely to use e-cigarettes than cigarette smoking rural youth. Those attending urban schools who also smoke cigarettes were 86% more likely than those attending rural schools to also use e-cigarettes currently (95% CI: 1.02-3.40; p=0.043).	↓*
	N/A	Current use	For those that do not currently smoke cigarettes, there was no difference between the likelihood of urban and rural students to use e-cigarettes. Attending an urban school was associated with 0.86 times the odds of current e-cigarette use (95% CI: 0.58-1.28; p=0.46).	–
Pesko et al 2017	N/A	Current use	Prevalence of e-cigarette use increased more among urban youth (2011: 0.92%, CI: 0.65-1.18; 2014: 8.62% CI: 7.30-9.94; p<0.001) than rural (2011: 2.13%, CI: 1.15-3.11; 2014: 4.26%, CI: 1.80-6.71; p=0.05) between 2011 and 2014. Prevalence of current e-cigarette use among urban youth increased significantly between 2013 (2.42%, CI: 1.92-2.92; p<0.001) and 2014 (8.62%, CI: 7.30-9.94; p<0.001). Rural residency was not associated with e-cigarette use (aOR 0.80, 95% CI: 0.56-1.16).	↑
Wiggins et al 2020	N/A	Current use	There was no difference in rate of change in e-cigarette use between urban and rural middle or high school students. E-cigarette use increased over time among middle and high school students regardless of place of residence. E-cigarette use among middle school students is low in both urban and rural areas. However, rural middle school students were 1.3 times more likely to report past 30-day e-cigarette use than urban students (aRR=1.26, CI: 1.04-1.54).	↑

	N/A	Current use	There was no difference in e-cigarette use between urban and rural high school students (aRR=1.13, 95% CI: 0.97-1.35).	–
Author	**Interaction(s)**	**Outcome(s)**	**Results**	**Association**
			Ever use findings	
			Advertising	
Beleva et al 2019	Exposure	Ever use	Exposure to point-of-sale tobacco advertising was significantly associated with use of e-cigarettes. Share of advertising voice demonstrated a significant moderating effect, where an increased proportion of point-of-sale advertising for e-cigarettes increased the effect of point-of-sale exposure on the use of e-cigarettes (B = 0.27, SE = 0.07; p < .001).	↑
Camenga et al 2018	Exposure	Ever use	E-cigarette advertising exposure on billboards was not associated with e-cigarette use upon follow-up (OR 1.01, 95% CI: 0.45-2.26; p=0.98).	–
	Exposure	Ever use	Exposure to advertisements in malls was not associated with e-cigarette use upon follow-up (OR 1.73, 95% CI:0.98-3.06; p=0.06).	–
	Exposure	Ever use	Exposure to advertisements in convenience stores was not associated with e-cigarette use upon follow-up (OR 0.91, 95% CI:0.38-2.15; p=0.82).	–
	Exposure	Ever use	Exposure to e-cigarette advertisements in tobacco shops was not associated with e-cigarette use upon follow-up (OR 0.80, 95% CI:0.47-1.36; p=0.41).	–
Chen-Sankey et al 2019	Exposure	Ever use	Exposure to e-cigarette marketing was associated with higher odds of subsequent e-cigarette experimentation (aOR = 1.53; 95% CI: 1.07-2.17). In addition, a higher number of marketing exposure places was associated with e-cigarette experimentation (aOR = 1.17; 95% CI: 1.09-1.25).	↑
	Exposure	Ever use	Exposure to posters or billboard marketing was associated with 1.65 times the odds (95% CI: 1.14-2.40) of e-cigarette experimentation.	↑
Cho et al 2019	Exposure	Ever use	Non-current users (ever users) of traditional tobacco cigarettes and e-cigarettes were more likely to report exposure to e-cigarette advertisements in stores that sell cigarettes (AOR = 1.53, 95% CI: 1.37, 1.70) when compared to never users.	↑

	Exposure	Ever use	Non-current users (ever users) of traditional tobacco cigarettes and e-cigarettes were more likely to report exposure to e-cigarette advertisements in kiosks or temporary sales locations (AOR = 1.33, 95% CI: 1.19, 1.49) when compared to never users.	↑
	Exposure	Ever use	Self-reported exposure to e-cigarette advertisements on billboard or posters was not associated with e-cigarette use **(no measure of association reported)**.	–
D'Angelo et al 2021	Exposure	Ever use	Noticing an e-cigarette advertisement (AOR 1.03, 95% CI: 0.78-1.36) was not associated with ever e-cigarette use.	–
Dai et al 2016	Exposure	Ever use	Greater exposure to e-cigarette advertisements in retail stores was significantly associated with increased odds of former e-cigarette use (aOR = 1.4; p < 0.01).	↑
Giovenco et al 2016	Exposure	Ever use	Self-reported exposure to e-cigarette advertisements within 1/2 mile of school (aPR = 1.01, 95% CI: 1.00, 1.02; p=0.084) was consistently associated with the probability of ever e-cigarette use.	↑
Lee et al 2017	Exposure	Ever use	Retail advertising exposure was associated with 1.24 RRR (95% CI: 1.03, 1.50; p < 0.05) of being at "early majority" (ever use, but not in past 30 days) level of e-cigarette use acceptability. Retail advertising exposure was associated with 1.12 odds (95% CI: 0.90, 1.40) of transitioning from "late majority" (intending to try e-cigarettes) to "early majority" (ever use/trying e-cigarettes but did not use in past 30 days).	↑
Loukas et al 2019	Exposure	Ever use	Recall of retail e-cigarette marketing as baseline was associated with higher odds of subsequent e-cigarette initiation among youth (12-17 years) (aOR = 1.99, 95% CI: 1.25-3.17) and young adults (18-29 years) (aOR = 1.30, 95% CI: 1.05-1.61).	↑
Nicksic et al 2017	Exposure	Ever use	The odds of ever e-cigarette use was 1.51 times higher at baseline for students who recalled advertisements in retail stores compared to those who did not (95% CI: 1.07-2.15; p<0.05). There was also a 1.14 increase in odds at baseline for each recall of an advertisement (95% CI: 1.04-1.25; p<0.05). For students who recalled retail store advertisements at baseline, the odds of ever e-cigarette use was 2.99 times higher at follow-up compared to those who did not recall the advertisements (95% CI: 1.50-5.97; p<0.05).	↑
Pasch et al 2018	Exposure	Ever use	Recall of e-cigarette marketing in any type of retail store at baseline predicted ever e-cigarette use at 6-month follow-up (AOR = 2.71, 95% CI: 1.36, 5.4; p<0.05).	↑

	Exposure	Ever use	Exposure to point-of-sale e-cigarette marketing in convenience stores was associated with 2.82 odds (95% CI: 1.4, 5.66; p<0.05) of ever e-cigarette use.	↑
	Exposure	Ever use	Exposure to marketing in drug stores was associated with 3.31 odds (95% CI: 1.36, 8.03; p<0.05) of ever e-cigarette use.	↑
	Exposure	Ever use	Exposure to marketing in grocery stores was associated with 3.95 odds (95% CI: 1.65, 9.46; p<0.05) of ever e-cigarette use.	↑
Giovenco et al 2016	Volume (Density?)	Ever use	The volume of e-cigarette advertisements (# of total e-cig ads x the proportion of all tobacco ads that were for e-cigs within 1/2 mile of school: aPR=1.02, 95% CI: 0.99,1.05; p=0.141) was not associated with the probability of ever e-cigarette use.	–
			Policy	
Astor et al 2019	Availability	Ever use	Those living in jurisdictions with the most restrictive tobacco retail policies had lower odds of e-cigarette initiation between baseline and follow up than those living in less restrictive jurisdictions (OR 0.74; 95% CI: 0.55-0.99). When adjusting for time since turning legal purchase age (18 years) at follow-up, there was no change in the effect of living in a restrictive jurisdiction ("results not shown").	↓
Borodovsky et al 2017	Availability	Ever use	Longer duration of legal cannabis laws (>10 years) (OR 2.82, 95% CI: 2.24, 3.55) was associated with an increased likelihood of trying vaping cannabis.	↑
Jun et al 2020	Availability	Ever use	Among those 18-24 years, state laws defining e-cigarettes (OR 0.951, 95% CI: 0.899-1.006) was not significantly associated with ever e-cigarette use (for the entire adult population, all state e-cigarette regulations were associated with decreased e-cigarette use).	–
	Availability	Ever use	Restricting youth access (OR 0.962, 95% CI: 0.856-1.081) was not associated with ever e-cigarette use.	–
	Availability	Ever use	Packaging regulation (OR 0.964, 95% CI: 0.915-1.016) was not associated with ever e-cigarette use.	–
	Availability	Ever use	Non-sales taxation (OR 0.945, 95% CI: 0.861-1.036) was not associated with ever e-cigarette use.	–
	Availability	Ever use	Minimum sale age of 21+ (vs 18) (OR 0.927, 95% CI: 0.860-1.001) was not associated with ever e-cigarette use.	–

	Availability	Ever use	Retail licensing (OR 0.942, 95% CI: 0.898-0.994; p<0.05) was associated with decreased ever use.	↓
	Availability	Ever use	Minimum sale age of 19+ (vs 18) (OR 0.715, 95% CI:0.637-0.802; p<0.001) was associated with decreased ever use.	↓
	Availability	Ever use	States with all 5 e-cigarette regulations had lower rates of ever e-cigarette use for those 18-24 years than states with no regulation (42.1%, statistically significant in χ^2 analyses p<0.001, while in those with no regulations it was 42.6%). However, only one state had all 5 regulations.	↓
			Retail	
Bigwanto et al 2019	Accessibility	Ever use	Accessibility to a vape shop was not independently associated with higher odds of e-cigarette use (AOR 0.92, 95% CI: 0.50-1.69; p=0.786).	–
D'Angelo et al 2021	Accessibility	Ever use	Frequent convenience store access was associated with e-cigarette use after 2 years. Youth who visited a convenience store 1-3 times in 30 days (vs never) had 1.48 times the odds of e-cigarette initiation (OR 1.48 95% CI: 1.03-2.12). Youth who visited a convenience store at least weekly (vs never) had 1.79 times the odds of e-cigarette initiation (95% CI: 1.29-2.48).	↑
Best et al 2016	Availability	Ever use	Those who recalled seeing e-cigarettes in small shops (OR 2.89, 99% CI:2.36-3.54) and supermarkets (OR 2.56, 99% CI: 1.89-3.47) were more likely to have tried e-cigarettes.	↑
Bostean et al 2016	Availability	Ever use	Presence of an e-cigarette retailer within 1/4 mile of a middle school predicted ever e-cigarette use among students (OR = 1.70, 95% CI: 1.02-2.83).	↑
	Availability	Ever use	Presence of an e-cigarette retailer within 1/4 mile of a high school was not associated with ever e-cigarette use among students (OR = 1.02, 95% CI: 0.81-1.29).	–
Cole et al 2019	Availability	Ever use	E-cigarette retailer availability (any within 500m: AOR 1.04, 95% CI:0.68,1.60, any within 1000m: AOR 0.92, 95% CI:0.75,1.13; any within 1500m: AOR 1.01, 95% CI:0.85,1.20) was not significantly associated with ever e-cigarette use among students.	–
	Density	Ever use	E-cigarette retailer density around schools (each additional retailer within 500m: AOR = 1.04, 95% CI:0.68, 1.60; 1000m: AOR = 0.98, 95% CI:0.88, 1.10; 1500m:	–

			AOR 1.00, 95% CI:0.95, 1.05) was not significantly associated with ever e-cigarette use among students.	
Borodovsky et al 2017	Density	Ever use	Higher cannabis dispensary density (>/= 1 per 100k people) (OR: 2.68, 95% CI: 2.12, 3.38) was associated with an increased likelihood of trying vaping cannabis.	↑
Giovenco et al 2016	Density	Ever use	E-cigarette retailer density around schools was consistently associated with the probability of ever e-cigarette use (aPR= 1.04, 95% CI:1.02, 1.07; p=0.001).	↑
King et al 2020	Density	Ever use	Waterpipe cafés (OR 2.1, 95% CI:0.5, 8.2), vape shops (OR 0.6, 95% CI:0.1, 3.0), and traditional tobacco retailer (OR 1.1, 95% CI:0.8, 1.5) density (per 1000 pop [tract level]) were not associated with past 6-month e-cigarette use.	–
	Proximity	Ever use	Proximity to nearest waterpipe café in miles driving (OR 0.98, 95% CI:0.96, 1.01), proximity to nearest vape shop (OR 0.9, 95% CI:0.9, 1.01), and proximity to nearest traditional retailer (OR 0.9, 95% CI: 0.7, 1.2) were not associated with past 6-month e-cigarette use.	–
Neighbourhood Social Characteristics				
Shih et al 2017	N/A	Ever use	Perceived neighbourhood problems with alcohol/drugs was associated with higher odds of past year e-cigarette use (OR 1.25, 95% CI: 1.13, 1.38; p<0.001).	↑
	N/A	Ever use	Perceived neighbourhood disorganization was associated with higher odds of past year e-cigarette use (OR 1.59, 95% CI: 1.29, 1.96; p<0.001).	↑
	N/A	Ever use	Perceived increased neighbourhood cohesion was significantly associated with lower odds of past-year e-cigarette use (OR 0.83, 95% CI: 0.7, 0.97; p<0.05).	↓
	N/A	Ever use	Objectively measured neighbourhood socioeconomic disadvantage was not significantly associated with e-cigarette use (OR 1.01, 95% CI: 0.85, 1.19).	–

↑ Statistically greater e-cigarette use
↓ Statistically lower e-cigarette use
– Not significant
* Association is contrary to hypothesis
N/A: Not applicable

2.5 Discussion

To our knowledge, this is the first systematic review to examine the relationship between elements of the neighbourhood environment and e-cigarette use among young people. Although e-cigarette use is an emerging research area, there is a substantial body of literature exploring how it relates to neighbourhood characteristics, most of which has been published since 2016.

2.5.1 Advertising

Although the overall findings for this review were mixed, the impact of advertising demonstrated significantly greater current and ever use. Only one study in this review used an objective measure of advertising exposure. Giovenco et al. (2016) calculated the volume of e-cigarette advertisements within a half mile of schools (i.e., advertising density) to estimate potential exposure and found an association with significantly greater e-cigarette use (Giovenco et al., 2016). It should be noted that all other studies relied on self-reported exposure data. While research has demonstrated a moderate association between more objective measures of exposure and self-reported exposure of retail advertising of traditional cigarettes (Henriksen, Schleicher, Feighery, & Fortmann, 2010; Fong, et al., 2006), self-reported data presents the potential for biases. For example, Loukas et al. (2019) explained that self-reported exposure may include informational content, rather than just advertisements. In addition, self-reported exposure mostly demonstrates conscious exposure (Loukas et al., 2019), in which many experiences of exposure may not be recalled and are difficult to count (Nicksic et al., 2018; Shiffman, Stone, & Hufford, 2008). Young people who use e-cigarettes would presumably be more likely to observe e-cigarette advertising while purchasing the devices and more likely to be captivated by the advertisements (Collins, Glasser, Abudayyeh, Pearson, & Villanti, 2019). Given this, a correlation between self-reported advertising exposure and e-cigarette use would be likely.

Four of the studies examined multiple types of advertisements in addition to built environment advertising (e.g., retail or billboard) exposure (Simon et al., 2018; Kreitzberg et al., 2019a; Kreitzberg et al., 2019b; Papaleontiou et al., 2020; Pesko et al., 2017; Hammond et al., 2020); however, they did not stratify the results by type or location of advertisement. Various marketing methods may have differential impact on e-cigarette use (Loukas et al., 2019; U.S. Department of Health and Human Services, 2016). As a result, the findings of built environment advertisement exposure are complicated by other advertisements, such as TV/movies, Internet, newspaper/magazine, etc. This underscores the importance of evaluating marketing channels individually (Loukas et al., 2019). Previous research identified that retail advertising exposure is the most common marketing channel, closely followed by Internet or TV/movie advertisements (Papaleontiou et al., 2020; Singh, et al., 2016; Krishnan-Sarin, Morean, Camenga, Cavallo, & Kong, 2015), and therefore, retail may have a substantial role on the association. The relationship between neighbourhood-level exposures to e-cigarette advertising and e-cigarette use among young people demonstrates the need for further research using objective measures to inform advertisement regulation and reduce potential negative health impacts for young people.

2.5.2 Policy

There were various types of policies studied in this review, such as those that restrict e-cigarette use (e.g., e-cigarette age restrictions, retail licenses, and taxation) and those that restrict other types of substance use (e.g., traditional cigarette taxes and age restrictions). Most policies were not significantly associated with current or ever e-cigarette use among young people. Of the policies that were significantly associated with e-cigarette use, many demonstrated a significant decrease in e-cigarette use after the policy was initiated, or significantly lower odds of e-cigarette use in jurisdictions that implemented policies. The results are difficult to compare given the differing policies. Two policies – smoke-free policies for traditional tobacco products (Hawkins et al., 2019) and duration of cannabis legalization (Borodovsky et al., 2017) – were associated with a significant increase in e-cigarette use as expected. When there are policies limiting where people can smoke traditional cigarettes, e-cigarettes may be an acceptable substitute as a legal method of substance delivery. In addition, a longer duration of legal cannabis laws means the substance has been legal for longer allowing for more opportunity for marijuana e-cigarette use. One finding contradicted a key hypothesis. Current e-cigarette use increased in New York City after the introduction of a minimum purchase age for tobacco and e-cigarettes, but this also occurred in the control group (Macinko et al., 2018).

Small sample sizes may be an explanation for the lack of significant findings in many studies (Jun & Kim, 2021). In addition, as the health impacts of e-cigarettes have been largely unknown, regulatory policies are still changing and emerging, making it difficult to assess their longer-term impact on e-cigarette use of young people. Given that policies limiting retail access to traditional cigarettes are associated with a decrease in tobacco sales and retailer density (Coxe, et al., 2014; Myers, Hall, Isgett, & Ribisl, 2015; Luke, et al., 2017; Chen & Forster, 2006), similar and multi-level policies that address e-cigarettes may be an effective method of reducing use among young people (Azagba et al., 2020). Additionally, policymakers need to consider the unintended consequences of regulating substances, whereby people may adopt other substances to evade new policies.

2.5.3 Retail

A roughly equal number of studies found that interaction with retailers was associated with either a significant increase in odds of current and ever e-cigarette use or a non-significant outcome. Given this, the hypothesis that interaction with e-cigarette retailers is associated with greater e-cigarette use cannot be confirmed. The studies used different methods of measuring interaction with retailers, including exposure, accessibility, proximity, and density. It is difficult to compare the interactions as some may have a different effect than others. In addition, like self-reported exposure to advertisements, some studies relied on self-reported data for interactions such as exposure and accessibility, introducing the potential for bias.

Local small shops may be significant as a source of e-cigarette retail exposure because they are frequently visited by young people and are an influential part of their environments (Best et al., 2016). Retailers, such as convenience stores, gas stations, and specialty vape shops, are reported by youth to be the most common locations for vape advertisement exposure, especially in jurisdictions with less regulations (Cho, Thrasher, Reid, Hitchman, & Hammond, 2019). Given this, retail displays may normalize e-cigarettes to young people, making them seem socially acceptable and harmless, which has been observed with traditional tobacco cigarettes (Brown & Moodie, 2009). Additionally, exposure to e-cigarette retail makes their accessibility known to young people, which has also been documented in traditional tobacco smoking literature (Doubeni, Li, Fouayzi, & DiFranza, 2008). Research has demonstrated that restrictions on vaping advertisements in retail settings can significantly reduce vaping advertisements around secondary schools and thus reduce the potential for young people to be exposed to vaping promotions (Martin, et al., 2021).

When e-cigarettes first emerged, they were primarily sold on the internet, but once the market for the devices expanded with lack of regulation, they became more available in traditional retail stores and sales grew most for conveniences stores (Giovenco, Hammond, Corey, Ambrose, & Delnevo, 2015). In many jurisdictions, however, there are age restrictions to purchase e-cigarettes and if enforced, this may limit those under the legal age to purchase e-cigarettes at typical retailers. Research has shown that minors can and do easily circumvent age restrictions by purchasing e-cigarettes online, where vendors have not implemented age-verification methods (Williams, Derrick, & Ribisl, 2015). Therefore, internet e-cigarette retailers may be a more convenient method of accessing e-cigarettes for minors than retailers in the neighbourhood environment. Social sources may also be a more convenient method of obtaining e-cigarettes, as acquisition through friends was reportedly the most common source of acquisition (Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2017).

The findings may be complicated by the types of e-cigarette retailers included in the studies. Some studies only examined specialty retailers (Bostean et al., 2016), when e-cigarettes are also commonly sold in convenience stores and gas stations. In addition, studies may be limited by the methods in which researchers obtained e-cigarette retail locations, such as online search engines (Cole et al., 2019), which may not capture all types of retailers.

Despite the mixed results of the relationship between interaction with retailers and e-cigarette use, a previous review identified a correlation between density and proximity of tobacco retailers and adolescent smoking (Gwon, DeGuzman, Kulbok, & Jeong, 2017). It is possible with more research using objective measures, e-cigarette use may have the same association. For this reason, further regulation of e-cigarette retail in young people's environments is warranted.

2.5.4 Neighbourhood Social Characteristics

Several neighbourhood social characteristics were examined for their relationship with e-cigarette use. Urbanicity demonstrated mixed results. Although rural communities have less dense built environments, and therefore fewer retail and outdoor advertisements, the tobacco industry has adopted more sophisticated marketing methods that transverse locations (e.g., social media, TV, and movies). In addition, due to economic pressures, rural communities may be less likely than urban communities to introduce smoke-free policies (American Lung Association, 2012). If this is also true for e-cigarette related policies, rural residents may be subject to less restrictions for advertisements, purchasing, and using e-cigarettes. Given this, urbanicity may not be a critical environmental influence of e-cigarette use.

Only one article examined ever-use and various neighbourhood social characteristics (Shih et al., 2017). Perceived negative social characteristics were associated with greater odds of e-cigarette use, while perceived positive social characteristics were associated with less e-cigarette use. However, the single objectively measured neighbourhood socioeconomic disadvantage was not associated with e-cigarette use. It might be that adolescents' perceptions of their neighbourhood's social characteristics are more influential in e-cigarette use than census derived socioeconomic measures. However, with a lack of research on this element of young people's environments, it is difficult to draw conclusions. Nevertheless, multi-level interventions should be introduced to establish greater social cohesion in neighbourhoods (Shih et al., 2017).

2.5.5 Strengths and Limitations

This systematic review was comprehensive with a search of 8 databases, generating 8,625 initial results. Full-text screening and data extraction was conducted independently by two researchers, strengthening the rigour of the screening and inclusion process.

Moreover, the inclusion criteria were comprehensive. With a broad context of the neighbourhood environment, the review comprised various elements of the environment. Various groups of young people were included in the review (i.e., adolescents and youth), allowing the findings to be more applicable to a larger population. Finally, the review applied a global scope, thus reviewing studies from multiple countries.

There are several limitations that should be considered when evaluating the results. First, studies in languages other than English were not included and most studies were in the US, Canada, or the UK, producing a more western-centric review, and thus limiting its generalizability. Qualitative studies were not included because they could not be compared with quantitative results. However, examining qualitative studies would complement the quantitative findings, giving a more thorough understanding of neighbourhood influences of e-cigarette use.

Since the definition of neighbourhood was applied broadly for the sake of this review, elements of the neighbourhood environment identified for potential influence on e-cigarette use may not have occurred within the home neighbourhood of the young person. As such, there was no standardized definition of neighbourhood used in the literature. Neighbourhood may be defined differently depending on location or population density (e.g., rural areas). Many papers did not mention the term neighbourhood or make explicit that the interactions of study occurred within the neighbourhood environment. Some studies focused on school neighbourhoods rather than home neighbourhoods, which may have a different impact.

Second, all studies are based on self-reported e-cigarette use, rather than biometric validation. A study of the validity of self-reported traditional cigarette smoking in adolescents revealed that self-reported smoking was an accurate measurement (Wong, Shields, Leatherdale, Malaison, & Hammond, 2012). Regardless, it is possible that rates of e-cigarette use are underreported, as participants may be reluctant to admit to their use due to fear of punishment or stigmatization. On the contrary, e-cigarette use could be overreported as participants may report use if it is socially acceptable or cool regardless of actual use. Due to the rapidly changing discourse used to refer to e-cigarettes, participants may misunderstand survey questions and as a result, may not report true e-cigarette use (Cole et al., 2019). Similarly, the studies included in this review may use slightly different terminology for e-cigarettes making it difficult to corroborate findings. For example, some studies refer to e-cigarettes as electronic nicotine delivery systems (ENDS) and this term may encompass devices such as hookah pens or e-pipes, which are not considered e-cigarettes or included in most other studies. In addition, this study does not look at frequency of use beyond “ever use” and “current use (i.e., past 30 days)” because very few studies examined additional measures of frequency. Next, as this review did not conduct a quality assessment, some studies included may be of low quality. Finally, many studies rely on cross-sectional data in which causal inferences cannot be deduced.

Overall, this review examines factors within the neighbourhood environment that could be predisposing young people to use e-cigarettes. More research using objective measures of interactions is imperative. Longitudinal studies should be conducted to evaluate the long-term impact of policies, interventions, and interactions within the neighbourhood environment. Furthermore, given the mixed results, a meta-analysis could be carried out to enhance the precision of the effect estimates by pooling the quantitative data for more statistical power. Identifying potentially influential elements of the neighbourhood environment will aid in formulating policies to intervene, potentially reducing e-cigarette use among young people and thus promoting health.

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Chapter 3

3 Distribution of E-Cigarette Retailers: A Southwestern Ontario Case Study

3.1 Abstract

Youth e-cigarette use is an increasingly popular phenomenon that has become a public health concern. There is a lack of evidence of the long-term impacts, however concerns have arisen that e-cigarette use may lead to respiratory illness and nicotine dependency, harming brain development among children and youth. Studies have demonstrated that geographic accessibility to e-cigarette retailers may be associated with higher use. Given that schools are a significant context in children's daily lives, the e-cigarette retail environment surrounding schools may influence e-cigarette use among students. Studies have demonstrated that imposing policies restricting e-cigarette sales within certain distances of schools would reduce the number and density of e-cigarette sales. The current research on geographic accessibility is typically limited by examining different types of retailers together. In addition, many studies rely on retail locations obtained from online search engines, which may not capture all types of retailers. This research has two objectives. The first is to understand how e-cigarette retailers are geographically distributed throughout Middlesex, Oxford, and Elgin counties, in relation to school locations and neighbourhood characteristics. The second is to understand how policies restricting the locations of e-cigarette retailers around schools may reduce potential youth access and make the distribution of e-cigarette retailers between neighbourhoods more equitable. The relationship between the distribution of e-cigarette retailers and educational attainment, low-income households, lone parent households, and visible minority status correlated with larger effect sizes at greater distances from schools. Effect sizes were not as strong for specialty retailers, but similar patterns occurred. When simulating policies eliminating e-cigarette retailers within 500m and 1000m of schools, the distribution of retailers across quintiles is substantially reduced. As e-cigarette use among youth is a growing health concern, more research is critical to formulate effective and equitable policies to protect youth from potential health risks.

3.2 Background

Youth e-cigarette use (also known as ‘vaping’) has rapidly become a public health concern in Canada. Vaping is a recent phenomenon that involves inhaling an aerosol that is produced by a vaporizing device, such as an electronic cigarette (also referred to as an e-cigarette, vape, or vapour product) (Health Canada, 2019a). The device heats a liquid into a vapour, which often contains flavouring and varying levels of nicotine or tetrahydrocannabinol (THC) (Health Canada, 2019a). When vaporizing devices first emerged on the market in 2007, they were marketed by tobacco companies as a method of smoking cessation (Jones & Salzman, 2020). However, e-cigarette use among non-smoking children and youth has significantly increased in recent years. During the 2018-19 school year, 20% of Canadian students in grades seven to twelve had used an e-cigarette in the past 30 days, which doubled from ten percent in 2016-17 (Health Canada, 2019b). In 2020, among youth 15-19 years of age, fourteen percent reported having used an e-cigarette in the past 30 days, while thirty-five percent reported having ever used an e-cigarette (Health Canada, 2021).

While there is a lack of evidence of the long-term impacts, concerns have arisen that e-cigarette use may lead to nicotine dependency and respiratory illness among children and youth (Yuan, Cross, Loughlin, & Leslie, 2015; England, Bunnell, Pechacek, Tong, & McAfee, 2015; Miyashita & Foley, 2020). E-cigarette use may also have harmful effects on brain development, impacting memory, cognition, learning, mental health, and behaviour (Tobore, 2019). In addition, children and youth exposed to nicotine may be more susceptible to other substance use in the future (Yuan, Cross, Loughlin, & Leslie, 2015). A recent meta-analysis found that vaping in non-smoking youth was associated with a significant increase in smoking traditional cigarettes (Khouja, Suddell, Peters, Taylor, & Munafò, 2020). This puts them at risk of other health effects associated with tobacco smoking, such as cancer, stroke, and heart and lung diseases (Centers for Disease Control and Prevention, 2010).

3.2.1 E-cigarette Retail Regulation

In Canada, e-cigarettes are regulated at the federal level by the Tobacco and Vaping Products Act (TVPA). The TVPA allows the federal government to regulate industry reporting, manufacturing standards, product and package labelling, ingredients and flavours, and promotion of vaping products. The TVPA prohibits vaping products from being sold or given to anyone under the age of 18 years and from being sold in a way that appeals to youth. The TVPA permits e-cigarettes to be sold only in specialized shops, such as e-cigarette retailers or cannabis dispensaries, and as of May 2018, they can also be sold in non-specialized tobacco retailers, such as convenience stores and gas stations (Health Canada, 2020). This regulatory change led to the dramatic increase in retail access to e-cigarettes.

At the provincial level, the Smoke-Free Ontario Act (SFOA) regulates the sale, supply, promotion, and use of vaping products, as well as enforcement and offences. In Ontario, one must be 19 years of age to purchase e-cigarettes. As of July 1, 2020, flavoured e-cigarettes can only be sold in specialty e-cigarette retailers or licensed cannabis dispensaries, apart from menthol, mint, and tobacco flavoured products (Government of Ontario, 2020). In addition, retail establishments other than specialty e-cigarette retailers are prohibited from selling e-cigarettes with a nicotine concentration greater than 20 milligrams per milliliter (Government of Ontario, 2020). The SFOA also prohibits retailers from displaying promotions of e-cigarettes that are visible from outside their store (Government of Ontario, 2020).

3.2.2 Geographic Accessibility

While little is known of the predictors of youth e-cigarette use in Canada, it is likely that, similar to smoking (East, Hitchman, McNeill, Thrasher, & Hammond, 2019; Jayakumar, O'Connor, Diemert, & Schwartz, 2020), various personal and environmental factors may be associated with youth e-cigarette use. Geographic accessibility to e-cigarette retailers may be associated with higher use, as found in studies of proximity and density of tobacco retailers (Chan & Leatherdale, 2011; Gwon, DeGuzman, Kulbok, & Jeong, 2017). In addition, those who reside in areas of high tobacco retailer density may have greater exposure to tobacco advertisements in retail settings, promoting higher demand and use of the products (Loomis, et al., 2012). The few existing Canadian studies examining geographic accessibility of retailers focus on specialty e-cigarette shops and are limited by a lack of data of where e-cigarettes are sold (Cole, Aleyan, & Leatherdale, 2019; Robitaille, Bergeron, & Houde, 2019). A review of U.S. studies on the sale and marketing practices of e-cigarette retailers found that they were often located in proximity of elementary and secondary schools, colleges, and universities (Lee, Orlan, Sewell, & Ribisl, 2018). Given that schools are a significant context in children's daily lives, the retail environment surrounding schools may influence e-cigarette use. A study of e-cigarette marketing near schools and e-cigarette use among youth found that e-cigarette retailer density was associated with the probability of ever using an e-cigarette (Giovenco, et al., 2016a). Previous research has demonstrated that density of tobacco retailers within a defined geographic area around a school or neighbourhood is associated with tobacco use among those who attend school or reside in the area (Marsh, et al., 2021; Valiente, et al., 2021).

The current literature regarding e-cigarette retailer locations in relation to schools and e-cigarette use among youth has demonstrated mixed findings. Cole et al. (2019) found that density and proximity of specialty e-cigarette retailers around schools were not significantly associated with ever or current use of e-cigarettes. However, Giovenco et al. (2016a) found that e-cigarette retailer density within a half-mile of high schools was associated with ever and current e-cigarette use. While Bostean et al. (2016) found this to be true only for presence of a specialty e-cigarette retailer within one-quarter mile of middle schools but not high schools. Given the lack of consistency in such findings, the impact of zoning ordinances to limit e-cigarette retailer exposure and accessibility and thus e-cigarette use may be complicated.

The current research on geographic accessibility is typically limited by examining only one retailer type, such as specialty retailers, rather than all retailers that sell e-cigarettes. In addition, many studies rely on retail locations obtained from online search engines, which may not capture all types of retailers. There is a critical need for improving research on geographic accessibility to inform the development of effective policies to limit the impacts of vaping on youth.

3.2.3 Policy

Several policy solutions have been implemented in various jurisdictions to limit the exposure of tobacco retailers to young people, such as licensing and zoning ordinances. One study in North Carolina, USA of various policy scenarios found that implementing policies to restrict tobacco sales in pharmacies, within 1000ft of schools, and/or within 500ft of another tobacco retailer would significantly reduce the number and density of tobacco retailers (Myers, Hall, Isgett, & Ribisl, 2015). Another study found that imposing a licensing fee for tobacco retailers in Santa Clara County resulted in an immediate reduction in retailers, as well as their density and proximity to schools (Coxe, et al., 2014). An Israeli study found that limiting points of sale of two e-cigarette types (IQOS and JUUL) within 400m of schools would reduce exposure to IQOS retailers for 54% of schools and 35% of schools to JUUL retailers. Limiting retailers within 100m would only impact exposure for 8% of schools to IQOS retailers and 4% of schools to JUUL retailers. There is currently a gap in the literature assessing equity implications of policies limiting the sale of e-cigarette retailers around schools.

This research seeks to answer two questions. The first is how are e-cigarette retailers geographically distributed throughout Middlesex, Oxford, and Elgin counties, in relation to school locations and neighbourhood characteristics? The second is how might policies restricting the locations of e-cigarette retailers around schools reduce potential youth access and make the distribution of e-cigarette retailers between neighbourhoods more equitable?

3.3 Methods

3.3.1 Study Area

This study was conducted in three counties of Southwestern Ontario, Middlesex, Oxford, and Elgin counties, and the single-tier municipalities within this area (i.e., City of London, City of St. Thomas) (Figure 3). The main outcomes of this study were the availability, proximity, and density of e-cigarette retailers within 100m-1600m of each school, as well as the impact of two policy scenarios limiting retailers within 500m and 1000m of schools.

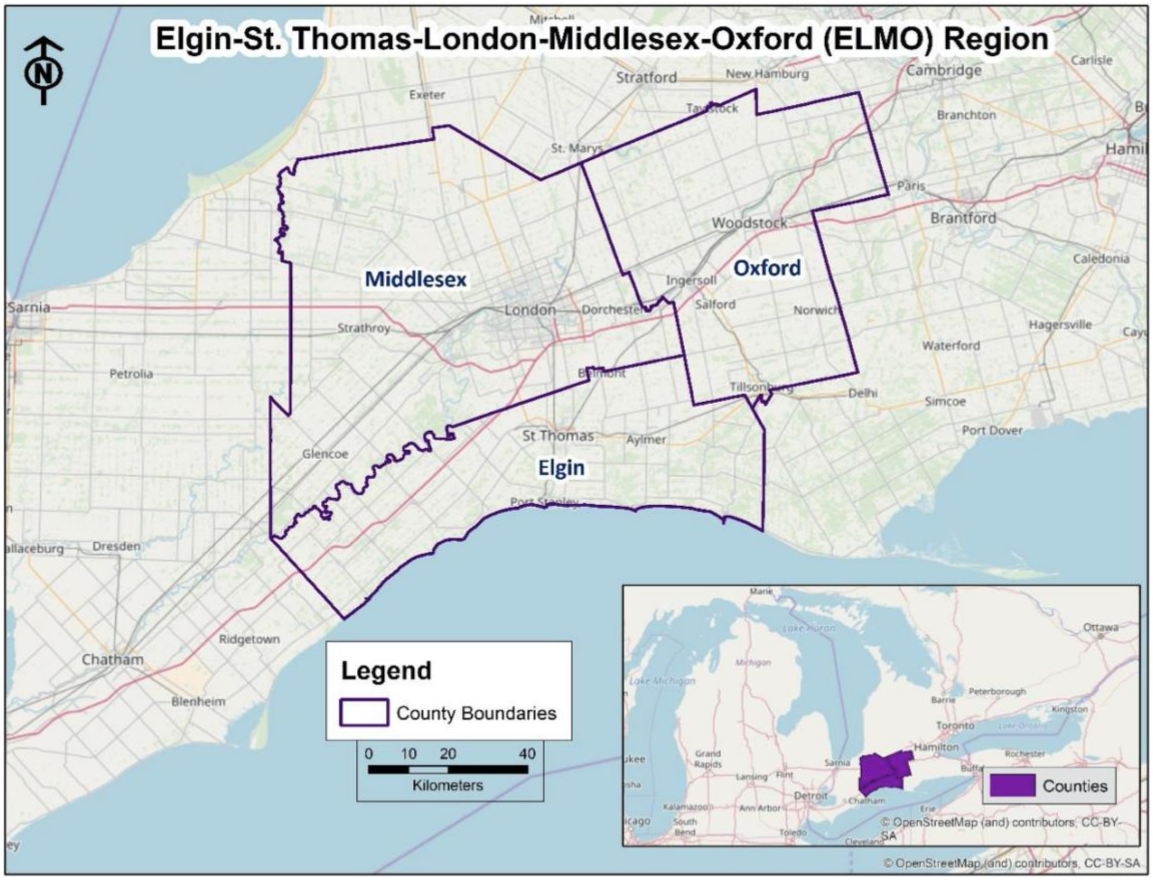

Figure 3: Study Area (Buttazzoni, 2018)

3.3.2 Data Sources

3.3.2.1 Retailers

The locations of retailers were obtained in August 2021 from the regional public health units representing the area, Middlesex London Health Unit and Southwestern Public Health. All e-cigarette retailers must be registered with the local public health unit. E-cigarette retailers (n=359) were identified as any retailers that are permitted to sell e-cigarettes, such as convenience stores, gas stations, and specialty shops. Additionally, specialty shops (n=26) were identified as a sub-classification due to differences in regulation. Specialty e-cigarette retailers are retail establishments that primarily sell e-cigarettes and as such, are exempt from certain display, promotion, and product sampling restrictions that apply to other e-cigarette retailers (Government of Ontario, 2020).

3.3.2.2 Schools

School locations were obtained from the Ontario Ministry of Education by obtaining all school addresses from school boards within the study area (from London District Catholic School Board, Thames Valley District School Board, Conseil scolaire Viamonde, and Conseil scolaire catholique Providence) which yielded 187 elementary schools and 44 secondary schools. Retailer and school locations were geocoded and mapped using ArcGIS Pro (Version 2.3, ESRI Canada Ltd.).

3.3.3 Measures

3.3.3.1 Neighbourhood Characteristics

Data were obtained for neighbourhoods around the schools from the 2016 Census through Statistics Canada (2017) for all Dissemination Areas (DA) within the study area and adjusted based on a proportion of the population from each DA within 800m of the school. Specifically, these measures included: percentage of adults in the DA who have not completed a university degree or higher, percentage of households in the DA that fall below the low-income cut-off after taxes (LICOAT), percentage of family households in the DA headed by lone parents, and percentage of the DA population that identifies as visible minority. Such variables were chosen as they demonstrate sociodemographic and socioeconomic characteristics of the population of Southwestern Ontario and represent fundamental social determinants of health (Gilliland, 2012). Percentage of adults in the DA who have not completed a university degree or higher was chosen as a variable as people with higher educational attainment tend to have better health outcomes (Cutler and Lleras-Muney, 2007). Previous research has demonstrated an association between educational attainment and density of e-cigarette retailers (Dai, Hao, & Catley, 2017). Percentage of households in the DA that fall below the LICOAT was chosen as a variable as it represents people who may have difficulty affording necessities. Previous research has demonstrated mixed results regarding its association with the distribution of e-cigarette retailers (Elbaz, Zeev, Berg, Abroms, & Levine, 2021; Venugoapl, Morse, Tworek, & Change, 2020). There is a lack of literature examining the distribution of e-cigarette retailers and percentage of family households headed by lone parents. However, this variable can be a significant indicator of socioeconomic status, as lone parent households are dependent on a single income and are thus, more likely to be low-income (Campbell, Thomson, Fenton, & Gibson, 2016). In addition, lone parenthood has also been associated with decreased physical and psychological health among family members (Pérez & Beaudet, 1999), making it a key social determinant of health. Percentage of the DA population that identifies as visible minority was chosen as a variable as in Canada, visible minorities are more likely to live in poverty and have greater health risks when compared to other Canadians (Galabuzi, 2004). Previous literature has demonstrated an association between the density of e-cigarette retailers and visible minority populations (Venugopal et al., 2020). Data on level of urbanicity was obtained from the Human Environments Analysis Laboratory which classifies each DA as either urban, suburban, rural small town, or rural.

To determine the distribution of retailers in relation to neighbourhood characteristics, schools were sorted and grouped into quintiles by each sociodemographic and socioeconomic measure (percent no post-secondary education, LICOAT, lone parent household, and visible minority) using IBM SPSS (version 28.0.1.0). Quintile 1 consisted of schools in the lowest percentage of the given sociodemographic or socioeconomic measure (least disadvantaged) and Quintile 5 consisted of schools in the highest percentage of the sociodemographic or socioeconomic measure (most disadvantaged).

3.3.3.2 Count of e-cigarette retailers

Buffer zones around each point of interest (i.e., schools) were created with distances ranging from 100m to 1600m. A service area buffer (i.e., a street network), was used for all distance increments from 100m to 1600m around school centroids to analyze the accessibility of retailers within walking distance of schools. A maximum distance of 1600m was chosen for this analysis as it is defined as a school walk zone, where children who reside in this area can typically walk to school and beyond which, school boards in the region provide busing (Gilliland, 2012). Next, buffer and retailer point data was intersected using spatial join analysis. If a buffer intersected the retailer point, the points were matched. The number of retailers within each buffer was then calculated.

The number of retailers within each buffer for each school were geographically weighted using inverse distance weighting. Given that things closer together are more interrelated than distanced things (Tobler, 1970), retailers that are in closer buffers to the schools have a more meaningful relationship and were therefore assigned greater weight (Table 1). For example, retailers within 100m of a school were weighted the highest and multiplied by 1, retailers in the 200m buffer were multiplied by ½, retailers in the 300m buffer were multiplied by 1/3, etc. The values of each weighted buffer were added to give each school geographically weighted scores (e.g., Figure 4 and Table 4).

3.3.3.3 Availability of e-cigarette retailers

Availability was defined as the presence (vs absence) of a retailer in a given area of interest (e.g., 100m buffer zone). Each buffer (as described above) was assessed for presence of retailer(s) and calculated in binary terms (i.e., 1/0) to determine whether there is at least one retailer (or not) within each buffer distance.

3.3.3.4 Density of e-cigarette retailers

Density was defined as the count of e-cigarette retailers within a given area divided by the area of each buffer (as described above) per square kilometer, rounded to 4 decimal places. Density measures within each buffer for each school were geographically weighted using inverse distance weighting. The values of each buffer were added to give each school geographically weighted density scores (e.g., Figure 4 and Table 4).

3.3.3.5 Proximity to e-cigarette retailers

Proximity was defined as the distance (in meters) to the closest e-cigarette retailer from a school. To measure proximity, the closest facility analysis in ArcGIS Pro was used to find the closest e-cigarette retailer to each school and to calculate the shortest distance along a street network between them. Parameters such as network dataset and travel mode were defined in the analysis. Travel mode was set as ‘driving’ to calculate distance along a street network.

3.3.4 Statistical Analysis

Descriptive statistics (means and proportions) were used to examine how e-cigarette retailers are geographically distributed throughout Middlesex, Oxford, and Elgin counties, in relation to school locations. Availability was calculated in binary terms for descriptive statistics only and proximity was not calculated by buffer zones. As such, these measurements were not included in further analysis. To assess how the count and density of e-cigarette retailers around schools relate to school neighbourhood characteristics, correlation coefficients were used. First, histograms were created for count and density measures. The resulting histograms demonstrated a non-parametric distribution, as such, Spearman's correlation coefficient was used. This assesses the direction and strength of the relationship between the count and density of e-cigarette retailers with the DA-level percent no post-secondary education, percent LICOAT, percent lone parent household, and percent visible minority population. Additionally, Kruskal-Wallis H test was used to examine any statistically significant differences for each quintile of the neighbourhood sociodemographic or socioeconomic measure, followed by a post hoc analysis to determine which quintiles had a statistically significant difference.

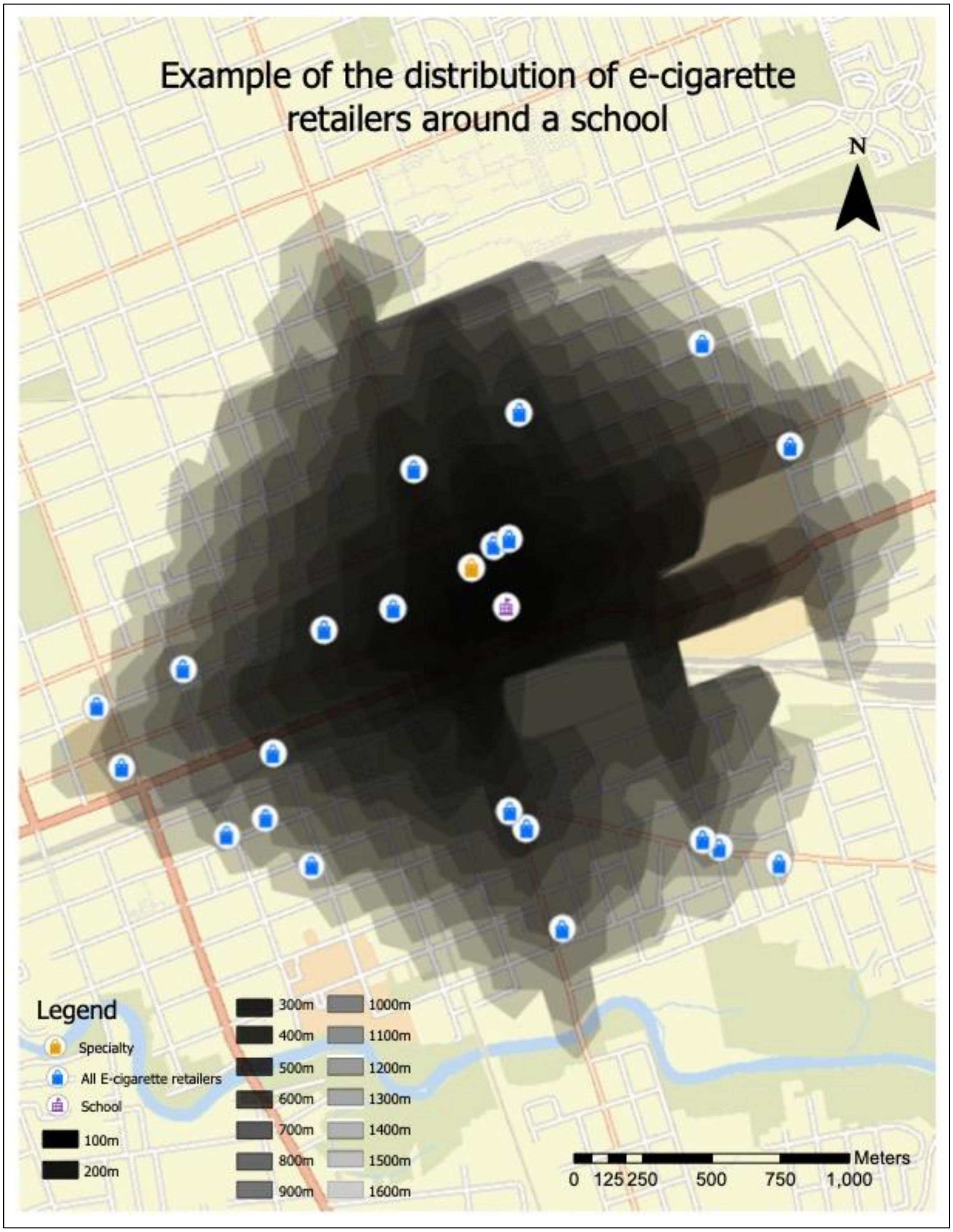

Figure 4: Example of the distribution of e-cigarette retailers around a school

Table 4: Example of geographically weighted retailers

Buffer	# of Retailers	Weight	Score
100m	0	1	0
200m	0	1/2	0
300m	2	1/3	0.67
400m	2	1/4	0.50
500m	1	1/5	0.20
600m	0	1/6	0
700m	1	1/7	0.14
800m	3	1/8	0.38
900m	1	1/9	0.11
1000m	1	1/10	0.10
1100m	0	1/11	0
1200m	1	1/12	0.08
1300m	3	1/13	0.23
1400m	4	1/14	0.29
1500m	2	1/15	0.13
1600m	2	1/16	0.13
		Total Score	**2.96**

3.3.5 Policy Simulation

To assess the impact of simulating two policy scenarios banning the sale of e-cigarettes from all types of e-cigarette retailers within 500m (scenario A) and 1000m (scenario B) of schools, average geographically weighted accessibility scores were calculated three times to reflect proposed policy changes (i.e., restricting all sales). Weighted scores were calculated first including all existing retailers, and again when all retailers and specialty retailers were eliminated within 500m (scenario A) and 1000m (scenario B). Kruskal-Wallis H test was used to examine any statistically significant differences calculated for each quintile of the given neighbourhood sociodemographic or socioeconomic measures under the new scenarios. The geographically weighted accessibility scores were compared by quintile for each scenario with the initial analysis (i.e., no policy change). All statistical analysis was conducted using IBM SPSS version 28.0.1.0.

3.4 Results

There were 359 e-cigarette retailers, 26 of which were specialty retailers (selling e-cigarette products only), identified in the City of London, and Middlesex, Oxford and Elgin Counties. The average distance from schools to the nearest e-cigarette retailer was 1826m (Min: 8m, Max: 25600m, SD: 3818m). The average distance from schools to the nearest specialty retailer was 6843m (Min: 121m and Max: 52439m, SD: 9560m). Further descriptive statistics can be found in Table 5.

Table 5: Descriptive Statistics of Geographic Measures of E-Cigarette Retailers Surrounding Schools

Geographic Measure	Retailer Type	Buffer size	Mean/%		Std. Dev.	Median	Range	Min	Max
			Statistic	Std. Error					
Count	All e-cigarette retailers	100m	0.08	0.23	3.53	0	3	0	3
		500m	0.67	0.072	1.098	0	6	0	6
		800m	1.44	0.125	1.901	1	9	0	9
		1600m	4.97	0.364	5.532	4	35	0	35
	Specialty retailers	100m	0	0.004	0.066	0	1	0	1
		500m	0.06	0.018	0.280	0	2	0	2
		800m	0.13	0.028	0.432	0	2	0	2
		1600m	0.47	0.065	0.995	0	6	0	6
Availability	All e-cigarette retailers	100m	6%	0.015	0.231	0	1	0	1
		500m	37%	0.032	0.483	0	1	0	1
		800m	55%	0.033	0.498	1	1	0	1
		1600m	79%	0.027	0.410	1	1	0	1
	Specialty retailers	100m	0%	0.004	0.066	0	1	0	1
		500m	6%	0.015	0.231	0	1	0	1
		800m	10%	0.020	0.300	0	1	0	1
		1600m	26%	0.029	0.442	0	1	0	1

Density	E-cigarette retailers	100m	0.620	0.184	2.793	0	22.659	0	22.659
		500m	0.867	0.092	1.391	0	7.985	0	7.985
		800m	0.773	0.612	0.930	0.500	3.605	0	3.605
		1600m	0.710	0.426	0.647	0.613	3.749	0	3.749
	Specialty retailers	100m	0.405	0.405	0.616	0	9.361	0	9.361
		500m	0.073	0.021	0.321	0	2.662	0	2.662
		800m	0.061	0.013	0.197	0	1.236	0	1.236
		1600m	0.059	0.008	0.117	0	0.643	0	0.643

3.4.1 Locations of e-cigarette retailers and neighbourhood characteristics

Spearman's correlation coefficients demonstrate the direction and strength of the relationship between provision (count and density) of e-cigarette retailers and neighbourhood sociodemographic and socioeconomic measures (Table 6-9).

3.4.1.1 Educational Attainment

For all e-cigarette retailers, there is generally a weak statistically significant positive correlation between percentage of adults without post-secondary education in the neighbourhood and the density of e-cigarette retailers at 500m, 800m, and 1600m from a school. The exception is that the density of retailers within 100m is not significantly correlated with education. For specialty retailers only, there were weak positive correlations between the percentage of adults without a post-secondary education in the neighbourhood and the density of specialty retailers in proximity of a school at 500m, 800m, and 1600m; whereas at 100m, there is no significant correlation. Correlation coefficients between the count of retailers and percentage of adults without post-secondary education in the neighbourhood demonstrated similar results.

Table 6: Spearman's correlation coefficients between percent no post-secondary education and density of e-cigarette retailers

	Percent no post-secondary

Density	All e-cigarette retailers	100m	0.081
		500m	0.286**
		800m	0.276**
		1600m	0.278**
	Specialty retailers	100m	0.018
		500m	0.183**
		800m	0.174**
		1600m	0.196**

* significant at the 0.05 level (2-tailed)

** significant at the 0.01 level (2-tailed)

3.4.1.2 Low Income Households

For all e-cigarette retailers, the correlation between percentage of households in the neighbourhood that fall below the low-income cutoff after taxes (LICOAT) and density of e-cigarette retailers increases from no significant correlation to strong positive correlation as the buffer distance from the school increases. There is a statistically significant correlation between the percentage of households in the neighbourhood that fall below the LICOAT and the density of e-cigarette retailers at 800m and 1600m from a school. For specialty retailers only, the correlation coefficient between the percentage of households below the neighbourhood LICOAT and the density of specialty retailers in proximity of a school increases as distance from a school increases. At 500m there is a weak positive correlation, and at 800m and 1600m there are moderate positive correlations. At 100m there is no significant correlation between the two variables. Correlation coefficients between the count of retailers and percentage of households in the neighbourhood that fall below the LICOAT demonstrated similar results as those for retailer density.

Table 7: Spearman's correlation coefficients between percent low-income cutoff after taxes and density of e-cigarette retailers

Low Income Cut-off After Taxes			
Density		100m	0.167*

	All e-cigarette retailers	500m	0.451**
		800m	0.560**
		1600m	0.663**
	Specialty retailers	100m	0.074
		500m	0.267**
		800m	0.312**
		1600m	0.401**

* significant at the 0.05 level (2-tailed)

** significant at the 0.01 level (2-tailed)

3.4.1.3 Lone Parent Households

Percentage of households in the neighbourhood that are headed by lone parents and the density of e-cigarette retailers around schools was also examined at increasing distances from the school for any associations. There is a weak positive correlation between percent lone parent households and e-cigarette retailer density at 100m, whereas at 500m there is a moderate positive correlation, and at 800m and 1600m there are strong positive correlations. Meanwhile, the correlation between the density of specialty e-cigarette retailers and percentage of households in the neighbourhood that are headed by lone parents increases from no significant correlation to moderate positive correlation as distance from schools increases. At 500m and 800m there are weak positive correlations and at 1600m there is a moderate positive correlation between the two variables. At 100m there is no significant correlation between the two variables. Correlation coefficients between the count of retailers and percentage of households in the neighbourhood that are headed by lone parents demonstrated similar results as those for retailer density.

Table 8: Spearman's correlation coefficients between percent lone parent household and density of e-cigarette retailers

Percent Lone Parent Household			
Density	All e-cigarette retailers	100m	0.175**
		500m	0.457**
		800m	0.536**

		1600m	0.625**
	Specialty retailers	100m	0.079
		500m	0.242**
		800m	0.242**
		1600m	0.333**

* significant at the 0.05 level (2-tailed)

** significant at the 0.01 level (2-tailed)

3.4.1.4 Visible Minority Status

Percentage of the population that identifies as visible minority in the neighbourhood and the density of e-cigarette retailers around schools was also examined at increasing distances from the school for any associations. For all e-cigarette retailers, there was a weak positive correlation between the two variables only at 1600m. At 100m, 500m, and 800m there was no significant correlation between the two variables. For specialty retailers, there was no correlation between percentage of visible minority population in the neighbourhood and the density of specialty retailers around schools. Correlation coefficients between the count of retailers and percent visible minority demonstrated similar results as those for retailer density.

Table 9: Spearman's correlation coefficients between percent visible minority and density of e-cigarette retailers

			Visible Minority
Density	All e-cigarette retailers	100m	0.034
		500m	0.111
		800m	0.229**
		1600m	0.307**
	Specialty retailers	100m	0.027
		500m	0.029
		800m	0.030
		1600m	0.133*

* significant at the 0.05 level (2-tailed)

** significant at the 0.01 level (2-tailed)

3.4.2 Geographically Weighted Accessibility Scores

3.4.2.1 Educational Attainment

All schools were grouped into quintiles based on the percentage of adults in the neighbourhood without post-secondary education. Quintile 1 represents the schools located in neighbourhoods with the lowest percentage of adults without post-secondary education, whereas quintile 5 represents the schools located in neighbourhoods with the highest percentage of adults without post-secondary education. Geographically weighted density scores were then examined to determine whether there was a difference in scores between no-post secondary education quintiles. There was a statistically significant difference in geographically weighted density scores for all e-cigarette retailers between no-post secondary education quintiles at 500m (H= 20.061, p<0.01). Post hoc tests revealed significant differences between quintiles 1 and 4 (p=0.032) and 1 and 5 (p<0.01). There was a significant difference between quintiles at 1000m (H=26.887, p<0.001), with post hoc analysis revealing significant differences between quintiles 1 and 5 (p<0.01), 2 and 5 (p=0.001), and 3 and 5 (p=0.003).

For specialty retailers, the difference in geographically weighted density scores between no-post secondary education quintiles was significant at 1000m (H=13.965, p=0.007), with post hoc analysis revealing significant differences between quintiles 3 and 5 (p=0.006) and 2 and 5 (p=0.036). The difference between quintiles was not significant at 500m. Kruskal Wallis H tests revealed similar results for the difference in geographically weighted count of retailers between no-post secondary education quintiles as those for retailer density.

Table 10: Kruskal Wallis H Test - Percent No Post-Secondary

Percent no post-secondary			Kruskal-Wallis H	Asymp. Sig
Density	All E-cigarette retailers	500m	20.061	<0.01
		1000m	26.887	<0.001

	1600m	24.248	<0.01
Specialty retailers	500m	8.743	0.07
	1000m	13.965	0.007
	1600m	15.515	0.004

3.4.2.2 Low Income Households

Schools were grouped into quintiles based on the percentage of households in the neighbourhood that fell below the LICOAT, with quintile 1 being the lowest (least disadvantaged), and quintile 5 being the highest (most disadvantaged). Geographically weighted density scores were then examined to determine if there was a difference in scores between percent LICOAT quintiles. There was a statistically significant difference in scores for all e-cigarette retailers between percent LICOAT quintiles at 500m (H= 54.937; p<0.01). Post hoc analysis revealed significant difference between quintiles 2 and 4 (p<0.01), 2 and 5 (p<0.01), 1 and 4 (p=0.002), 1 and 5 (p<0.01), 3 and 4 (p=0.038), and 3 and 5 (p<0.01). For the measure at 1000m (H=93.767, p<0.001), there was a statistically significant difference in geographically weighted density scores with a post hoc analysis revealing significant differences between quintiles 2 and 3 (p=0.017), 2 and 4 (p<0.01), 2 and 5 (p<0.01), 1 and 3 (p=0.024), 1 and 4 (p<0.01), 1 and 5 (p<0.01) 3 and 4 (p=0.04), and 3 and 5 (p<0.01).

For specialty retailers, the difference in geographically weighted density scores between percent LICOAT quintiles was significant at 500m (H=23.186; p<0.01). Post hoc tests revealed significant differences between quintiles 1 and 5 (p=0.001), 2 and 5 (p=0.001), and 3 and 5 (p=0.003). At 1000m (H=28.422, p<0.001) there was also a significant difference between quintiles with a post hoc analysis revealing significant differences between quintiles 1 and 4 (p=0.035), 1 and 5 (p<0.01), 2 and 4 (p<0.035), 2 and 5 (p<0.01). Kruskal Wallis H tests revealed similar results for the difference in geographically weighted count of retailers between LICOAT quintiles as those for retailer density.

Table 11: Kruskal Wallis H Test - Percent Low Income Cutoff After Taxes

Percent LICOAT			Kruskal-Wallis H	Asymp. Sig
Density	All E-cigarette retailers	500m	54.937	<0.01
		1000m	93.767	<0.001
		1600m	101.539	<0.01
	Specialty retailers	500m	23.186	<0.01
		1000m	28.422	<0.001
		1600m	34.168	<0.01

3.4.2.3 Lone Parent Households

Schools were grouped into quintiles based on the percentage of households headed by lone parents in their neighbourhoods, with quintile 1 being the lowest (least disadvantaged), and quintile 5 being the highest (most disadvantaged). Geographically weighted density scores were then examined to determine whether there was a difference in scores between lone parent household quintiles. There was a statistically significant difference in geographically weighted density scores for all e-cigarette retailers between lone parent household quintiles at 500m (H=54.815, p<0.01). A post hoc analysis revealed significant difference between quintiles 2 and 4 (p=0.017), 2 and 5 (p<0.01), 1 and 4 (p=0.023), 1 and 5 (p<0.01), 3 and 5 (p<0.01), and 4 and 5 (p=0.013). The difference between quintiles was also significant at 1000m (H=75.371, p<0.001) with post hoc analysis revealing a significant difference between quintiles 1 and 3 (p=0.002), 1 and 4 (p<0.01), 1 and 5 (p<0.01), 2 and 4 (p=0.001), 2 and 5 (p<0.01), and 3 and 5 (p<0.01).

For specialty retailers, there was a statistically significant difference in geographically weighted density scores between lone parent household quintiles at 500m (p=0.002), with post hoc analysis revealing significant differences between quintiles 1 and 5 (0.002), 2 and 5 (0.017), 3 and 5 (0.015). Additionally, there was a statistically significant difference in scores between quintiles at 1000m (H=14.698, p=0.005) with post hoc analysis revealing a significant difference between quintiles 1 and 4 (p=0.033) and 1 and 5 (p=0.007). Kruskal Wallis H tests revealed similar results for the difference in geographically weighted count of retailers between lone parent household quintiles as those for retailer density.

Table 12: Kruskal Wallis H Test - Percent Lone Parent Households

Percent Lone parent			Kruskal-Wallis H	Asymp. Sig
Density	All E-cigarette retailers	500m	54.815	<0.01
		1000m	75.371	<0.001
		1600m	86.324	<0.01
	Specialty retailers	500m	16.969	0.002
		1000m	14.698	0.005
		1600m	24.976	<0.01

3.4.2.4 Visible Minority Status

Schools were grouped into quintiles based on the percentage of the population in the neighbourhood that self-report as visible minority, with quintile 1 being the lowest (least disadvantaged), and quintile 5 being the highest (most disadvantaged). Geographically weighted density scores were then examined to determine whether there was a difference in scores between visible minority quintiles. There was a statistically significant difference in geographically weighted density scores for all e-cigarette retailers between visible minority quintiles at 1000m (H=21.850, p<0.001), with post hoc analysis revealing a statistically significant difference between quintiles 1 and 4 (p<0.01) and 2 and 4 (p=0.021). However, the difference between visible minority quintiles was not significant at 500m. For specialty retailers, the difference in geographically weighted density scores between visible minority quintiles was not significant at any buffer distance. Kruskal Wallis H tests revealed similar results for the difference in geographically weighted count of retailers between visible minority quintiles as those for retailer density.

Table 13: Kruskal Wallis H Test - Percent Visible Minority

Percent Visible Minority			Kruskal-Wallis H	Asymp. Sig
Density	All E-cigarette retailers	500m	7.165	0.13
		1000m	21.248	<0.001
		1600m	31.289	<0.01
	Specialty retailers	500m	5.221	0.27
		1000m	28.422	<0.001
		1600m	3.463	0.48

3.4.3 Policy Simulations

To evaluate the impact of two policy scenarios banning the sale of e-cigarettes from all retailers within 500m (scenario A) and 1000m (scenario B) of schools, average geographically weighted density scores were calculated three times to reflect proposed policy changes (i.e., restricting all sales). Weighted scores were calculated first including the current retailer distribution, and again when all retailers and specialty retailers were eliminated within 500m (scenario A) and 1000m (scenario B). Graphs displaying geographically weighted density scores in relation to sociodemographic and socioeconomic measures demonstrate the change in scores based on the two policy simulation scenarios (Figures 5-12).

3.4.3.1 Educational Attainment

When examining geographically weighted density scores for all e-cigarette retailers in relation to percentage of adults without post-secondary education in the neighbourhood, with current retailer density, scores generally increased in each quintile as percent no post-secondary education increased (Figure 5). However, quintile 2 had the lowest score (1.77), rather than quintile 1. The highest score was in quintile 5 at 4.43. This pattern was not demonstrated for specialty retailers. The lowest geographically weighted density score was in quintile 2 at 0.04 and the highest score was in quintile 3 at 0.23. Similar results were demonstrated for the geographically weighted count of e-cigarette retailers and percent no post-secondary education quintiles as those for retailer density.

When simulating a ban on all e-cigarette retailers within 500m of a school, the geographically weighted density scores decreased substantially in all percent no post-secondary education quintiles, making them more equal. The lowest quintile score (quintile 2) decreased from 1.77 to 0.76, while the highest quintile score (quintile 5) decreased from 4.43 to 1.60. However, a Kruskal Wallis H test revealed that the differences between quintiles remained significant (No policy: $p<0.001$; 500m: $p<0.001$). There was also a substantial decrease in geographically weighted density scores among specialty retailers. The lowest percent no post-secondary education quintile score (quintile 2) decreased from 0.04 to 0.03, while the highest quintile score (quintile 3) decreased from 0.23 to 0.18. However, the difference between quintiles remained significant (No policy: $p=0.004$; 500m: $p=0.004$).

With a 1000m ban on all e-cigarette retailers, the geographically weighted density scores decreased substantially again. The lowest percent no post-secondary education quintile (quintile 2) decreased from 1.77 to 0.29 and the highest quintile (quintile 5) decreased from 4.43 to 0.61. However, the difference between quintiles remained significant ($p<0.001$). Geographically weighted density scores also decreased more substantially for specialty retailers, where the lowest no post-secondary education quintile score (quintile 2) decreased from 0.04 to 0.01 and the highest quintile score (quintile 3) decreased from 0.23 to 0.06. The difference between quintiles again remained significant ($p=0.006$). Similar results were demonstrated for the geographically weighted count of e-cigarette retailers for each policy scenario as those for retailer density.

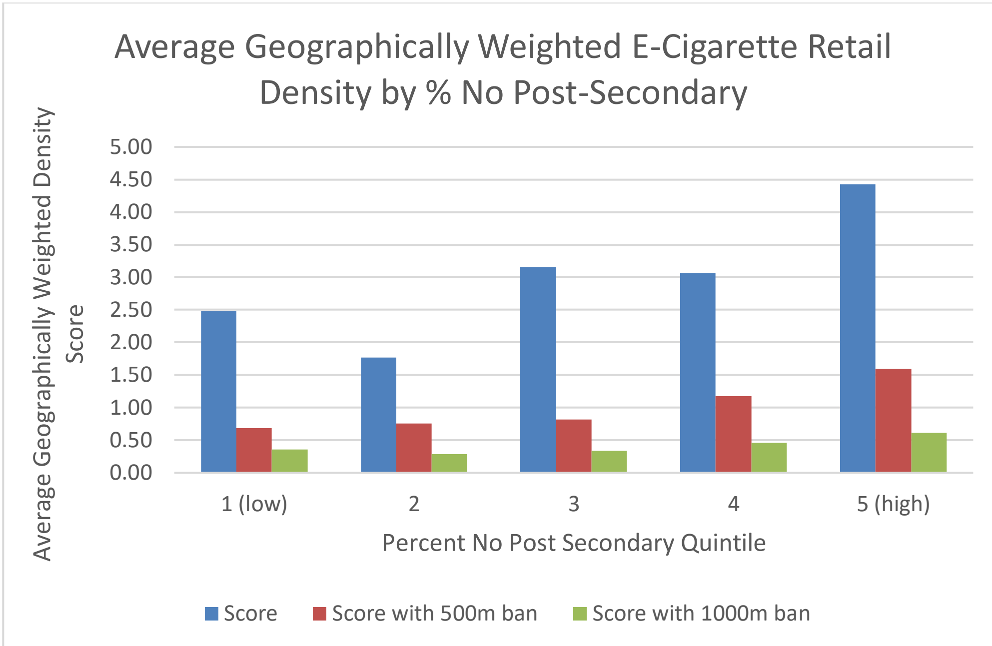

Figure 5: Average Geographically Weighted E-Cigarette Retail Density by % No Post-Secondary

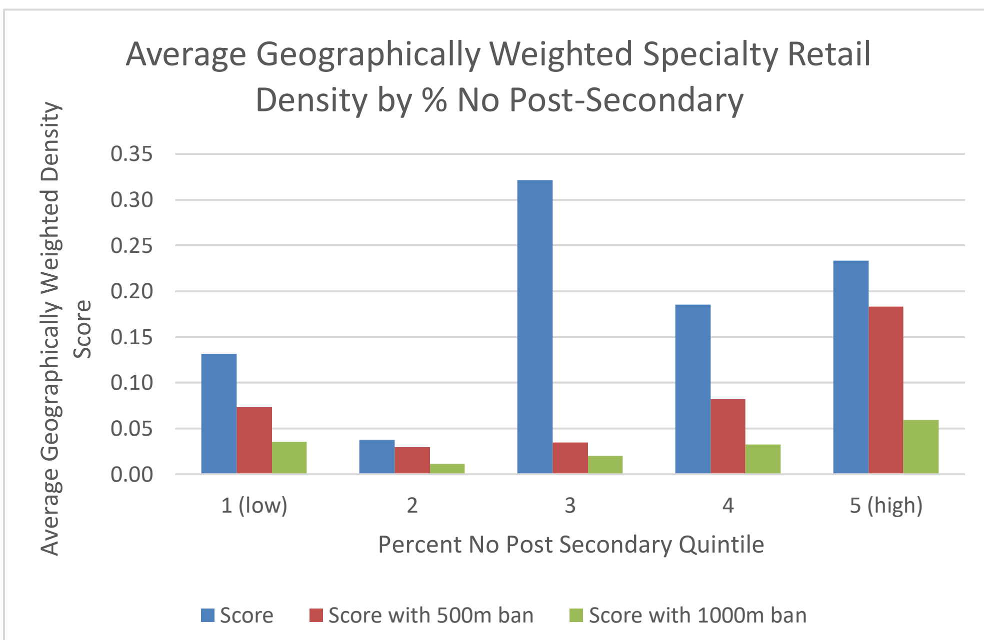

Figure 6: Average Geographically Weighted Specialty Retail Density by % No Post-Secondary

3.4.3.2 Low Income Households

When examining geographically weighted density scores for all e-cigarette retailers in relation to percent of households in the neighbourhood that fall below the LICOAT, with current retailer density, scores increased in each quintile as percent LICOAT increased, except for quintile 2 which had the lowest score (0.45). Quintile 5 had the highest score at 7.17. This trend was similar for specialty retailers, where percent LICOAT quintile 1 had the lowest geographically weighted density score at 0. Scores increased in each quintile, with quintile 5 being the greatest at 0.64. This demonstrates that retailers are more densely distributed in neighbourhoods of greater percent LICOAT. Similar results were demonstrated for the geographically weighted count of e-cigarette retailers in relation to percent of households in the neighbourhood that fall below the LICOAT as those for density retailers.

When simulating a ban on retailers within 500m of schools, geographically weighted density scores decreased in all percent LICOAT quintiles. For all e-cigarette retailers, the score of the lowest quintile (quintile 2) decreased from 0.45 to 0.31. The score in the highest quintile (quintile 5) decreased substantially from 7.17 to 2.08. However, a Kruskal Wallis H test revealed that the differences between quintiles remained significant (No policy: $p<0.001$, 500m: $p<0.001$). For specialty retailers, there were minimal decreases in geographically weighted density scores in the lower percent LICOAT quintiles, but more substantial decreases in the higher quintiles. The score of the lowest quintile (quintile 1) remained at 0 and the score of the highest quintile (quintile 5) decreased from 0.65 to 0.21. Again, the difference between percent LICOAT quintiles remained significant for specialty retailers (No policy: $p<0.001$, 500m: $p<0.001$).

When simulating a ban on retailers within 1000m of schools, geographically weighted density scores decreased in all percent LICOAT quintiles more substantially. For all e-cigarette retailers, the score of the lowest quintile (quintile 2) decreased from 0.45 to 0.17 and the score of the highest quintile (quintile 5) decreased from 7.17 to 0.81. For specialty retailers, the trend was similar. The score of the lowest percent LICOAT quintile (quintile 1) remained at 0, while the score in the highest quintile (quintile 5) decreased from 0.65 to 0.07. However, for both types of retailers a Kruskal Wallis H test revealed that the difference between quintiles remained significant with a ban on retailers within 1000m ($p<0.001$). Similar results were demonstrated for the geographically weighted count of e-cigarette retailers for all policy scenarios as those for retailer density.

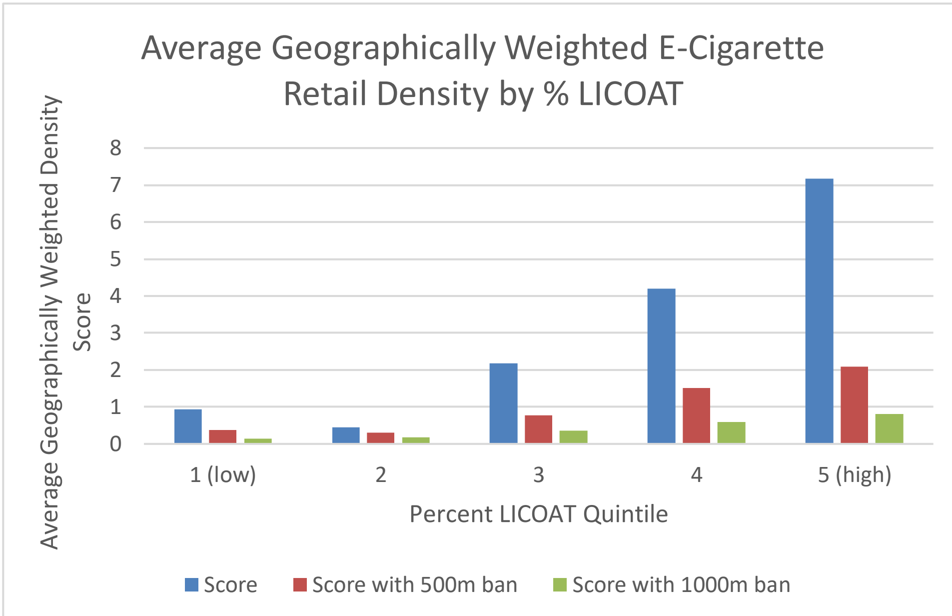

Figure 7: Average Geographically Weighted E-Cigarette Retail Density by % LICOAT

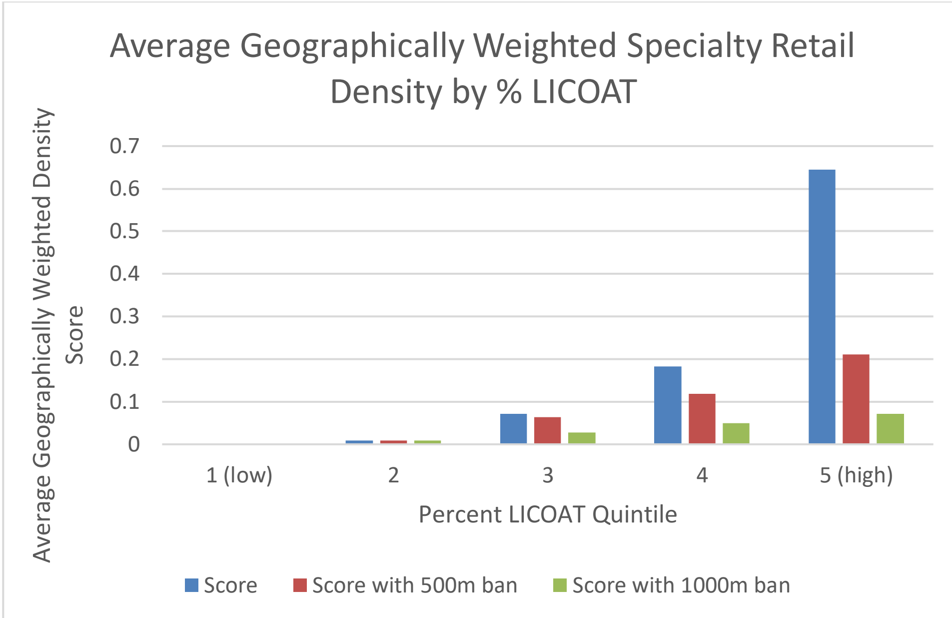

Figure 8: Average Geographically Weighted Specialty Retail Density by % LICOAT

3.4.3.3 Lone Parent Households

When examining geographically weighted density scores for all e-cigarette retailers in relation to percent of households in the neighbourhood headed by lone parents, with current retailer density, scores increased in each quintile as percent lone parent household increased (Figure 9). Given this, e-cigarette retailers are denser in neighbourhoods of higher percent lone parent households. The lowest score was in quintile 1 at 0.60 and the highest score was in quintile 5 at 6.50. This pattern also occurred with specialty retailer density, where the lowest geographically weighted density score was in quintile 1 at 0, and the highest score was in quintile 5 at 0.50. Given this, retailers are more densely distributed in neighbourhoods of greater percent lone parent households. Similar results were demonstrated for the geographically weighted count of e-cigarette retailers in relation to percent of households in the neighbourhood headed by lone parents as those for retailer density.

When simulating a policy banning all e-cigarette retailers within 500m, geographically weighted density scores decreased in all percent lone parent household quintiles and most substantially in quintiles of greater percent lone parent household. The score in the lowest quintile (quintile 1) decreased from 0.60 to 0.3 and the score in the highest quintile (quintile 5) decreased from 6.50 to 1.99. However, a Kruskal Wallis H test revealed that the difference between quintiles remained significant (No policy: $p<0.001$, 500m: $p<0.001$). The decrease was also reflected among specialty retailers, where the geographically weighted density score in the lowest percent lone parent household quintile (quintile 1) remained at 0 and the score in the highest quintile (quintile 5) decreased from 0.50 to 0.16. The difference between quintiles also remained significant for specialty retailers (No policy: $p<0.001$, 500m: $p<0.001$).

With a ban on all e-cigarette retailers within 1000m of a school, geographically weighted density scores decreased further making them more equal. The lowest percent lone parent household quintile score (quintile 1) decreased from 0.60 to 0.12 and the score in the highest quintile (quintile 5) decreased from 6.50 to 0.70. This also occurred among specialty retailers, where the geographically weighted density score in the lowest quintile (quintile 1) remained at 0 and the score in the highest quintile (quintile 5) decreased from 0.50 to 0.05. For both types of retailers, the difference between quintiles remained significant with a ban on retailers within 1000m ($p<0.001$). Similar results were demonstrated for the geographically weighted count of e-cigarette retailers in all policy scenarios as those for retailer density.

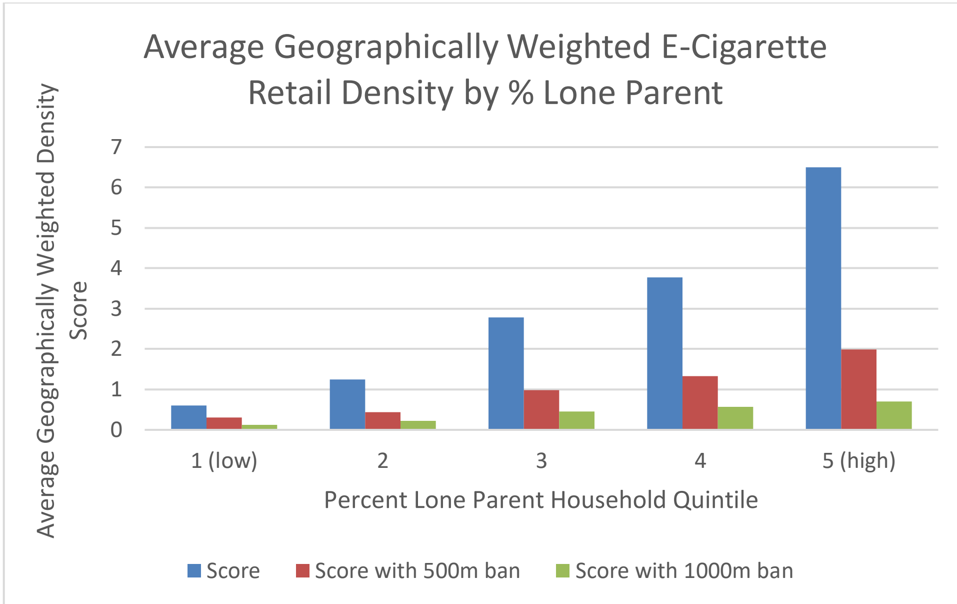

Figure 9: Average Geographically Weighted E-Cigarette Retail Density by % Lone Parent

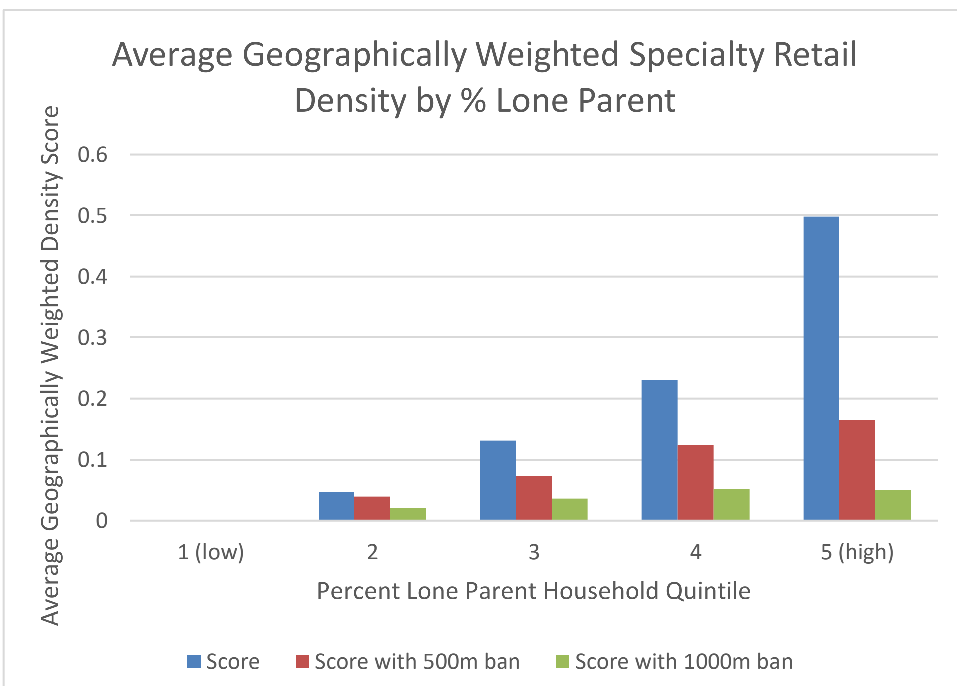

Figure 10: Average Geographically Weighted Specialty Retail Density by % Lone Parent

3.4.3.4 Visible Minority Status

When examining the geographically weighted density scores for all e-cigarette retailers in relation to percentage of the population in the neighbourhood that self-report as visible minority, scores increased from quintile 1 to quintile 3, before decreasing from quintile 3 to quintile 5. The score in the lowest quintile (quintile 1) was 1.45 and the score in the highest quintile (quintile 3) was 4.28. This was different from specialty retailers, where geographically weighted density scores were low in all percent visible minority quintiles except quintiles 2 and 4 where they were substantially higher. The score in the lowest quintile (quintile 1) was 0.04 and the score in the highest quintile (quintile 4) was 0.48. Similar results were demonstrated for the geographically weighted count of e-cigarette retailers in relation to percent of households of visible minority in the neighbourhood as those for retailer density.

When simulating a ban on all e-cigarette retailers within 500m of a school, geographically weighted density scores decreased substantially in all percent visible minority quintiles. In the lowest quintile (quintile 1) the score decreased from 1.45 to 0.55 and the score in the highest quintile (quintile 3) decreased from 4.28 to 1.06. However, with this simulation, quintile 3 no longer has the highest geographically weighted density score, and quintile 4 now has the highest score at 1.59. A Kruskal Wallis H test revealed that the difference between quintiles remained significant (No policy: $p=0.001$, 500m: $p<0.001$). For specialty retailers, geographically weighted density scores decreased most substantially in the highest percent visible minority quintiles (quintiles 2 and 4), but only decreased minimally or not at all in the other quintiles. The score in the lowest quintile (quintile 1) decreased from 0.04 to 0.03 and the score in the highest quintile (quintile 4) decreased from 0.48 to 0.05. For specialty retailers, the difference between quintiles was not significant (No policy: $p=0.45$; 500m: $p=0.44$).

With a ban on all e-cigarette retailers within 1000m of a school, there was a greater decrease in geographically weighted density scores across all percent visible minority quintiles making them more equal. The lowest quintile (quintile 1) decreased from 1.45

to 0.23 and the score in the highest quintile (quintile 3) decreased from 4.28 to 0.44. Again, with this simulation quintile 3 is no longer the highest quintile, with quintile 4 now having the highest geographically weighted density score at 0.68. The difference between quintiles remained significant with a ban on retailers within 1000m ($p<0.001$). Similarly, for specialty retailers, there was a greater decrease in geographically weighted density scores across all percent visible minority quintiles making them more equal. The score in the lowest quintile (quintile 1) decreased from 0.04 to 0.01 and the score in the highest quintile (quintile 4) decreased from 0.48 to 0.05. The difference between quintiles was not significant ($p=0.45$). Similar results were demonstrated for the geographically weighted count of e-cigarette retailers in all policy scenarios as those for retailer density.

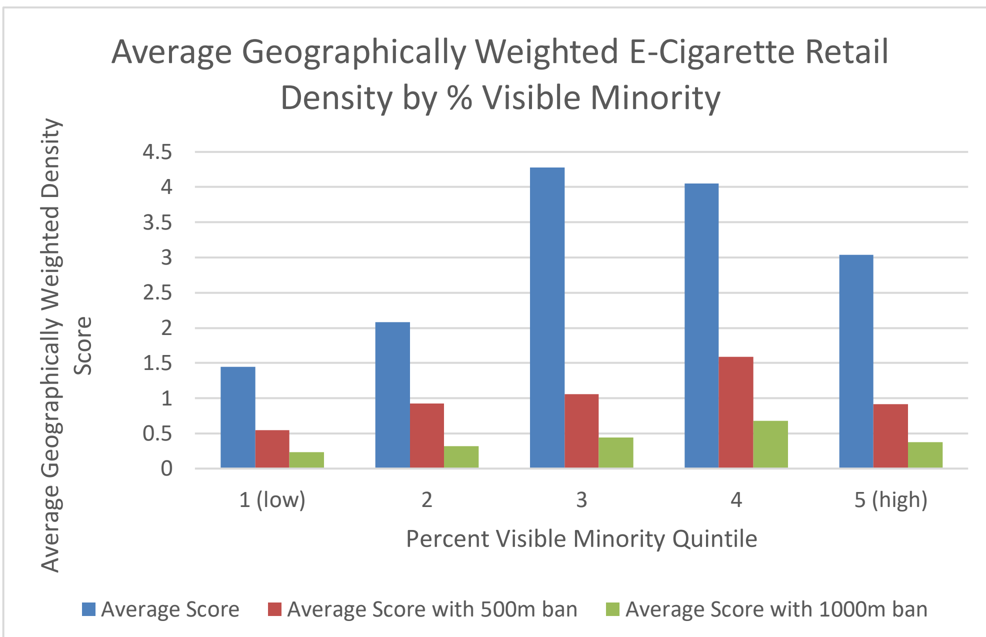

Figure 11: Average Geographically Weighted E-Cigarette Retail Density by % Visible Minority

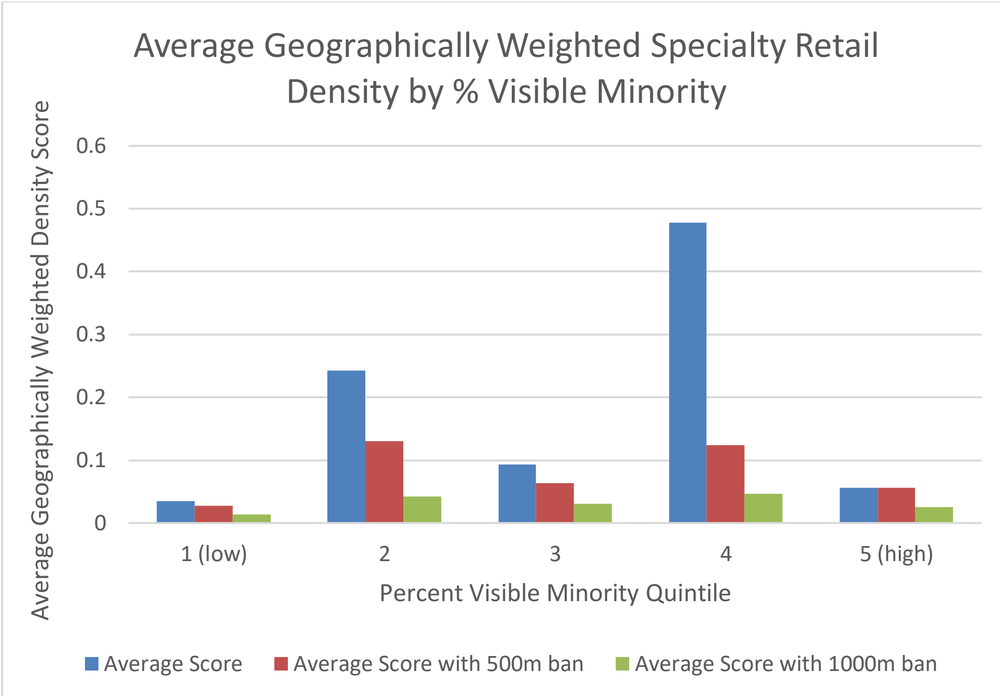

Figure 12: Average Geographically Weighted Specialty Retail Density by % Visible Minority

3.5 Discussion

There were two objectives to this research. The first was to assess the locations of e-cigarette retailers in relation to school locations as well as neighbourhood sociodemographic and socioeconomic measures. The second was to assess the impacts of simulated changes in policy on accessibility of e-cigarette retailers within certain distances of schools in relation to neighbourhood sociodemographic and socioeconomic measures.

3.5.1 Distribution of e-cigarette retailers in relation to schools and neighbourhood characteristics

The relationship between the distribution of e-cigarette retailers and neighbourhood characteristics correlated with larger effect sizes at greater distances from schools. At 100m from schools, most correlation coefficients demonstrate no significant correlations or weak positive correlations between the count or density of e-cigarette retailers and neighbourhood characteristics for all e-cigarette retailers and specialty retailers. As distance from the school increases, the correlation often increases to moderate or strong significant positive correlations. Given this, the relationship between neighbourhood deprivation and access to e-cigarette retailers closer to the school is sensitive to distance-thresholds used in analysis. This may be due to a small number of retailers within a short distance of the school. Most e-cigarette retailers are convenience stores or gas stations and as such, access to e-cigarette retailers may be more dependent on other forces that shape the distribution of convenience stores.

3.5.1.1 Educational Attainment

When examining the correlation between percent of the population with no post-secondary education at the neighbourhood level and count and density of all e-cigarette retailers and specialty retailers, there was generally a weak significant positive correlation with no significant correlation at 100m from the school. A study from the United States found that e-cigarette retailers were less likely to be concentrated in census tracts of higher education levels (Dai, Hao, & Catley, 2017). However, they did not examine different retailer types separately. In addition, Dai et al. (2017) obtained e-cigarette retailer locations from Yelp.com, a business review site which allows retailers to self-identify as e-cigarette retailers.

3.5.1.2 Low-Income Households

Neighbourhood low-income status, specifically the percentage of households falling below low-income cut-off after taxes, was positively associated with the count and density of e-cigarette retailers at 800m and 1600m. This pattern also occurred for specialty retailers; however, the correlation effect is not as strong. The literature on the distribution of e-cigarette retailers and income demonstrates mixed results. An Israeli study found that there was greater density of IQOS and JUUL (e-cigarette brands) retailers near schools in middle and high SES neighbourhoods compared to low SES neighbourhoods (Elbaz, et al., 2021). This aligns with United States epidemiological data that demonstrates that JUUL use is more common among young adults of higher SES households (Roberts, Keller-Hamilton, Ferketich, & Berman, 2020). A study from the United States found that e-cigarette retailers (that do not sell other tobacco, cannabis, or related products) are located further from schools in districts of greater proportions of poverty (Venugoapl, et al., 2020). A specialty retailer may target higher income neighbourhoods that fit the demographic of a typical person who uses e-cigarettes (Giovenco, 2018). However, most e-cigarette retailers, such as convenience stores, existed before e-cigarettes came on the market and do not primarily sell e-cigarettes, so they would not target any particular SES neighbourhood. When examining the distribution of traditional tobacco retailers, such as convenience stores, many studies demonstrate a greater density of tobacco retail in low SES neighborhoods (Marashi-Pour, et al., 2015; Galiatsatos, et al., 2018; Lee, Henriksen, Rose, Moreland-Russel, & Ribisl, 2015; Lee, et al., 2017).

3.5.1.3 Lone Parent Households

Percent lone-parent household was positively associated with the count and density of e-cigarette retailers at 800m and 1600m. The effect size is not as strong for specialty retailers, but the same pattern occurred. There is a lack of literature examining the relationship between the count and density of e-cigarette retailers and lone parent households. Percent lone-parent household may be associated with count and density of e-cigarette retailers similar to percent low-income cut-off. This is because lone parent households are dependent on a single income and given this, they may be more likely to be low-income (Campbell et al., 2016).

3.5.1.4 Visible Minority Status

There was a small significant positive correlation between visible minority and count and density of all e-cigarette retailers at 1600m, but no significant correlation for specialty retailers. These findings differ from a study from the United States which found that e-cigarette retailers are more densely distributed in school districts that have greater Asian and Black or African American populations (Venugoapl et al., 2020). In addition, they were located in closer proximity to schools in districts that had greater Asian and Black or African American, and Hispanic or Latino populations. These findings are consistent with other United States studies that found e-cigarette (Berg, 2018; Dai, Hao, & Catley, 2017) and tobacco (Rodriguez, Carlos, Adachi-Mejia, Berke, & Sargent, 2013) retailers to be disproportionately concentrated in racial or ethnic minority communities. However, a study from New Jersey found that specialty e-cigarette retailers were less common in census tracts with a greater proportion of minority populations (Giovenco, Duncan, Coups, Lewis, & Delnevo, 2016). Giovenco et al. (2018) argue that the conflicting results are owing to different definitions of e-cigarette retailer. Dai et al. (2017) included retailers that are also tobacco retailers, such as convenience stores. When tobacco retailers are not included, e-cigarette retailers are typically located in neighbourhoods with primarily White residents. This finding reflects epidemiological data that vaping rates are greater among White men and considerably lower among African American men and women (Giovenco, et al., 2016a). For this reason, this thesis examined specialty retailers separately from all e-cigarette retailers but did not find any significant findings potentially owing to a small number of specialty retailers. There is a weak positive correlation between visible minority populations and both count and density of all e-cigarette retailers at 800m from schools and a moderate positive correlation at 1600m which is consistent with other studies that examine e-cigarette retailers that also sell traditional tobacco products.

3.5.2 Policy Simulations

The measures of the number of retailers and density within each buffer for each school were geographically weighted using inverse distance weighting to give schools geographically accessibility weighted scores. School neighbourhood quintiles of greater socioeconomic/sociodemographic deprivation generally tended to have greater geographically weighted accessibility of retailers. However, when e-cigarette retailers within 500m and 1000m of schools are eliminated from geographically weighted scores, the distribution of retailers across sociodemographic or socioeconomic quintiles is substantially reduced. This policy simulation reduced disparities between quintiles by making geographically weighted accessibility scores more equal, especially with a 1000m ban. This is because the burden of retailers was most substantially reduced in quintiles that had greater geographically weighted accessibility scores and greater disadvantage. Based on both simulations, the policies were successful in reducing e-cigarette retailers across quintiles. In a study simulating a ban on tobacco sales in proximity of schools in two United States cities, Ribisl et al. (2017) found that banning tobacco sales near schools also had a strong pro-equity effect. This is because it resulted in decreased tobacco retail accessibility among lower income and racial/ethnic minority groups that have been historically targeted by tobacco companies. If this policy were to be fully implemented it would not only reduce disparities, but also potentially place more tobacco retailers and a greater density of tobacco retailers in areas of higher income and white residents. They recommend that governments use a tobacco retailer licensing program with location restrictions associated with the license (Ribisl, Luke, Bohannon, Sorg, & Moreland-Russell, 2017). Given that registries of licensed e-cigarette retailers already exist Ontario among local public health units, additional retailer restrictions could be imposed with the licensing program.

Due to the uncertain potential of e-cigarettes to aid in smoking cessation as well as their harm to young people and non-smokers, policy makers were slow to act in regulating the products. This gave e-cigarette companies the opportunity to take advantage of the lack of regulations to promote them to young people and increase retail availability. E-cigarettes are now difficult to regulate since they have been popularized, especially among youth. However, restrictions can be imposed, as they have been with traditional tobacco cigarettes to protect young people and never smokers. The Government of Ontario, in January 2020, took such a step by implementing a ban on e-cigarette retail advertisements – exempting specialty retailers. The goal of this ban was to limit e-cigarette advertisement exposure to youth. This resulted in a significant reduction of e-cigarette advertisements around high schools (Martin, et al., 2021). In addition, online retail has not been subject to the same regulations and is vulnerable to loopholes allowing people under the legal age to purchase e-cigarettes. In this case, physical retail location may not be as important in influencing vaping among young people and there must be tighter regulations to limit online sales and advertising for young people.

Stokols (1992) socioecological model of health-promoting environments relies on risk and protective factors to produce positive health outcomes or mitigate negative health outcomes. This model can be applied to understand the significance of the distribution of e-cigarette retailers in relation to school locations and neighbourhood characteristics.

Given the results of this study, it appears that neighbourhoods that are characterized by measures of lower socioeconomic status are disproportionately affected by the number of e-cigarette retailers, which in turn increases exposure to e-cigarettes among the people who live and go to school in these neighbourhoods. As explored in Chapter 2, if the presence, accessibility, or exposure to e-cigarette retailers is associated with e-cigarette use among young people, retailers are an environmental force beyond the individual that may influence their behaviour. Implementing pro-equity policies to limit e-cigarette retailers would help control the environmental forces that may influences one's behaviour. Policies that promote equity in the distribution of e-cigarette retailers in relation to neighbourhood characteristics would ensure that disadvantaged neighbourhoods are not disproportionately exposed to environmental forces that may negatively influence their health.

3.5.3 Implications for e-cigarette use

As reported in Chapter 2, there are mixed findings related to the density of e-cigarette retailers and e-cigarette use. A study in New Jersey, USA found that density of e-cigarette retailers within a half mile of high schools was associated with current and ever e-cigarette use among high school students (Giovenco, et al., 2016b). However, a study in Cleveland, Ohio, USA did not find an association between density of e-cigarette retailers within a square mile and current e-cigarette use (Trapl, Anesetti-Rothermel, Pike Moore, & Gittleman, 2020). Similarly, studies in Texas (Pérez, et al., 2017) and Canada (Cole, Aleyan, & Leatherdale, 2019) found that e-cigarette retailer density around schools was not significantly associated with current or ever e-cigarette use. Given the findings of these early studies, albeit limited, it cannot be concluded that the density of retailers around schools are significant in influencing e-cigarette use among students. Furthermore, inequities in their distribution according to neighbourhood socioeconomic and sociodemographic status may not result in inequities in e-cigarette use. Further studies are needed with better data, in various settings, to understand the relationship between neighbourhood characteristics and e-cigarette retail density and use more fully.

Two United States studies found that youth are more likely to obtain e-cigarettes from social sources such as friends or family members (Baker, et al., 2019; Pepper, Coats, Nonnemaker, & Loomis, 2018). A study in Canada found that purchasing an e-cigarette was more common among adolescents of legal age and those who vape more frequently. However, it was more common for adolescents under the legal age to purchase from an e-cigarette retailer, such as a convenience store, rather than a specialty retailer (Braak, Cummings, Nahhas, Reid, & Hammond, 2020). This demonstrates that although retailers may not be a significant source of obtaining e-cigarettes for those under the legal age, retailers such as convenience stores are more significant compared to specialty retailers.

3.5.4 Strengths and Limitations

This study has several strengths. This study relied on a comprehensive database of e-cigarette retailer locations from the local public health units in which they are regulated. Many similar studies are limited in some cases by a lack of local regulation on retailers and they instead obtain retailer locations from business review websites like Yelp, YellowPages.com, ReferenceUSA, and GoogleMaps, where retailers can self-identify as e-cigarette retailers. Such websites have varying degrees of sensitivity and may not be as reliable as a regulatory list (Lee, D'Angelo, Kuteh, & Martin, 2016). In addition, this study examined specialty retailers separately from all e-cigarette retailers. Specialty retailers are inherently different from other retailers that sell e-cigarettes, such as convenience stores and gas stations. Specialty retailers sell a wide variety of e-cigarette products and customers are permitted to test them in store. Employees are knowledgeable and can educate customers on the products. Tobacco products are not typically sold in specialty retailers. One reason for this is that many specialty retailer owners and employees advocate for e-cigarettes as a method of smoking cessation (Giovenco, 2018). Many studies that examine the distribution of e-cigarette retailers do not distinguish between the different types of retailers, or they examine specialty retailers only, which could complicate the findings and make them difficult to compare. In this study, specialty retailers were examined separately, as the distinction between the two types of retailers may lead to different results.

Despite these strengths, this study was limited by a few factors. First, this study only examined physical retail locations which by law can only sell e-cigarettes to people above the age of eighteen. Although it is possible for youth under the legal age to circumvent this at points of sale, they can also obtain e-cigarettes from other sources, such as social sources or online sources that may not verify age. Therefore, retail locations around schools may not be as important in obtaining e-cigarettes. However, seeing e-cigarette retail locations, retail advertising and displays within the neighbourhood environment may normalize e-cigarettes to young people, making their use more socially acceptable, which has been observed with traditional tobacco cigarettes (Slater, Chaloupka, & Wakefield, 2007; Brown & Moodie, 2009). Additionally, this study only focused on retailers within 1600m of schools. It is possible that students may travel longer distances to school and thus be exposed to retailers outside of this distance or more proximal to their homes.

Moreover, the policy simulation assumes that all e-cigarette sales will be banned within 500m or 1000m of schools. This may not be feasible as retailers around schools have already been granted permission to sell e-cigarettes, and as such, specialty retailers that only sell e-cigarettes would lose their business. This may be contested by affected business owners. This policy may otherwise work for retailers, such as convenience stores, which also generate revenue from other products and would not lose their business. Future policies may instead need to prevent any additional points of sale. However, policies restricting traditional tobacco retail locations have been implemented in the past (Government of Ontario, 2017) and while they were not business friendly, they were able to reduce access and exposure to tobacco products.

Another limitation to such policies is that they may not be sufficient on their own as e-cigarette companies use a multitude of methods of attracting potential users, hence retail restrictions may need to be combined with other prevention programs such as education. The programs and policies employed will need to depend on the target audience. Different levels of the socioecological model are more significant to different populations or age groups. For younger children, family and school may play a stronger role, whereas for older children, school, peers, and community may become more significant. As such, any policies aimed at preventing e-cigarette use among young people will need to be sensitive to this.

3.5.5 Conclusions

In conclusion, as the distance from a school increases, the distribution of e-cigarette retailers and neighbourhood characteristics are correlated with larger effect sizes. When simulating policy scenarios banning e-cigarette retailers within 500m and 1000m of schools, both scenarios were successful in reducing the accessibility of e-cigarette retailers across sociodemographic/socioeconomic quintiles. The policy simulations also reduced the accessibility of e-cigarette retailers more substantially in quintiles of greater socioeconomic disadvantage, thereby making accessibility more equitable; that is, such policies would result in a more equitable distribution of the environmental burden associated with neighbourhood e-cigarette retailers. This research contributes to the current body of literature by examining specialty retailers separately from other e-cigarette retailers and obtaining comprehensive location data from licensing registries. In addition, this study highlighted the need for future policies to address inequities in potential youth exposure to e-cigarette retail. However, it should be noted that further studies are needed with more consistent approaches in defining accessibility and proximity, as well as in analysis of different types of retailers, in various settings, to better understand the relationship between neighbourhood characteristics, e-cigarette retail density, and e-cigarette use. In addition, future studies should examine access to other marketing channels and retail environments that may be significant to youth, such as the home environment or the internet. Overall, as e-cigarette use among youth is a growing health concern, more research is required to formulate effective and equitable policies to protect youth from potential health risks.

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Chapter 4

4 Synthesis and Conclusions

This thesis explores environmental influences on e-cigarette use among young people. Chapter 2 consists of a systematic review exploring various neighbourhood environment influences on current and ever use of e-cigarettes among young people. In Chapter 3, I present a geospatial analysis that considers the distribution of e-cigarette retailers in relation to school locations and neighbourhood characteristics in Middlesex, Oxford, and Elgin counties of Ontario.

The first study in Chapter 2 systematically reviews the peer-reviewed literature examining environmental influences on e-cigarette use among youth. The review considered multiple elements of neighbourhood environments, including retail, advertisements, policy, and neighbourhood social characteristics. This study reviewed how such elements of the neighbourhood environment impact ever and current use of e-cigarettes among young people aged 10-24 years. Literature published after 2006 was gathered through systematic searches of eight bibliographic databases. This resulted in 8,625 studies identified, which, after inclusion/exclusion criteria were applied, was narrowed down to 43 studies included in the review. This systematic review demonstrated mixed results regarding neighbourhood environment influences on e-cigarette use among young people. This highlights the need for more research on neighbourhood influences, particularly from a diversity of environments. Understanding such influences is critical for developing awareness campaigns and preventing e-cigarette use among young people. Based on current knowledge of the role of the neighbourhood environment obtained from this review, this thesis aimed to provide a better understanding of the role of the neighbourhood environment, and e-cigarette retailers in particular, in influencing e-cigarette use among young people and any associated socioeconomic or sociodemographic disparities.

Overall, Chapter 2 highlights the need for additional research on influences in the neighbourhood environment. Specifically, research is needed which examines the distribution of different types of e-cigarette retailers separately as they are inherently different. In addition, studies should obtain more comprehensive and reliable data on e-cigarette retailer locations. Future research should employ objective measures of interactions with the neighbourhood environment rather than relying on self-reported data. In addition, longitudinal studies would be beneficial to evaluate long term impacts of interactions within the neighbourhood environment as well as any interventions imposed to prevent or reduce e-cigarette use (e.g., changing regulations). Such research would identify any influential features of the neighbourhood environment that could be addressed through evidence-based policies and programs.

To address the research gaps that were revealed through the systematic review, I undertook a case study in Southwestern Ontario which examined the distribution of e-cigarette retailers and specialty retailers (which sell e-cigarette products only), in relation to school locations and neighbourhood characteristics (Chapter 3). This study compiled comprehensive and reliable retailer location data from official sources (public health units). A novel aspect of this research was that this study also conducted a policy simulation to examine the potential equity impacts of instituting hypothetical yet realistic new policies restricting e-cigarette retailers within 500m and 1000m of schools. This was deemed important as previous tobacco literature has demonstrated an association between proximity and density of tobacco retailers and smoking (Chan & Leatherdale, 2011; Gwon, DeGuzman, Kulbok, & Jeong, 2017). Given that schools are significant contexts in the lives of young people, the surrounding retail environment may be influential in e-cigarette use as it has with smoking (Marsh, et al., 2021; Valiente, et al., 2021). However, as revealed in Chapter 2, the current evidence of the distribution of e-cigarette retailers in the school neighbourhood and e-cigarette use is mixed (Cole, Aleyan, & Leatherdale, 2019; Giovenco, et al., 2016; Bostean, Crespi, Vorapharеuk, & McCarthy, 2016). Therefore, it is important to continue to examine the distribution of different types of retailers in different contexts to gain a greater understanding of how various populations may be differentially impacted by the distribution of e-cigarette retailers.

As such, this study sought to understand the distribution of retailers and whether they are disproportionately located by neighbourhood characteristics. This study examined associations with the percent of adults in the neighbourhood with no post-secondary education, the percent of households in the neighbourhood that fall below low-income cut-off, the percent of family households in the neighbourhood headed by lone parents, and the percent of the population in the neighbourhood who self-report as a visible minority. For all neighbourhood characteristics, associations were stronger as distance from the school increased. This may be due to a small number of retailers within a short distance of schools. School neighbourhoods of greater socioeconomic and sociodemographic deprivation tended to have greater geographically weighted density of retailers. The policy simulation revealed that eliminating retailers within 500m and 1000m of schools would substantially reduce the distribution of retailers for all quintiles, while also making the distribution of the burden more equitable. Given the history of tobacco companies targeting minority and lower socioeconomic status populations, future policies preventing e-cigarette use among young people need to be based in equity considerations.

4.1 Research Contributions

As vaping is a relatively recent phenomenon, there is a lack of research relating to environmental influences of e-cigarette use, especially in Canada. The existing research is complicated by a lack of objective measures of exposure, different definitions of an e-cigarette retailer, and a lack of longitudinal data. The studies in Chapters 2 and 3 contribute to the growing body of literature examining the role of different elements of the neighbourhood environment in e-cigarette use. In addition, both chapters contribute to the literature on children's environments as well as the role of the neighbourhood environment in influencing health behaviour. Chapter 2 specifically contributed to the body of literature by reviewing the existing literature to identify gaps in the current knowledge. Chapter 3 examined the geographic distribution of e-cigarette retailers in relation to schools and neighbourhood characteristics while simulating policy scenarios limiting access to retailers. Chapter 2 identified a need for studies that obtained retailer locations from objective sources (Lee, D'Angelo, Kuteh, & Martin, 2016) and to analyze specialty retailers separately from other types of e-cigarette retailers (Giovenco, 2018). This was carried out in Chapter 3 whereby a comprehensive database of retailer locations was obtained from the local public health units.

4.2 Methodological Contributions

The distinction between specialty retailers and all e-cigarette retailers used in the analysis of Chapter 3 was a significant methodological contribution to the current literature. As Giovenco et al. (2018) underscore, examining different types of retailers separately is critical, as specialty retailers are inherently different from typical e-cigarette retailers, such as convenience stores or gas stations. Specialty retailers sell e-cigarette products only, which is different from other retailers, such as convenience stores which also sell a variety of other products including traditional tobacco cigarettes. Specialty retailers specifically market e-cigarettes as an alternative to tobacco cigarettes and as such, may attract a different clientele than other retailers such as convenience stores (Giovenco, 2018). Given this, specialty retailers may have a different geographic distribution in relation to school locations and neighbourhood characteristics. In addition, other studies have been limited by a lack of regulatory databases containing retailer locations and instead must rely on building databases through internet searches of business review sites like Yelp. Such websites may not contain comprehensive or accurate information on e-cigarette retailers (Lee, D'Angelo, Kuteh, & Martin, 2016). Chapter 3 contributed to current methodologies by obtaining e-cigarette retailer locations from administrative data sources (i.e., the local public health units).

4.3 Limitations

There are a few limitations to this research that should be considered when interpreting the findings. The systematic review in Chapter 2 was limited by only reviewing studies written in English, and most of which were conducted in the United States, Canada, or the United Kingdom, which may limit the generalizability of the findings to only western countries. Moreover, the review considered the neighbourhood environment in a broad context, as there was no standardized definition employed in the literature. Identified elements of the neighbourhood may not have been located within a home neighbourhood, and many papers did not mention the term neighbourhood explicitly. In addition, many studies relied on self-reported exposure to neighbourhood elements such as advertising, which introduces the potential for bias. Self-reported exposure mostly illustrates conscious exposure (Loukas et al., 2019), and in this case many experiences of exposure may not be recalled and are difficult to quantify (Nicksic et al., 2018; Shiffman, Stone, & Hufford, 2008). People who use e-cigarettes would undoubtedly be more likely to observe e-cigarette advertising while purchasing the devices (Collins, Glasser, Abudayyeh, Pearson, & Villanti, 2019). As such, self-reported exposure and e-cigarette use would be expected to be related.

Chapter 3 also includes a few limitations worth noting. First, this study only examined physical retail locations, which can more easily enforce minimum purchasing age restrictions for e-cigarettes compared to online sellers, or access through third parties such as friends or schoolmates. For this reason, it is more difficult for young people below the legal age to purchase e-cigarettes from physical retailers. While age restrictions also apply to online purchases, it is easier for young people to circumvent them (Williams, Derrick, & Ribisl, 2015). Social sources are also a more convenient and common way that young people obtain e-cigarettes (Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2017). In addition, only retailers within 1600m of schools were analysed. Consequently, this study is limited by not considering other means of accessing e-cigarettes outside of physical retailers within 1600m of schools. Moreover, the policy simulation assumes that all e-cigarette retailers will be banned within 500m or 1000m of schools. If this policy were to be implemented, it would not be favourable among business owners, especially specialty retailer owners. Existing retailers may need to be grandfathered in, which would limit the impact of the policies.

4.4 Implications for Policy and Practice

E-cigarette use among young people is a public health concern due to the potential for e-cigarettes to cause nicotine addiction (US Department of Health and Human Services, 2012) and respiratory diseases (Yuan, Cross, Loughlin, & Leslie, 2015; England, Bunnell, Pechacek, Tong, & McAfee, 2015; Miyashita & Foley, 2020), harm brain development (Tobore, 2019), and lead to smoking (O'Brien, et al., 2021; Khouja, Suddell, Peters, Taylor, & Munafò, 2020). Policymaking for e-cigarettes has been complicated over the potential for e-cigarettes to aid in smoking cessation. However, due to their associated health risks, policies need to be developed to prevent use among young people and never smokers. Policies need to consider the socioecological model and how various facets may influence e-cigarette use among young people. This research considers the neighbourhood environment and associated policies. While Chapter 2 demonstrated mixed results of the role of elements of the neighbourhood environment, it highlights the importance of policies that regulate any potential elements that may negatively influence health behaviour. Chapter 2 also specifically examined the role of policies in influencing e-cigarette use. This also demonstrated mixed results, with many policies being not significantly related to use. Given this, policies need to be carefully constructed and avoid loopholes, such as the ability to purchase online without age restrictions. Policies have previously been implemented to prevent smoking and have seen success in reducing smoking rates. However, there is a common misconception that e-cigarettes are not harmful, which was also the case with traditional tobacco cigarettes in the past. With education and awareness, people have become aware of the health risks associated with smoking; thus, similar education programs need to be implemented again to educate people on the risks of vaping.

Chapter 3 specifically explored two policy scenarios that could be implemented to reduce e-cigarette retailers surrounding schools. It examined the equity impacts across neighbourhoods for four different socioeconomic and sociodemographic measures. The results of this study demonstrated that limiting e-cigarette retailers within 500m and even more so within 1000m of schools would substantially reduce the number and density of retailers, especially in more disadvantaged quintiles, making their distribution more equitable. Therefore, prior to implementing policies, analyses should be undertaken to examine whether certain neighbourhoods or socioeconomic or sociodemographic groups are disproportionately impacted by e-cigarette retailers. In doing so, policies need to adopt an equity lens to prevent any disproportionately negative impacts.

4.5 Recommendations for Future Research

To gain a better understanding of the influences of e-cigarette use among young people, additional research needs to be conducted. First, this research demonstrated mixed results of the role of the neighbourhood environment in youth e-cigarette use; therefore, other environments need to be considered. As social sources are a more common and convenient method of acquiring e-cigarettes (Kong, Morean, Cavallo, Camenga, &

Krishnan-Sarin, 2017) and underage people can easily circumvent age restrictions by purchasing e-cigarettes online (Williams, Derrick, & Ribisl, 2015), additional research is needed to understand these sources. Future studies should also examine other environments that may be significant to youth, such as the role of the school, home, or online environments in influencing e-cigarette use. Second, Chapter 2 identified various areas in which future research is needed. It was limited by mainly examining cross-sectional studies and therefore, causal effects could not be established. However, this is because there is a lack of longitudinal studies, which are urgently needed to evaluate the long-term impacts of any policies or interventions.

In terms of advertising in the neighbourhood environment, many studies rely on self-reported advertising exposure, which has the potential to be inaccurate due to recall bias. Additional research is needed using objective measures (i.e., direct assessments) of advertising exposure to understand its true effect and inform policy.

In terms of policies related to e-cigarettes, the harms of the devices have been largely unknown and as more knowledge emerges of their potential benefits and harms, policies change and emerge making it difficult to assess their long-term impact. Given this, more research needs to be undertaken to assess the impacts of policies.

As e-cigarettes are a new and evolving phenomenon with potential societal benefits and harms, it is critical to gain a more complete understanding of their role in public health. As neighbourhoods are an important context in health promoting environments, a better understanding of their role in e-cigarette use is needed to formulate effective policies which can lead to reduced e-cigarette use among young people, and ultimately promote health.

4.6 Conclusion

E-cigarettes are an increasingly popular method of nicotine, tobacco, cannabis, and/or flavouring delivery. E-cigarette use among non-smoking children and youth has increased significantly in recent years (Health Canada, 2019). This is a public health concern as the devices have various potential health risks associated with their use. The purpose of this thesis was to understand neighbourhood environmental influences on e-cigarette use among young people. Chapter 2 revealed mixed results relating to the role of neighbourhoods, highlighting the need for additional research employing more objective or standardized measures to allow results to be more easily compared. The review informed Chapter 3, which specifically examined the retail environment around schools in relation to neighbourhood characteristics. The results of this study found that the density and number of e-cigarette retailers were associated with percent of the neighbourhood with no post-secondary education, low-income, households headed by lone parents, and people who self-report as a visible minority as distance from the school increases. Upon simulating two policy interventions to reduce e-cigarette retailers around schools, the count and density of retailers were substantially reduced across socioeconomic and sociodemographic quintiles. This suggests that some neighbourhoods are disproportionately impacted by e-cigarette retailers and reducing their distribution would improve equity in potential exposure. Findings from both studies can be used to inform various multi-dimensional policies to reduce or prevent e-cigarette use among young people.

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Appendices

Appendix A: Spearman's correlation coefficients between neighbourhood characteristics and count of e-cigarette retailers

Percent no post-secondary			
Count	All E-cigarette retailers	100m	0.080
		500m	0.292**
		800m	0.271**
		1600m	0.253**
	Specialty retailers	100m	0.018
		500m	0.183**
		800m	0.169**
		1600m	0.186**
Low Income Cut-off After Taxes			
Count	All e-cigarette retailers	100m	0.165*
		500m	0.468**
		800m	0.570**
		1600m	0.687**
	Specialty retailers	100m	0.074
		500m	0.267**
		800m	0.314**
		1600m	0.406**
Percent Lone Parent Household			
Count	All e-cigarette retailers	100m	0.174**
		500m	0.462**
		800m	0.271**
		1600m	0.639**
	Specialty retailers	100m	0.079
		500m	0.240**
		800m	0.239**
		1600m	0.337**
Visible Minority			
Count	All e-cigarette retailers	100m	0.034
		500m	0.112
		800m	0.217**
		1600m	0.322**
	Specialty retailers	100m	0.027
		500m	0.026

800m	0.030
1600m	0.129

* significant at the 0.05 level (2-tailed)
** significant at the 0.01 level (2-tailed)

Appendix B: Kruskal Wallis H Test – Count & Neighbourhood Characteristics

Percent no post-secondary			Kruskal-Wallis H	Asymp. Sig
Count	All E-cigarette retailers	100m Euclidian	2.838	0.59
		100m	5.470	0.24
		500m	20.605	<0.01
		800m	18.468	0.001
		1000m	25.773	<0.001
		1600m	22.143	<0.01
	Specialty retailers	100m Euclidian	0	1
		100m	4.022	0.40
		500m	8.622	0.07
		800m	13.252	0.01
		1000m	13.632	0.009
		1600m	14.755	0.01
Percent LICOAT			Kruskal-Wallis H	Asymp. Sig
Count	All E-cigarette retailers	100m Euclidian	19.720	0.001
		100m	7.043	0.13
		500m	57.386	<0.01
		800m	82.951	<0.01
		1000m	96.460	<0.001
		1600m	110.198	<0.01
	Specialty retailers	100m Euclidian	0	1
		100m	4.022	0.40
		500m	23.262	<0.01
		800m	24.152	<0.01
		1000m	28.889	<0.001
		1600m	35.457	<0.01
Percent Lone Parent			Kruskal-Wallis H	Asymp. Sig
Count	All E-cigarette retailers	100m Euclidian	10.616	0.03
		100m	7.915	0.10
		500m	54.293	<0.01

		800m	63.337	<0.01
		1000m	77.103	<0.001
		1600m	90.879	<0.01
	Specialty retailers	100m Euclidian	0	1
		100m	4.022	0.40
		500m	16.510	0.002
		800m	12.960	0.01
		1000m	14.548	0.006
		1600m	25.506	<0.01
Percent Visible Minority			Kruskal-Wallis H	Asymp. Sig
Count	All E-cigarette retailers	100m Euclidian	6.449	0.17
		100m	3.607	0.46
		500m	8.636	0.071
		800m	20.304	<0.01
		1000m	21.850	<0.001
		1600m	31.719	<0.01
	Specialty retailers	100m Euclidian	0	1.00
		100m	3.915	0.42
		500m	5.405	0.25
		800m	7.643	0.11
		1000m	4.417	0.353
		1600m	3.287	0.51

Appendix C: Post Hoc Analysis – Quintiles for Neighbourhood Characteristics

Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of E-Cigarette Retailers at 500m

Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-12.130	11.916	-1.018	.309	1.000
1.00-3.00	-15.815	11.980	-1.320	.187	1.000
1.00-4.00	-34.207	11.980	-2.855	.004	.043
1.00-5.00	-48.609	11.980	-4.057	.000	.000
2.00-3.00	-3.685	11.916	-.309	.757	1.000
2.00-4.00	-22.077	11.916	-1.853	.064	.639
2.00-5.00	-36.479	11.916	-3.061	.002	.022
3.00-4.00	-18.391	11.980	-1.535	.125	1.000
3.00-5.00	-32.793	11.980	-2.737	.006	.062
4.00-5.00	-14.402	11.980	-1.202	.229	1.000

Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of E-Cigarette Retailers at 800m

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
1.00-2.00	-2.915	13.141	-.222	.824	1.000
1.00-3.00	-8.500	13.212	-.643	.520	1.000
1.00-4.00	-25.793	13.212	-1.952	.051	.509
1.00-5.00	-48.152	13.212	-3.645	.000	.003
2.00-3.00	-5.585	13.141	-.425	.671	1.000
2.00-4.00	-22.878	13.141	-1.741	.082	.817
2.00-5.00	-45.237	13.141	-3.442	.001	.006
3.00-4.00	-17.293	13.212	-1.309	.191	1.000
3.00-5.00	-39.652	13.212	-3.001	.003	.027
4.00-5.00	-22.359	13.212	-1.692	.091	.906
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	.542	13.464	.040	.968	1.000
2.00-3.00	-6.912	13.464	-.513	.608	1.000
2.00-4.00	-33.151	13.464	-2.462	.014	.138
2.00-5.00	-55.129	13.464	-4.095	.000	.000
1.00-3.00	-6.370	13.536	-.471	.638	1.000
1.00-4.00	-32.609	13.536	-2.409	.016	.160
1.00-5.00	-54.587	13.536	-4.033	.000	.001
3.00-4.00	-26.239	13.536	-1.938	.053	.526
3.00-5.00	-48.217	13.536	-3.562	.000	.004
4.00-5.00	-21.978	13.536	-1.624	.104	1.000
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-3.00	-16.867	13.760	-1.226	.220	1.000
2.00-1.00	17.138	13.760	1.246	.213	1.000
2.00-4.00	-49.062	13.760	-3.566	.000	.004
2.00-5.00	-53.214	13.760	-3.867	.000	.001
3.00-1.00	.272	13.833	.020	.984	1.000
3.00-4.00	-32.196	13.833	-2.327	.020	.199
3.00-5.00	-36.348	13.833	-2.628	.009	.086
1.00-4.00	-31.924	13.833	-2.308	.021	.210
1.00-5.00	-36.076	13.833	-2.608	.009	.091
4.00-5.00	-4.152	13.833	-.300	.764	1.000
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-3.00	-.103	7.197	-.014	.989	1.000

2.00-4.00	-5.451	7.197	-.757	.449	1.000
2.00-1.00	5.701	7.197	.792	.428	1.000
2.00-5.00	-22.668	7.197	-3.150	.002	.016
3.00-4.00	-5.348	7.236	-.739	.460	1.000
3.00-1.00	5.598	7.236	.774	.439	1.000
3.00-5.00	-22.565	7.236	-3.119	.002	.018
4.00-1.00	.250	7.236	.035	.972	1.000
4.00-5.00	-17.217	7.236	-2.379	.017	.173
1.00-5.00	-16.967	7.236	-2.345	.019	.190
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of Specialty Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
3.00-2.00	4.307	7.972	.540	.589	1.000
3.00-4.00	-7.565	8.015	-.944	.345	1.000
3.00-1.00	8.228	8.015	1.027	.305	1.000
3.00-5.00	-27.239	8.015	-3.399	.001	.007
2.00-4.00	-3.258	7.972	-.409	.683	1.000
2.00-1.00	3.921	7.972	.492	.623	1.000
2.00-5.00	-22.932	7.972	-2.877	.004	.040
4.00-1.00	.663	8.015	.083	.934	1.000
4.00-5.00	-19.674	8.015	-2.455	.014	.141
1.00-5.00	-19.011	8.015	-2.372	.018	.177
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Count of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-3.00	-17.426	10.713	-1.627	.104	1.000
2.00-1.00	19.067	10.713	1.780	.075	.751
2.00-4.00	-30.099	10.713	-2.810	.005	.050
2.00-5.00	-38.491	10.713	-3.593	.000	.003
3.00-1.00	1.641	10.770	.152	.879	1.000
3.00-4.00	-12.674	10.770	-1.177	.239	1.000
3.00-5.00	-21.065	10.770	-1.956	.050	.505
1.00-4.00	-11.033	10.770	-1.024	.306	1.000
1.00-5.00	-19.424	10.770	-1.803	.071	.713
4.00-5.00	-8.391	10.770	-.779	.436	1.000
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of E-Cigarette Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-16.312	11.984	-1.361	.173	1.000
1.00-3.00	-19.337	12.048	-1.605	.108	1.000
1.00-4.00	-35.467	12.048	-2.944	.003	.032
1.00-5.00	-49.815	12.048	-4.135	.000	.000

2.00-3.00	-3.025	11.984	-.252	.801	1.000
2.00-4.00	-19.156	11.984	-1.598	.110	1.000
2.00-5.00	-33.503	11.984	-2.796	.005	.052
3.00-4.00	-16.130	12.048	-1.339	.181	1.000
3.00-5.00	-30.478	12.048	-2.530	.011	.114
4.00-5.00	-14.348	12.048	-1.191	.234	1.000
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-8.657	13.232	-.654	.513	1.000
1.00-3.00	-11.391	13.303	-.856	.392	1.000
1.00-4.00	-28.783	13.303	-2.164	.030	.305
1.00-5.00	-50.870	13.303	-3.824	.000	.001
2.00-3.00	-2.734	13.232	-.207	.836	1.000
2.00-4.00	-20.125	13.232	-1.521	.128	1.000
2.00-5.00	-42.212	13.232	-3.190	.001	.014
3.00-4.00	-17.391	13.303	-1.307	.191	1.000
3.00-5.00	-39.478	13.303	-2.968	.003	.030
4.00-5.00	-22.087	13.303	-1.660	.097	.968
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-3.273	13.535	-.242	.809	1.000
1.00-3.00	-8.065	13.608	-.593	.553	1.000
1.00-4.00	-35.391	13.608	-2.601	.009	.093
1.00-5.00	-57.783	13.608	-4.246	.000	.000
2.00-3.00	-4.792	13.535	-.354	.723	1.000
2.00-4.00	-32.118	13.535	-2.373	.018	.176
2.00-5.00	-54.510	13.535	-4.027	.000	.001
3.00-4.00	-27.326	13.608	-2.008	.045	.446
3.00-5.00	-49.717	13.608	-3.654	.000	.003
4.00-5.00	-22.391	13.608	-1.645	.100	.999
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	14.683	13.794	1.064	.287	1.000
2.00-3.00	-19.835	13.794	-1.438	.150	1.000
2.00-4.00	-50.955	13.794	-3.694	.000	.002
2.00-5.00	-55.563	13.794	-4.028	.000	.001
1.00-3.00	-5.152	13.868	-.372	.710	1.000
1.00-4.00	-36.272	13.868	-2.616	.009	.089
1.00-5.00	-40.880	13.868	-2.948	.003	.032

3.00-4.00	-31.120	13.868	-2.244	.025	.248
3.00-5.00	-35.728	13.868	-2.576	.010	.100
4.00-5.00	-4.609	13.868	-.332	.740	1.000
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-3.00	-.208	7.201	-.029	.977	1.000
2.00-4.00	-5.599	7.201	-.778	.437	1.000
2.00-1.00	5.708	7.201	.793	.428	1.000
2.00-5.00	-23.262	7.201	-3.230	.001	.012
3.00-4.00	-5.391	7.240	-.745	.456	1.000
3.00-1.00	5.500	7.240	.760	.447	1.000
3.00-5.00	-23.054	7.240	-3.184	.001	.015
4.00-1.00	.109	7.240	.015	.988	1.000
4.00-5.00	-17.663	7.240	-2.440	.015	.147
1.00-5.00	-17.554	7.240	-2.425	.015	.153
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of Specialty Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
3.00-2.00	4.383	7.978	.549	.583	1.000
3.00-4.00	-7.554	8.021	-.942	.346	1.000
3.00-1.00	8.207	8.021	1.023	.306	1.000
3.00-5.00	-27.576	8.021	-3.438	.001	.006
2.00-4.00	-3.171	7.978	-.397	.691	1.000
2.00-1.00	3.823	7.978	.479	.632	1.000
2.00-5.00	-23.193	7.978	-2.907	.004	.036
4.00-1.00	.652	8.021	.081	.935	1.000
4.00-5.00	-20.022	8.021	-2.496	.013	.126
1.00-5.00	-19.370	8.021	-2.415	.016	.157
Pairwise Comparisons of Quintiles for Percent No Post-Secondary & Geographically Weighted Density of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-3.00	-17.517	10.749	-1.630	.103	1.000
2.00-1.00	18.604	10.749	1.731	.083	.835
2.00-4.00	-30.941	10.749	-2.879	.004	.040
2.00-5.00	-39.409	10.749	-3.666	.000	.002
3.00-1.00	1.087	10.807	.101	.920	1.000
3.00-4.00	-13.424	10.807	-1.242	.214	1.000
3.00-5.00	-21.891	10.807	-2.026	.043	.428
1.00-4.00	-12.337	10.807	-1.142	.254	1.000
1.00-5.00	-20.804	10.807	-1.925	.054	.542
4.00-5.00	-8.467	10.807	-.784	.433	1.000

Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of E-Cigarette Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	8.033	11.980	.670	.503	1.000
2.00-3.00	-19.817	11.916	-1.663	.096	.963
2.00-4.00	-53.859	11.980	-4.496	.000	.000
2.00-5.00	-75.500	11.980	-6.302	.000	.000
1.00-3.00	-11.784	11.916	-.989	.323	1.000
1.00-4.00	-45.826	11.980	-3.825	.000	.001
1.00-5.00	-67.467	11.980	-5.631	.000	.000
3.00-4.00	-34.042	11.916	-2.857	.004	.043
3.00-5.00	-55.683	11.916	-4.673	.000	.000
4.00-5.00	-21.641	11.980	-1.806	.071	.709
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	8.793	13.212	.666	.506	1.000
2.00-3.00	-47.817	13.141	-3.639	.000	.003
2.00-4.00	-83.359	13.212	-6.310	.000	.000
2.00-5.00	-94.413	13.212	-7.146	.000	.000
1.00-3.00	-39.023	13.141	-2.970	.003	.030
1.00-4.00	-74.565	13.212	-5.644	.000	.000
1.00-5.00	-85.620	13.212	-6.481	.000	.000
3.00-4.00	-35.542	13.141	-2.705	.007	.068
3.00-5.00	-46.596	13.141	-3.546	.000	.004
4.00-5.00	-11.054	13.212	-.837	.403	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-.511	13.536	-.038	.970	1.000
1.00-3.00	-45.715	13.464	-3.395	.001	.007
1.00-4.00	-84.739	13.536	-6.260	.000	.000
1.00-5.00	-102.152	13.536	-7.547	.000	.000
2.00-3.00	-45.204	13.464	-3.357	.001	.008
2.00-4.00	-84.228	13.536	-6.222	.000	.000
2.00-5.00	-101.641	13.536	-7.509	.000	.000
3.00-4.00	-39.024	13.464	-2.898	.004	.038
3.00-5.00	-56.437	13.464	-4.192	.000	.000
4.00-5.00	-17.413	13.536	-1.286	.198	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of E-Cigarette Retailers at 1600m					

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
1.00-2.00	-22.196	13.833	-1.605	.109	1.000
1.00-3.00	-62.626	13.760	-4.551	.000	.000
1.00-4.00	-108.120	13.833	-7.816	.000	.000
1.00-5.00	-116.663	13.833	-8.433	.000	.000
2.00-3.00	-40.430	13.760	-2.938	.003	.033
2.00-4.00	-85.924	13.833	-6.211	.000	.000
2.00-5.00	-94.467	13.833	-6.829	.000	.000
3.00-4.00	-45.494	13.760	-3.306	.001	.009
3.00-5.00	-54.037	13.760	-3.927	.000	.001
4.00-5.00	-8.543	13.833	-.618	.537	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of Specialty Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	5.563	.000	1.000	1.000
1.00-3.00	-2.436	5.534	-.440	.660	1.000
1.00-4.00	-7.609	5.563	-1.368	.171	1.000
1.00-5.00	-22.543	5.563	-4.052	.000	.001
2.00-3.00	-2.436	5.534	-.440	.660	1.000
2.00-4.00	-7.609	5.563	-1.368	.171	1.000
2.00-5.00	-22.543	5.563	-4.052	.000	.001
3.00-4.00	-5.173	5.534	-.935	.350	1.000
3.00-5.00	-20.107	5.534	-3.634	.000	.003
4.00-5.00	-14.935	5.563	-2.684	.007	.073
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	7.236	.000	1.000	1.000
1.00-3.00	-12.106	7.197	-1.682	.093	.925
1.00-4.00	-15.043	7.236	-2.079	.038	.376
1.00-5.00	-30.337	7.236	-4.193	.000	.000
2.00-3.00	-12.106	7.197	-1.682	.093	.925
2.00-4.00	-15.043	7.236	-2.079	.038	.376
2.00-5.00	-30.337	7.236	-4.193	.000	.000
3.00-4.00	-2.937	7.197	-.408	.683	1.000
3.00-5.00	-18.231	7.197	-2.533	.011	.113
4.00-5.00	-15.293	7.236	-2.114	.035	.346
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of Specialty Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	8.015	.000	1.000	1.000

1.00-3.00	-14.309	7.972	-1.795	.073	.727
1.00-4.00	-22.728	8.015	-2.836	.005	.046
1.00-5.00	-35.467	8.015	-4.425	.000	.000
2.00-3.00	-14.309	7.972	-1.795	.073	.727
2.00-4.00	-22.728	8.015	-2.836	.005	.046
2.00-5.00	-35.467	8.015	-4.425	.000	.000
3.00-4.00	-8.420	7.972	-1.056	.291	1.000
3.00-5.00	-21.159	7.972	-2.654	.008	.080
4.00-5.00	-12.739	8.015	-1.589	.112	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Count of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-15.261	10.770	-1.417	.157	1.000
1.00-3.00	-25.314	10.713	-2.363	.018	.181
1.00-4.00	-43.326	10.770	-4.023	.000	.001
1.00-5.00	-57.467	10.770	-5.336	.000	.000
2.00-3.00	-10.053	10.713	-.938	.348	1.000
2.00-4.00	-28.065	10.770	-2.606	.009	.092
2.00-5.00	-42.207	10.770	-3.919	.000	.001
3.00-4.00	-18.012	10.713	-1.681	.093	.927
3.00-5.00	-32.153	10.713	-3.001	.003	.027
4.00-5.00	-14.141	10.770	-1.313	.189	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of E-Cigarette Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	9.120	12.048	.757	.449	1.000
2.00-3.00	-18.618	11.984	-1.554	.120	1.000
2.00-4.00	-53.283	12.048	-4.423	.000	.000
2.00-5.00	-74.522	12.048	-6.186	.000	.000
1.00-3.00	-9.499	11.984	-.793	.428	1.000
1.00-4.00	-44.163	12.048	-3.666	.000	.002
1.00-5.00	-65.402	12.048	-5.429	.000	.000
3.00-4.00	-34.664	11.984	-2.893	.004	.038
3.00-5.00	-55.904	11.984	-4.665	.000	.000
4.00-5.00	-21.239	12.048	-1.763	.078	.779
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	11.217	13.303	.843	.399	1.000
2.00-3.00	-47.011	13.232	-3.553	.000	.004
2.00-4.00	-82.978	13.303	-6.238	.000	.000
2.00-5.00	-96.304	13.303	-7.239	.000	.000

1.00-3.00	-35.793	13.232	-2.705	.007	.068
1.00-4.00	-71.761	13.303	-5.394	.000	.000
1.00-5.00	-85.087	13.303	-6.396	.000	.000
3.00-4.00	-35.968	13.232	-2.718	.007	.066
3.00-5.00	-49.294	13.232	-3.725	.000	.002
4.00-5.00	-13.326	13.303	-1.002	.316	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	1.348	13.608	.099	.921	1.000
2.00-3.00	-42.420	13.535	-3.134	.002	.017
2.00-4.00	-81.391	13.608	-5.981	.000	.000
2.00-5.00	-103.500	13.608	-7.606	.000	.000
1.00-3.00	-41.072	13.535	-3.034	.002	.024
1.00-4.00	-80.043	13.608	-5.882	.000	.000
1.00-5.00	-102.152	13.608	-7.507	.000	.000
3.00-4.00	-38.972	13.535	-2.879	.004	.040
3.00-5.00	-61.080	13.535	-4.513	.000	.000
4.00-5.00	-22.109	13.608	-1.625	.104	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-21.011	13.868	-1.515	.130	1.000
1.00-3.00	-57.581	13.794	-4.174	.000	.000
1.00-4.00	-101.522	13.868	-7.321	.000	.000
1.00-5.00	-114.043	13.868	-8.224	.000	.000
2.00-3.00	-36.571	13.794	-2.651	.008	.080
2.00-4.00	-80.511	13.868	-5.806	.000	.000
2.00-5.00	-93.033	13.868	-6.708	.000	.000
3.00-4.00	-43.940	13.794	-3.185	.001	.014
3.00-5.00	-56.462	13.794	-4.093	.000	.000
4.00-5.00	-12.522	13.868	-.903	.367	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of Specialty Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	5.565	.000	1.000	1.000
1.00-3.00	-2.372	5.536	-.429	.668	1.000
1.00-4.00	-7.728	5.565	-1.389	.165	1.000
1.00-5.00	-22.489	5.565	-4.041	.000	.001
2.00-3.00	-2.372	5.536	-.429	.668	1.000
2.00-4.00	-7.728	5.565	-1.389	.165	1.000
2.00-5.00	-22.489	5.565	-4.041	.000	.001

3.00-4.00	-5.356	5.536	-.968	.333	1.000
3.00-5.00	-20.117	5.536	-3.634	.000	.003
4.00-5.00	-14.761	5.565	-2.652	.008	.080
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	7.240	.000	1.000	1.000
1.00-3.00	-12.181	7.201	-1.691	.091	.907
1.00-4.00	-15.239	7.240	-2.105	.035	.353
1.00-5.00	-30.065	7.240	-4.153	.000	.000
2.00-3.00	-12.181	7.201	-1.691	.091	.907
2.00-4.00	-15.239	7.240	-2.105	.035	.353
2.00-5.00	-30.065	7.240	-4.153	.000	.000
3.00-4.00	-3.058	7.201	-.425	.671	1.000
3.00-5.00	-17.884	7.201	-2.483	.013	.130
4.00-5.00	-14.826	7.240	-2.048	.041	.406
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of Specialty Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	.000	8.021	.000	1.000	1.000
1.00-3.00	-14.234	7.978	-1.784	.074	.744
1.00-4.00	-23.424	8.021	-2.920	.003	.035
1.00-5.00	-34.848	8.021	-4.345	.000	.000
2.00-3.00	-14.234	7.978	-1.784	.074	.744
2.00-4.00	-23.424	8.021	-2.920	.003	.035
2.00-5.00	-34.848	8.021	-4.345	.000	.000
3.00-4.00	-9.190	7.978	-1.152	.249	1.000
3.00-5.00	-20.614	7.978	-2.584	.010	.098
4.00-5.00	-11.424	8.021	-1.424	.154	1.000
Pairwise Comparisons of Quintiles for Percent LICOAT & Geographically Weighted Density of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-15.446	10.807	-1.429	.153	1.000
1.00-3.00	-25.211	10.749	-2.345	.019	.190
1.00-4.00	-41.761	10.807	-3.864	.000	.001
1.00-5.00	-57.261	10.807	-5.299	.000	.000
2.00-3.00	-9.765	10.749	-.909	.364	1.000
2.00-4.00	-26.315	10.807	-2.435	.015	.149
2.00-5.00	-41.815	10.807	-3.869	.000	.001
3.00-4.00	-16.550	10.749	-1.540	.124	1.000
3.00-5.00	-32.050	10.749	-2.982	.003	.029
4.00-5.00	-15.500	10.807	-1.434	.151	1.000

Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of E-Cigarette Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-.284	11.992	-.024	.981	1.000
1.00-3.00	-25.045	11.790	-2.124	.034	.337
1.00-4.00	-39.092	11.855	-3.298	.001	.010
1.00-5.00	-75.027	11.855	-6.329	.000	.000
2.00-3.00	-24.761	12.053	-2.054	.040	.399
2.00-4.00	-38.808	12.116	-3.203	.001	.014
2.00-5.00	-74.743	12.116	-6.169	.000	.000
3.00-4.00	-14.047	11.916	-1.179	.238	1.000
3.00-5.00	-49.982	11.916	-4.194	.000	.000
4.00-5.00	-35.935	11.980	-2.999	.003	.027
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-16.405	13.224	-1.241	.215	1.000
1.00-3.00	-45.523	13.002	-3.501	.000	.005
1.00-4.00	-72.536	13.073	-5.548	.000	.000
1.00-5.00	-88.308	13.073	-6.755	.000	.000
2.00-3.00	-29.118	13.291	-2.191	.028	.285
2.00-4.00	-56.131	13.361	-4.201	.000	.000
2.00-5.00	-71.903	13.361	-5.382	.000	.000
3.00-4.00	-27.013	13.141	-2.056	.040	.398
3.00-5.00	-42.785	13.141	-3.256	.001	.011
4.00-5.00	-15.772	13.212	-1.194	.233	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-28.632	13.549	-2.113	.035	.346
1.00-3.00	-55.158	13.322	-4.141	.000	.000
1.00-4.00	-83.150	13.395	-6.208	.000	.000
1.00-5.00	-104.541	13.395	-7.805	.000	.000
2.00-3.00	-26.527	13.618	-1.948	.051	.514
2.00-4.00	-54.518	13.689	-3.983	.000	.001
2.00-5.00	-75.910	13.689	-5.545	.000	.000
3.00-4.00	-27.991	13.464	-2.079	.038	.376
3.00-5.00	-49.383	13.464	-3.668	.000	.002
4.00-5.00	-21.391	13.536	-1.580	.114	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of E-Cigarette Retailers at 1600m					

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
1.00-2.00	-33.350	13.846	-2.409	.016	.160
1.00-3.00	-71.492	13.614	-5.251	.000	.000
1.00-4.00	-101.255	13.688	-7.397	.000	.000
1.00-5.00	-109.646	13.688	-8.010	.000	.000
2.00-3.00	-38.141	13.917	-2.741	.006	.061
2.00-4.00	-67.904	13.990	-4.854	.000	.000
2.00-5.00	-76.295	13.990	-5.454	.000	.000
3.00-4.00	-29.763	13.760	-2.163	.031	.305
3.00-5.00	-38.154	13.760	-2.773	.006	.056
4.00-5.00	-8.391	13.833	-.607	.544	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of Specialty Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-3.00	-2.574	5.475	-.470	.638	1.000
1.00-2.00	-2.602	5.569	-.467	.640	1.000
1.00-4.00	-7.609	5.505	-1.382	.167	1.000
1.00-5.00	-19.913	5.505	-3.617	.000	.003
3.00-2.00	.028	5.597	.005	.996	1.000
3.00-4.00	-5.034	5.534	-.910	.363	1.000
3.00-5.00	-17.339	5.534	-3.133	.002	.017
2.00-4.00	-5.006	5.626	-.890	.374	1.000
2.00-5.00	-17.311	5.626	-3.077	.002	.021
4.00-5.00	-12.304	5.563	-2.212	.027	.270
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-7.602	7.243	-1.050	.294	1.000
1.00-3.00	-10.223	7.121	-1.436	.151	1.000
1.00-4.00	-15.543	7.160	-2.171	.030	.299
1.00-5.00	-24.489	7.160	-3.420	.001	.006
2.00-3.00	-2.621	7.279	-.360	.719	1.000
2.00-4.00	-7.941	7.318	-1.085	.278	1.000
2.00-5.00	-16.887	7.318	-2.308	.021	.210
3.00-4.00	-5.320	7.197	-.739	.460	1.000
3.00-5.00	-14.266	7.197	-1.982	.047	.475
4.00-5.00	-8.946	7.236	-1.236	.216	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of Specialty Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-10.284	8.022	-1.282	.200	1.000

1.00-3.00	-12.734	7.888	-1.614	.106	1.000
1.00-4.00	-23.000	7.931	-2.900	.004	.037
1.00-5.00	-26.967	7.931	-3.400	.001	.007
2.00-3.00	-2.450	8.063	-.304	.761	1.000
2.00-4.00	-12.716	8.105	-1.569	.117	1.000
2.00-5.00	-16.683	8.105	-2.058	.040	.396
3.00-4.00	-10.266	7.972	-1.288	.198	1.000
3.00-5.00	-14.233	7.972	-1.785	.074	.742
4.00-5.00	-3.967	8.015	-.495	.621	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Count of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-21.127	10.781	-1.960	.050	.500
1.00-3.00	-30.716	10.600	-2.898	.004	.038
1.00-4.00	-44.006	10.658	-4.129	.000	.000
1.00-5.00	-46.789	10.658	-4.390	.000	.000
2.00-3.00	-9.589	10.835	-.885	.376	1.000
2.00-4.00	-22.879	10.892	-2.101	.036	.357
2.00-5.00	-25.662	10.892	-2.356	.018	.185
3.00-4.00	-13.290	10.713	-1.241	.215	1.000
3.00-5.00	-16.073	10.713	-1.500	.134	1.000
4.00-5.00	-2.783	10.770	-.258	.796	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of E-Cigarette Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
2.00-1.00	1.938	12.059	.161	.872	1.000
2.00-3.00	-23.562	12.120	-1.944	.052	.519
2.00-4.00	-38.267	12.184	-3.141	.002	.017
2.00-5.00	-76.930	12.184	-6.314	.000	.000
1.00-3.00	-21.623	11.857	-1.824	.068	.682
1.00-4.00	-36.328	11.922	-3.047	.002	.023
1.00-5.00	-74.991	11.922	-6.290	.000	.000
3.00-4.00	-14.705	11.984	-1.227	.220	1.000
3.00-5.00	-53.368	11.984	-4.453	.000	.000
4.00-5.00	-38.663	12.048	-3.209	.001	.013
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-13.788	13.315	-1.035	.300	1.000
1.00-3.00	-40.961	13.092	-3.129	.002	.018
1.00-4.00	-71.138	13.163	-5.404	.000	.000
1.00-5.00	-88.920	13.163	-6.755	.000	.000

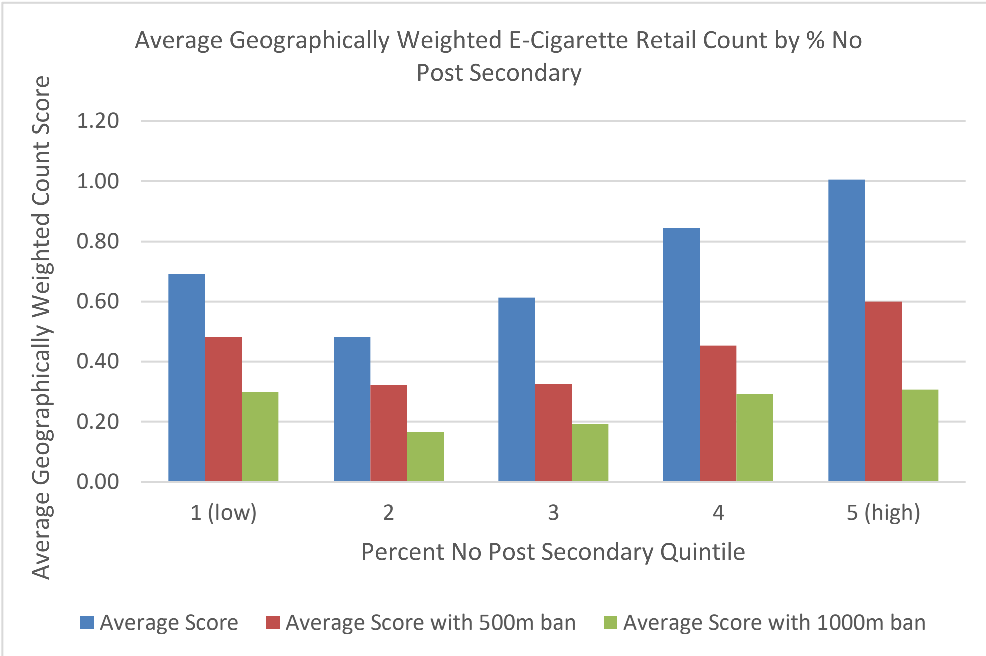
2.00-3.00	-27.173	13.383	-2.030	.042	.423
2.00-4.00	-57.350	13.453	-4.263	.000	.000
2.00-5.00	-75.132	13.453	-5.585	.000	.000
3.00-4.00	-30.177	13.232	-2.281	.023	.226
3.00-5.00	-47.959	13.232	-3.625	.000	.003
4.00-5.00	-17.783	13.303	-1.337	.181	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-27.468	13.620	-2.017	.044	.437
1.00-3.00	-49.530	13.392	-3.699	.000	.002
1.00-4.00	-79.887	13.465	-5.933	.000	.000
1.00-5.00	-104.887	13.465	-7.790	.000	.000
2.00-3.00	-22.062	13.690	-1.612	.107	1.000
2.00-4.00	-52.419	13.761	-3.809	.000	.001
2.00-5.00	-77.419	13.761	-5.626	.000	.000
3.00-4.00	-30.357	13.535	-2.243	.025	.249
3.00-5.00	-55.357	13.535	-4.090	.000	.000
4.00-5.00	-25.000	13.608	-1.837	.066	.662
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-28.170	13.881	-2.029	.042	.424
1.00-3.00	-68.293	13.648	-5.004	.000	.000
1.00-4.00	-97.554	13.723	-7.109	.000	.000
1.00-5.00	-105.772	13.723	-7.708	.000	.000
2.00-3.00	-40.122	13.952	-2.876	.004	.040
2.00-4.00	-69.384	14.025	-4.947	.000	.000
2.00-5.00	-77.601	14.025	-5.533	.000	.000
3.00-4.00	-29.262	13.794	-2.121	.034	.339
3.00-5.00	-37.479	13.794	-2.717	.007	.066
4.00-5.00	-8.217	13.868	-.593	.553	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of Specialty Retailers at 500m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-2.534	5.571	-.455	.649	1.000
1.00-3.00	-2.564	5.477	-.468	.640	1.000
1.00-4.00	-7.424	5.507	-1.348	.178	1.000
1.00-5.00	-20.174	5.507	-3.663	.000	.002
2.00-3.00	-.030	5.599	-.005	.996	1.000
2.00-4.00	-4.890	5.628	-.869	.385	1.000
2.00-5.00	-17.640	5.628	-3.134	.002	.017

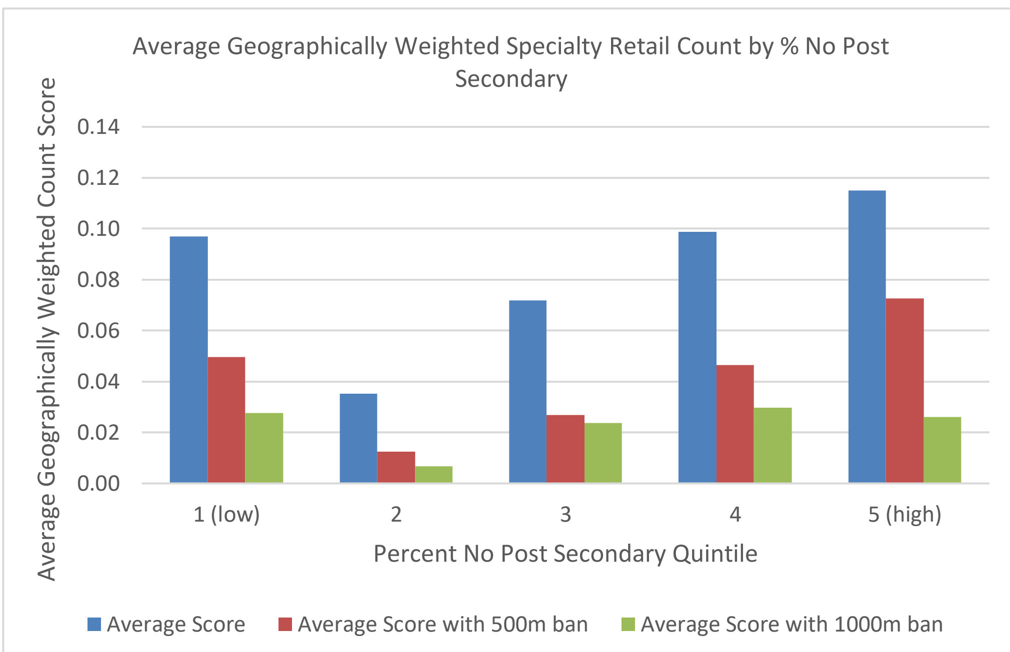
3.00-4.00	-4.860	5.536	-.878	.380	1.000
3.00-5.00	-17.610	5.536	-3.181	.001	.015
4.00-5.00	-12.750	5.565	-2.291	.022	.220
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of Specialty Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-7.420	7.247	-1.024	.306	1.000
1.00-3.00	-10.191	7.125	-1.430	.153	1.000
1.00-4.00	-15.348	7.164	-2.142	.032	.322
1.00-5.00	-24.891	7.164	-3.474	.001	.005
2.00-3.00	-2.771	7.284	-.380	.704	1.000
2.00-4.00	-7.927	7.322	-1.083	.279	1.000
2.00-5.00	-17.471	7.322	-2.386	.017	.170
3.00-4.00	-5.156	7.201	-.716	.474	1.000
3.00-5.00	-14.700	7.201	-2.041	.041	.412
4.00-5.00	-9.543	7.240	-1.318	.187	1.000
Pairwise Comparisons of Quintiles for Percent Lone Parent & Geographically Weighted Density of Specialty Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-20.406	10.817	-1.887	.059	.592
1.00-3.00	-30.595	10.635	-2.877	.004	.040
1.00-4.00	-44.390	10.693	-4.151	.000	.000
1.00-5.00	-45.596	10.693	-4.264	.000	.000
2.00-3.00	-10.189	10.872	-.937	.349	1.000
2.00-4.00	-23.984	10.929	-2.195	.028	.282
2.00-5.00	-25.190	10.929	-2.305	.021	.212
3.00-4.00	-13.795	10.749	-1.283	.199	1.000
3.00-5.00	-15.001	10.749	-1.396	.163	1.000
4.00-5.00	-1.207	10.807	-.112	.911	1.000
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Count of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-15.043	13.212	-1.139	.255	1.000
1.00-5.00	-20.320	13.285	-1.530	.126	1.000
1.00-3.00	-30.620	13.141	-2.330	.020	.198
1.00-4.00	-56.205	13.141	-4.277	.000	.000
2.00-5.00	-5.276	13.285	-.397	.691	1.000
2.00-3.00	-15.576	13.141	-1.185	.236	1.000
2.00-4.00	-41.161	13.141	-3.132	.002	.017
5.00-3.00	10.300	13.215	.779	.436	1.000
5.00-4.00	35.885	13.215	2.716	.007	.066
3.00-4.00	-25.585	13.070	-1.958	.050	.503

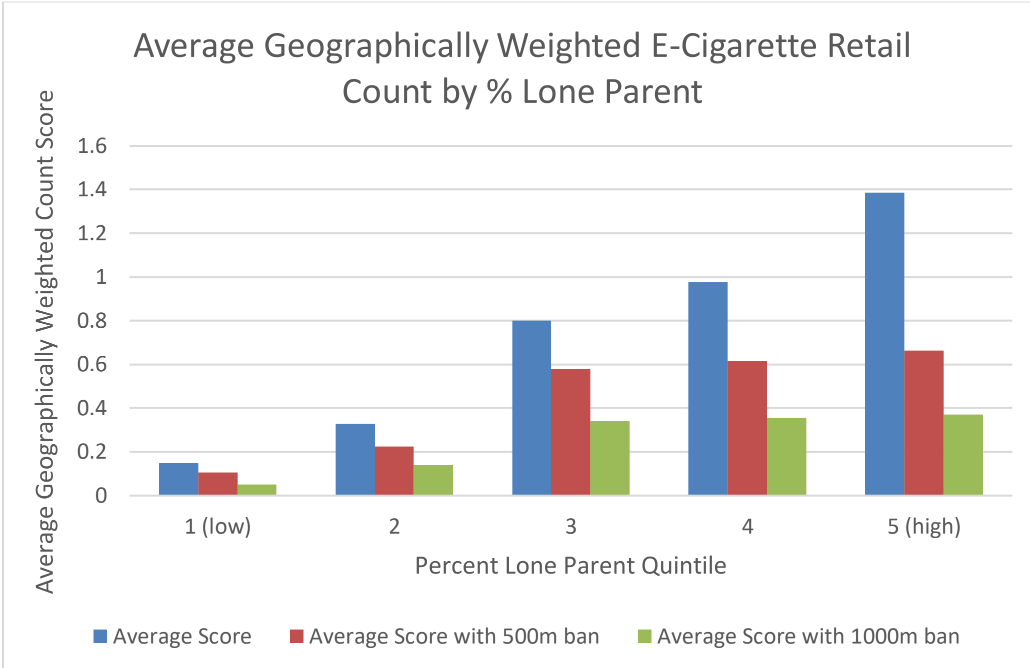
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Count of E-Cigarette Retailers at 1000m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-18.207	13.536	-1.345	.179	1.000
1.00-5.00	-30.283	13.611	-2.225	.026	.261
1.00-3.00	-34.112	13.464	-2.534	.011	.113
1.00-4.00	-60.538	13.464	-4.496	.000	.000
2.00-5.00	-12.076	13.611	-.887	.375	1.000
2.00-3.00	-15.906	13.464	-1.181	.237	1.000
2.00-4.00	-42.331	13.464	-3.144	.002	.017
5.00-3.00	3.830	13.539	.283	.777	1.000
5.00-4.00	30.255	13.539	2.235	.025	.254
3.00-4.00	-26.426	13.392	-1.973	.048	.485
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Count of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-20.728	13.833	-1.498	.134	1.000
1.00-5.00	-37.165	13.910	-2.672	.008	.075
1.00-3.00	-42.618	13.760	-3.097	.002	.020
1.00-4.00	-73.852	13.760	-5.367	.000	.000
2.00-5.00	-16.437	13.910	-1.182	.237	1.000
2.00-3.00	-21.890	13.760	-1.591	.112	1.000
2.00-4.00	-53.124	13.760	-3.861	.000	.001
5.00-3.00	5.453	13.837	.394	.693	1.000
5.00-4.00	36.687	13.837	2.651	.008	.080
3.00-4.00	-31.234	13.685	-2.282	.022	.225
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Density of E-Cigarette Retailers at 800m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-14.870	13.303	-1.118	.264	1.000
1.00-5.00	-23.519	13.376	-1.758	.079	.787
1.00-3.00	-26.886	13.232	-2.032	.042	.422
1.00-4.00	-57.205	13.232	-4.323	.000	.000
2.00-5.00	-8.649	13.376	-.647	.518	1.000
2.00-3.00	-12.017	13.232	-.908	.364	1.000
2.00-4.00	-42.336	13.232	-3.200	.001	.014
5.00-3.00	3.367	13.306	.253	.800	1.000
5.00-4.00	33.687	13.306	2.532	.011	.114
3.00-4.00	-30.319	13.160	-2.304	.021	.212
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Density of E-Cigarette Retailers at 1000m					

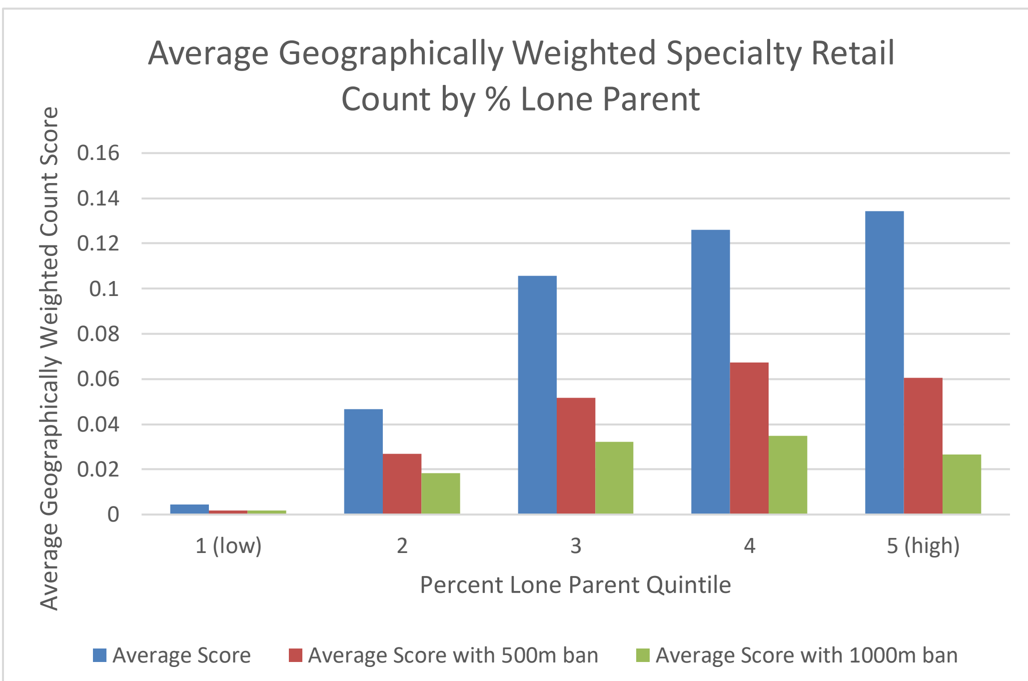
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-18.957	13.608	-1.393	.164	1.000
1.00-3.00	-29.772	13.535	-2.200	.028	.278
1.00-5.00	-31.394	13.683	-2.294	.022	.218
1.00-4.00	-60.623	13.535	-4.479	.000	.000
2.00-3.00	-10.815	13.535	-.799	.424	1.000
2.00-5.00	-12.437	13.683	-.909	.363	1.000
2.00-4.00	-41.667	13.535	-3.078	.002	.021
3.00-5.00	-1.622	13.611	-.119	.905	1.000
3.00-4.00	-30.851	13.462	-2.292	.022	.219
5.00-4.00	29.229	13.611	2.148	.032	.318
Pairwise Comparisons of Quintiles for Percent Visible Minority & Geographically Weighted Density of E-Cigarette Retailers at 1600m					
Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
1.00-2.00	-13.250	13.868	-.955	.339	1.000
1.00-5.00	-30.825	13.945	-2.211	.027	.271
1.00-3.00	-34.688	13.794	-2.515	.012	.119
1.00-4.00	-72.040	13.794	-5.223	.000	.000
2.00-5.00	-17.575	13.945	-1.260	.208	1.000
2.00-3.00	-21.438	13.794	-1.554	.120	1.000
2.00-4.00	-58.790	13.794	-4.262	.000	.000
5.00-3.00	3.863	13.871	.278	.781	1.000
5.00-4.00	41.214	13.871	2.971	.003	.030
3.00-4.00	-37.351	13.720	-2.722	.006	.065
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .050.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

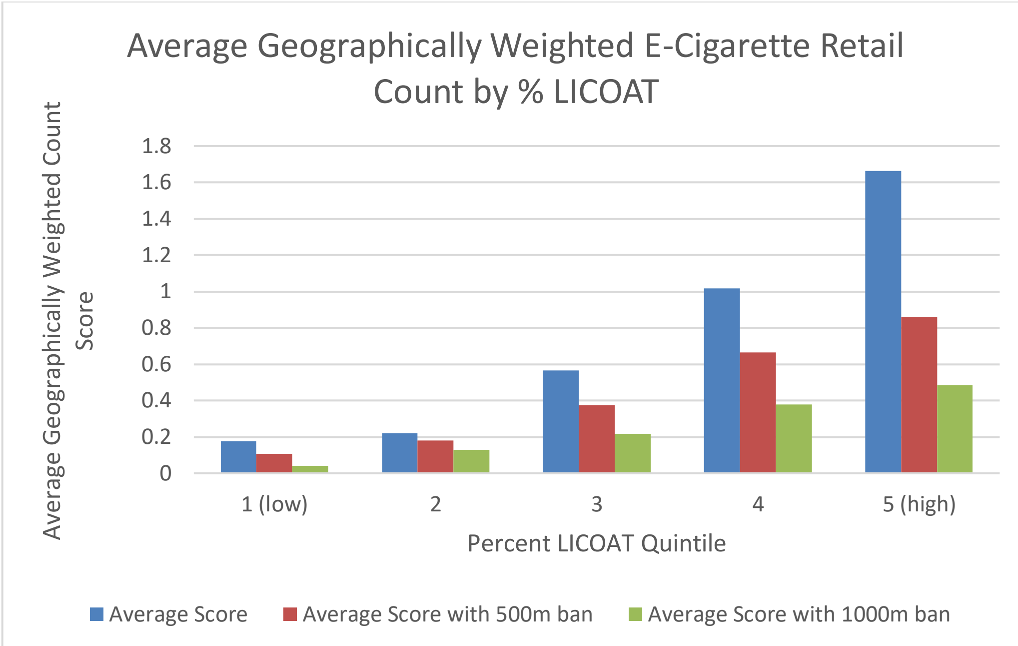
Appendix D: Policy Simulations – Average Geographically Weighted Retail Count by Neighbourhood Characteristics

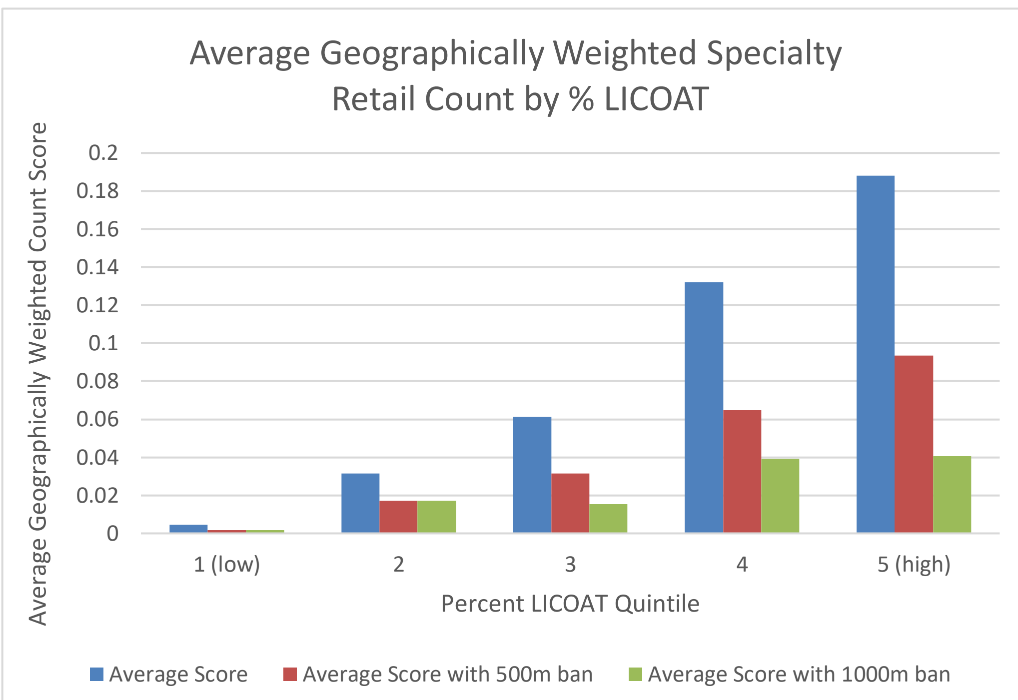


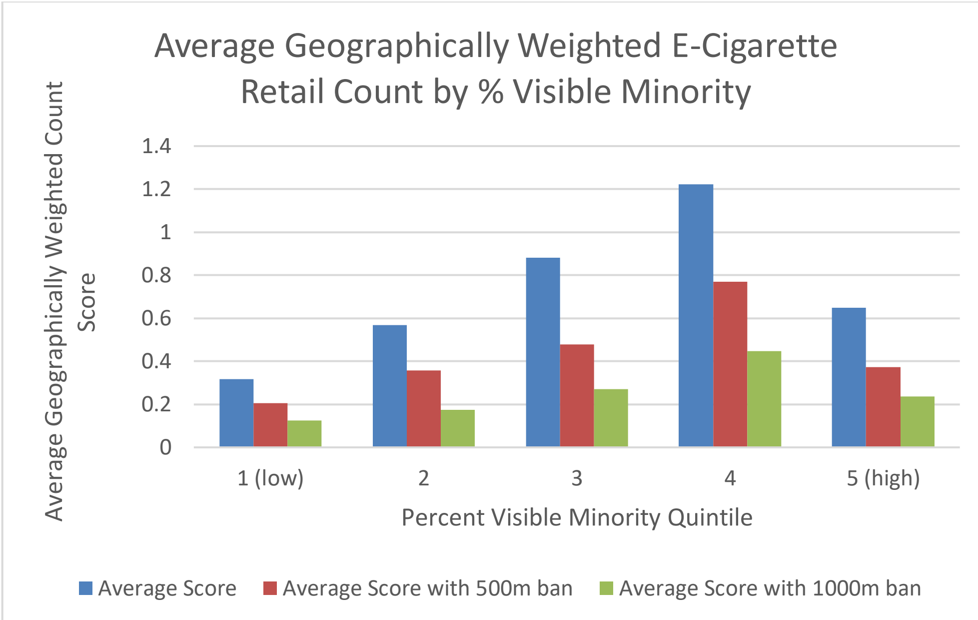


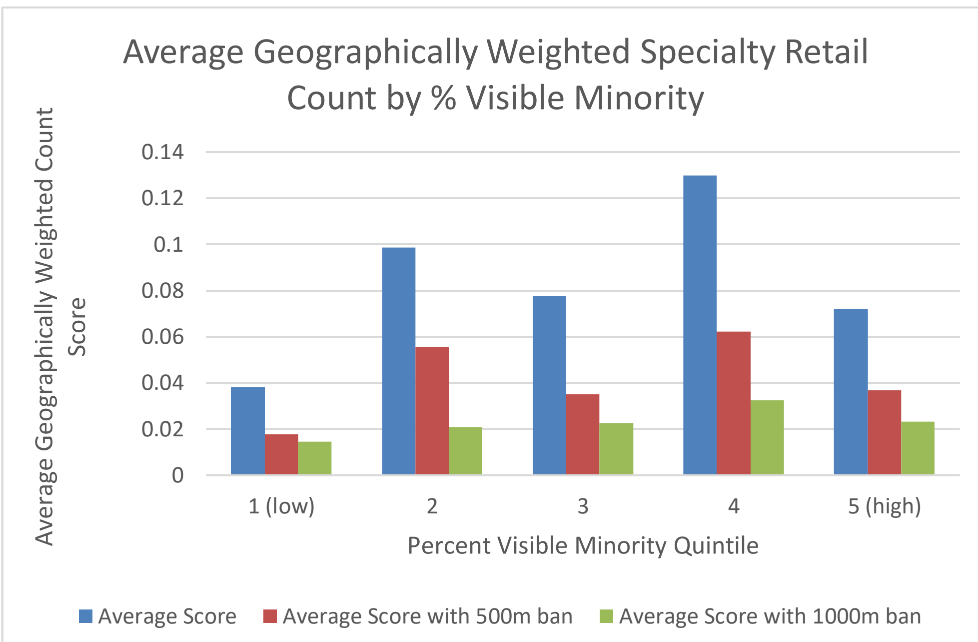

Average Geographically Weighted E-Cigarette Retail Count by % Lone Parent
Average Geographically Weighted Count Score
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1 (low)
2
3
4
5 (high)
Percent Lone Parent Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban


Average Geographically Weighted Specialty Retail Count by % Lone Parent
Average Geographically Weighted Count Score
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 (low)
2
3
4
5 (high)
Percent Lone Parent Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban


Average Geographically Weighted E-Cigarette Retail Count by % LICOAT
Average Geographically Weighted Count Score
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1 (low)
2
3
4
5 (high)
Percent LICOAT Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban


Average Geographically Weighted Specialty Retail Count by % LICOAT
Average Geographically Weighted Count Score
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 (low)
2
3
4
5 (high)
Percent LICOAT Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban


Average Geographically Weighted E-Cigarette Retail Count by % Visible Minority
Average Geographically Weighted Count Score
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1 (low)
2
3
4
5 (high)
Percent Visible Minority Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban


Average Geographically Weighted Specialty Retail Count by % Visible Minority
Average Geographically Weighted Count Score
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 (low)
2
3
4
5 (high)
Percent Visible Minority Quintile
Average Score
Average Score with 500m ban
Average Score with 1000m ban

Curriculum Vitae

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	Research Assistant The University of Western Ontario 2020-2021

Publications:

Martin, G., Bowman, D. D., Graat, M., Clark, A. F., Wray, A. J., Askwith, Z., . . . Gilliland, J. A. (2021). Examining how changes in provincial policy on vape marketing impacted the distribution of vaping advertisements near secondary schools in London, Ontario. *Canadian Journal of Public Health, 112,* 440-448.