



School proximity and census tract correlates of e-cigarette specialty retail outlets (vape shops) in central Texas

Onyema Greg Chido-Amajuoyi^{a,c,*}, Chamberline E. Ozigbu^b, Kai Zhang^a

^a Department of Epidemiology, Human Genetics and Environmental Sciences, The University of Texas Health Science Center at Houston, School of Public Health, United States

^b Department of Health Services Policy and Management, Arnold School of Public Health, University of South Carolina, Columbia, SC, United States

^c Department of Epidemiology, The University of Texas MD Anderson Cancer Center, Houston, TX, United States

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ABSTRACT

E-cigarettes are the most widely used tobacco product among middle and high school students in the United States. This study investigates the proximity of e-cigarette retail outlets (vape shops) to middle and high schools in Austin, Texas, as well as the sociodemographic determinants of outlet presence, at the census tract level. A proximity analysis was conducted using school geo-data derived from the Texas Education Agency and vape shop geo-data derived from a validated online search. Logistic regressions using 5-year estimates of the 2014 American Community Survey were performed to determine the correlates of vape shop presence in census tracts. Overall, 20% of the census tracts in Austin, Texas, had at least one vape shop. The proportion of vape shop-containing census tracts that met the criteria for classification as a “poverty area” (36.5%) was greater than that of vape shop-free census tracts (26.3%). Vape shops were more likely to be present in census tracts classified as poverty areas; however, the odds of vape shop presence declined as the percentage of the non-Hispanic Black population and the percentage of persons aged 10–14 years in census tracts increased. About 40% of the vape shops were located within 0.5 miles of a middle or high school. Sociodemographic disparities exist in the e-cigarette retail environment. In addition to the need to address the disparities identified in this study, our results showing the presence of vape shops within walkable distances of schools calls for tighter regulations and continued surveillance around the marketing practices of e-cigarette retailers.

1. Introduction

Electronic nicotine delivery systems, widely known as “e-cigarettes,” are the most widely used tobacco products among middle and high school students in the United States [1]. Having received widespread market acceptance, particularly among youth, e-cigarettes are fast becoming a symbol of social acceptance in this demographic [2].

Research in the United States has revealed that e-cigarette marketing targets adolescents [3], and e-cigarette retail outlets are more likely to be located in proximity to areas with high adolescent and youth populations, particularly school campuses [4,5]. Consequently, about 3.6 million middle and high school students were documented e-cigarette users in 2018 [6].

The presence of tobacco retailers close to schools is associated with tobacco use initiation and sustained tobacco use among adolescents [7,8]. A nationally representative study of U.S. youths revealed that a high density of tobacco retailers in surrounding environments is

associated with increased likelihood of tobacco use initiation [7]. Similarly, e-cigarette retailer density around schools is associated with an increased likelihood of e-cigarette use among adolescents [9,10]. Furthermore, as with traditional tobacco retail outlets [11], the presence of e-cigarette retail outlets (“vape shops”) in census tracts is associated with neighborhood sociodemographic characteristics [12].

Given the high prevalence of e-cigarette use among adolescents; [1,13,14] the association of vape shop-school proximity with adolescent e-cigarette use [9], and the poor understanding of e-cigarette retailer marketing behaviors, we investigated the proximity of vape shops to middle and high schools, as well as the correlates of outlet presence at the census tract level in Austin, Texas.

* Corresponding author at: Department of Epidemiology, The University of Texas MD Anderson Cancer Center, Houston, TX, United States.

E-mail address: ougreg@mdanderson.org (O.G. Chido-Amajuoyi).

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2. Materials and methods

2.1. Data sources and procedures

2.1.1. Geographic area

The geographic area of investigation was Austin, Texas. The state of Texas is unique given that it is one of the few US states that boasts an ethnically diverse population. Besides consistently ranking among the fastest-growing cities in the United States [15], Austin is even more unique, particularly because the racial/ethnic distribution of the adolescent population (which is the focus of the index study) differs from the overall population. The under-18 population in Austin is predominated by Latino/Hispanics (47.1%), while Whites (35.3%), Blacks (9.0%) and Asians (5.8%) made up the rest of the population [16]. Austin has an area of 271.8 square miles, with 2010 U.S. census-based population estimates placed at 811,456 and 2016 estimates placed at 947,890.

2.1.2. Vape shops

This study was exclusively restricted to tobacco outlets classified as vape shops. The aim was to investigate shops that identified primarily as vape shops, as suggested by business name and suggested activities. We conducted our search using vape-related search terminologies only, such as “vape”, “vape shop”, “vapor”, “e-cig”, and “e-cigarette”. The search for business names, physical addresses and zip codes of vape shops within the City of Austin were conducted via Yelp, Yellow Pages, and Google Maps using a validated methodology (Fig. 1) described previously [17]. According to a systematic review of studies on vape shops, these sources are among the top four used by researchers to identify vape shops [18]. That review recommends using Yelp in combination with another source [18]. Physical addresses were ge-verified using Google Maps and geocoded using BatchGeo, a free, publicly available online geocoding service [19] that has been shown to produce a high level of accuracy [20].

The online search was conducted between October 1, 2016, and

January 5, 2017, and yielded a total of 52 vape shops (Fig. 2) after excluding duplicate vape shops, online vape shops without verifiable physical addresses, and vape shops that fell outside the shapefile boundaries of the geographic region of study.

2.1.3. Middle and high school data

School data were obtained from the Texas Education Agency (TEA) database. This database collects data from central appraisal districts of all 254 counties in Texas. This included geo-data for the 2014–2015 statewide school districts for the state of Texas. The TEA accredits only public schools and has no oversight over private schools or vocational schools in Texas.

Using a shapefile provided by the TEA, we isolated schools in the area of interest using the “select by attribute” feature in ArcGIS 10.4. As surveillance of tobacco use among adolescents revealed that the use of e-cigarettes among middle and high school students more than tripled from 2013 to 2014 [13], we restricted the analyses to middle schools (6th – 8th grade) and high schools (9th – 12th grade), arriving at a total of 94 schools.

2.1.4. Sociodemographic data

Sociodemographic attributes of the City of Austin census tracts were derived from the TIGER/Line census tract map of Travis County, Texas, and the 5-year estimates of the 2014 American Community Survey (ACS). These data were obtained from the U.S. Census Bureau website. Sociodemographic variables of interest were the total population per census tract, total population male, total population female, percent distribution of adolescents and adults aged 10–24 years, percent distribution of racial/ethnic groups (Hispanic, non-Hispanic Black, non-Hispanic White, Other) within census tracts and percent families within census tracts that were living below federal poverty level (FPL).

According to the U.S. Census Bureau, a census tract in which more than 20% of the residents live below the FPL is considered a “poverty area” [21]. We therefore used the percentage of families living below the FPL as a direct index of poverty status of a census tract.

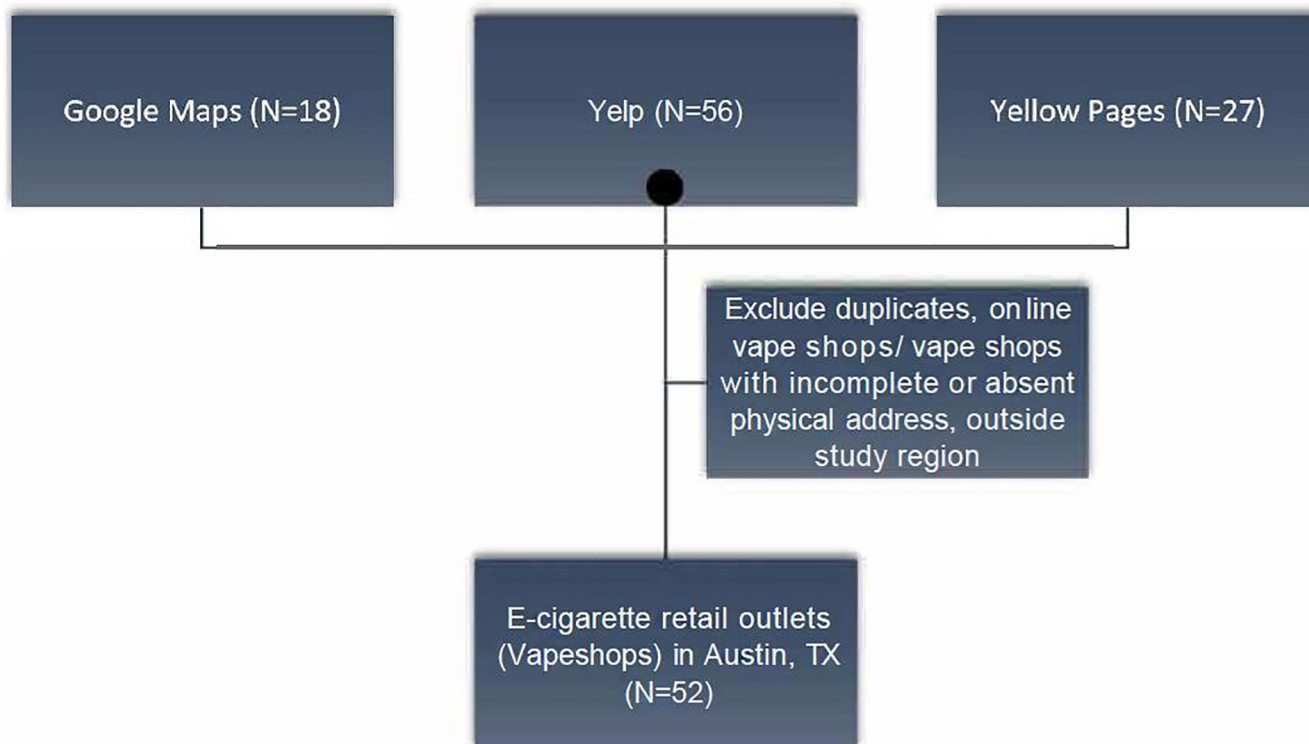


Fig 1. Methodology and results of online search for Vape shops in Austin, TX.

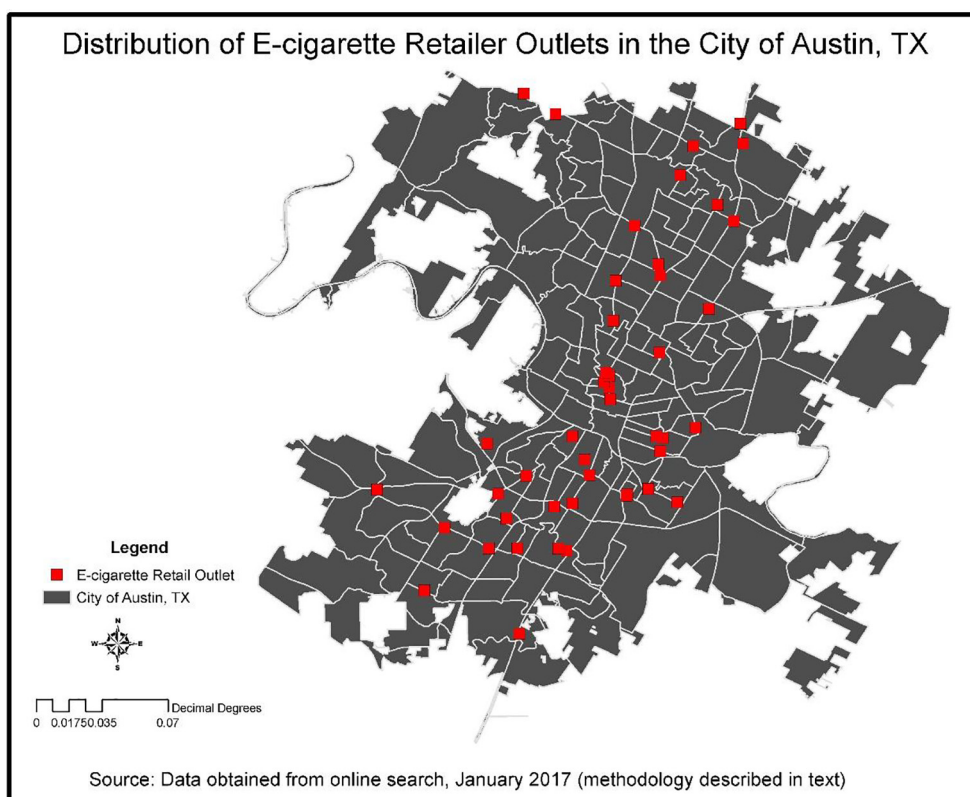


Fig 2. Distribution of vape shops in Austin, TX.

The selection of study sociodemographic covariates was largely informed by the findings of pertinent studies. For example, we used the percentage of families living below the FPL as an index of the socioeconomic status of census tracts because Marashi-Pour et al. found that neighborhoods with low socioeconomic status have a higher likelihood of high tobacco retail outlet density [22]. We chose to include race/ethnicity as a covariate because previous studies demonstrated that neighborhoods with predominant racial minority populations are more likely to have vape shops and traditional tobacco retail outlets [23–25].

2.2. Data analysis

We used a spatial approach to evaluate sociodemographic disparities in the e-cigarette retail environment and to evaluate the proximity of retailers to middle and high schools. Because census tracts are not available at the city level in the U.S. Census Bureau database, we obtained a Metro service area shape file of Austin and merged it to the TIGER/Line census tract map of Travis County using the “clip” tool on in ArcGIS 10.4. This yielded a shape file of Austin with all its census tracts. Because we obtained a Metro service area shapefile of Austin, we had to exclude from our clipped file neighboring census tracts belonging to Counties other than Travis County but were served by the City of Austin Metro service. These includes counties with FIP codes 053 (Burnet County), 491 (Williamson County), and 209 (Hays County). Using the “join” tool in ArcGIS, we matched sociodemographic data derived from the 2014 ACS 5-year estimates with their corresponding census tracts by GeoIDs. Unmatched census tracts belonging primarily to bordering towns and counties were excluded ($n = 18$). Study analysis was then conducted for 200 census tracts within the city of Austin.

2.2.1. Proximity of vape shops to middle and high schools

To determine the proximity of vape shops to middle and high schools in Austin, we performed a proximity analysis using the

“multiple ring buffer” tool in ArcGIS 10.4. Ring buffers were set at 0.5 and 1 mile. The primary proximity outcome was the presence of a vape shop within a 0.5-mile radius of middle or high schools. Half a mile has been shown to be a reasonable walking or biking distance for youth actively commuting to and from school in urban settings. [26–28]

2.2.2. Correlates of vape shop presence in census tracts

After appending sociodemographic variables from the 2014 ACS 5-year estimates to their corresponding census tracts, we created tables to describe the sociodemographic distribution of census tracts by the absence or presence of vape shops. Census tract level demographic variables provided in the ACS database are presented as proportions of the population and therefore analyzed as stand-alone variables. A multivariate logistic regression was used to examine the odds of vape shop presence in census tracts by census tract demographic characteristics. Independent variables (census tract demographic characteristics) were fitted into a single regression model simultaneously and each considered as an independent predictor. This analysis was carried out using STATA 14.

3. Results

We identified and geocoded 52 vape shops (Fig. 2). The sociodemographic characteristics of census tracts by vape shop presence or absence are given in Table 1. Of the 200 census tracts analyzed, 20% had at least one vape shop. Among vape shop-containing census tracts, the mean number of vape shops per tract was 1.23 (SD = 0.48; range = 1–3). Seven census tracts had more than one vape shop. The mean total population of vape shop-containing census tracts was 4,860 persons, whereas the mean in vape shop-free census tracts was 4,943 persons. Approximately 37.5% of vape shop-containing census tracts met the criteria for classification as a poverty area (over 20% of residents living below the FPL), whereas only 26.3% of vape shop-free census tracts qualified as a poverty area. Non-Hispanic Whites were the

Table 1
Demographic characteristics of 200 census tracts by vape shop presence and proximity of vape shops to middle and high schools in Austin, TX.

Characteristics	City of Austin Census Tracts	
	Vape Shop Present (n = 40) mean (SD)	Vape Shop Absent (n = 160) mean (SD)
Total Population	4859.9 (2214.6)	4942.9 (2699.4)
Total Population Male	2422.2 (1084.0)	2509.6 (1369.2)
Total Population Female	2437.7 (1162.4)	2433.2 (1360.5)
Percent Non-Hispanic White	77.7 (12.5)	75.1 (13.8)
Percent Non-Hispanic Black	5.7 (5.5)	8.8 (9.7)
Percent Other Race	6.8 (7.2)	7.3 (8.3)
Percent Hispanic	32.7 (19.3)	34.3 (22.3)
Percent Aged 10-14yrs	4.0 (2.3)	5.6 (2.9)
Percent Aged 15-19yrs	6.9 (11.5)	5.2 (2.6)
Percent Aged 20-24yrs	12.3 (14.6)	8.2 (6.7)
Percent Families Living Below FPL	n (%)	n (%)
0-20% below FPL	25 (62.5%)	118 (73.8%)
20-40% below FPL	9 (22.5%)	36 (22.5%)
40-60% below FPL	4 (10%)	6 (3.75%)
60-80% below FPL	2 (5%)	0 (0%)

Vape Shop	Within Distance of a Middle School/High School		
	< 0.5mile	0.5-1 mile	< 1 mile
Frequency (%)	21 (40%)	25 (48%)	46 (88%)

Abbreviations: SD, standard deviation; FPL, federal poverty level.

predominant racial group in all census tracts, regardless of the presence (77.7%) or absence (75.1%) of vape shops. Census tracts that had at least one vape shop had a lower proportion (5.7%) of Non-Hispanic Black residents than those that had no vape shop (8.8%). Similarly, there was a lower proportion of Hispanics (5.7%) in census tracts that had vape shops.

3.1. Proximity of vape shops to middle and high schools

The results of the proximity analysis using multiple ring buffers are shown in Fig. 3. Of the 52 vape shops identified, 21 (40%) were located within 0.5 miles of a middle or high school, and 25 (48%) were located between 0.5 mile and 1 mile from a middle or high school. Thus, 88% of the vape shops (46 of 52) were located within a mile of middle or high schools (Table 1).

3.1.1. Correlates of census tract vape shop presence

The results of the multivariate logistic regression performed to investigate the association between census tract sociodemographic characteristics and vape shop presence/absence are given in Table 2. We found significant associations between vape shop presence and census tract age, race, and socioeconomic distribution.

For every unit increase in the percent population of families living below FPL in a given census tract, the odds of presence of vape shops in such census tracts increased by 1.07 (adjusted odds ratio [aOR], 1.07; 95% CI, 1.010-1.125). Age distribution was marginally associated with vape shop presence; as the percent population of 10 to 14 year olds increased, the odds of presence of vape shop in census tracts decreased (aOR: 0.76 [95% CI: 0.631-0.927]). Similarly, as the percent population of non-Hispanic Blacks increased, the odds of a census tract having a vape shop decreased (aOR, 0.90; 95% CI, 0.815-0.997).

4. Discussion

We found that one-fifth of the census tracts within the City of Austin had at least one vape shop and that a significant proportion of these outlets were located within walking distance of a middle or high school.

We also found associations between census tract sociodemographic characteristics and the vape shop presence. Vape shops were more likely to be located in census tracts with a higher proportion of families living below the FPL but less likely to be located in census tracts whose populations are predominated by non-Hispanic Blacks or 10- to 14-year-olds.

Our finding that vape shops are more likely to be located in census tracts with a higher proportion of families living below the FPL corresponds with previous studies that show a heightened tendency for tobacco retail outlets to be located in regions of low socioeconomic status [5,25,29]. However, our findings are in contrast to those of previous studies of the e-cigarette retail environment, which did not find poverty to be a significant predictor of vape shop presence in census tracts [10,25].

Previous studies examining racial disparities in tobacco retail environment found that neighborhoods with a higher proportion of Blacks had a high density of tobacco retail outlets [30]. However, our study showed that census tracts with a high proportion of non-Hispanic Blacks were less likely to have a vape shop. This finding mirrors the results of a study of vape shops in New Orleans [12].

Fakunle et al. [29] examined tobacco outlet density in two counties with predominant Black populations and found differences in outlet densities when stratified by socioeconomic status. Such that, the county with a higher socioeconomic status had a significantly lower tobacco outlet density. The sustained impact of socioeconomic strata on tobacco outlet density even after eliminating the influence of race, is indicative of the strength of this relationship. This finding provides some perspective for the interpretation of our finding that vape shops were less likely to be located in regions with predominant Black populations, in the context of an increased odds of outlet presence in poverty areas.

Like previous studies [4,5], our study revealed that many vape shops were close to schools. Having tobacco outlets close to schools is a proven effective strategy employed by the traditional tobacco industry to recruit young smokers, and our findings suggest that the e-cigarette industry is adopting this tactic. Doing so might be yielding results, given the positive association between vape shop proximity to schools and adolescent e-cigarette use [9], the remarkably high prevalence of e-cigarette use among middle and high schoolers [1], and studies identifying vape shops as a leading source of adolescents' procurement of e-cigarettes [31,32].

Vape shops may be more appealing to this population owing to the availability of a wide array of e-cigarette products and accessories, opportunities to meet peers and share experiences and opportunities to participate in "fun" activities or recreational sporting events such as "cloud chasing" [33,34]. Despite prohibitory regulations, minors are able to purchase e-cigarettes in vapes shops [32]. Although our study found no positive association between the percentage of youth in a census tract and vape shop presence, this finding should be interpreted cautiously, as its predictive significance is flawed by the fact that some adolescents may attend school in tracts outside that of their residence.

Therefore, given a growing body of evidence suggesting that the e-cigarette industry deliberately markets their products to minors, we speculate that they may also do so in the school environment. Ribisl et al. found that banning tobacco retail within 1000 feet of schools can achieve the dual benefit of decreasing the density of tobacco retailers around schools and removing disparities seen in tobacco retail environment [30]. Given our finding that vape shops are within walkable distance of schools, further investigation using person-level data is needed to examine the impact of vape shop-school proximity on e-cigarette use behaviors among adolescents.

The use of e-cigarettes among middle and high school adolescents in the United States has been declared an epidemic [35]. In response, the U.S. Food and Drug Administration (FDA) has advanced new policies aimed at curbing youth access to flavored tobacco products [36]. While these are important steps in curbing adolescent tobacco use, other avenues for regulation, such as ordinances barring the presence of vape

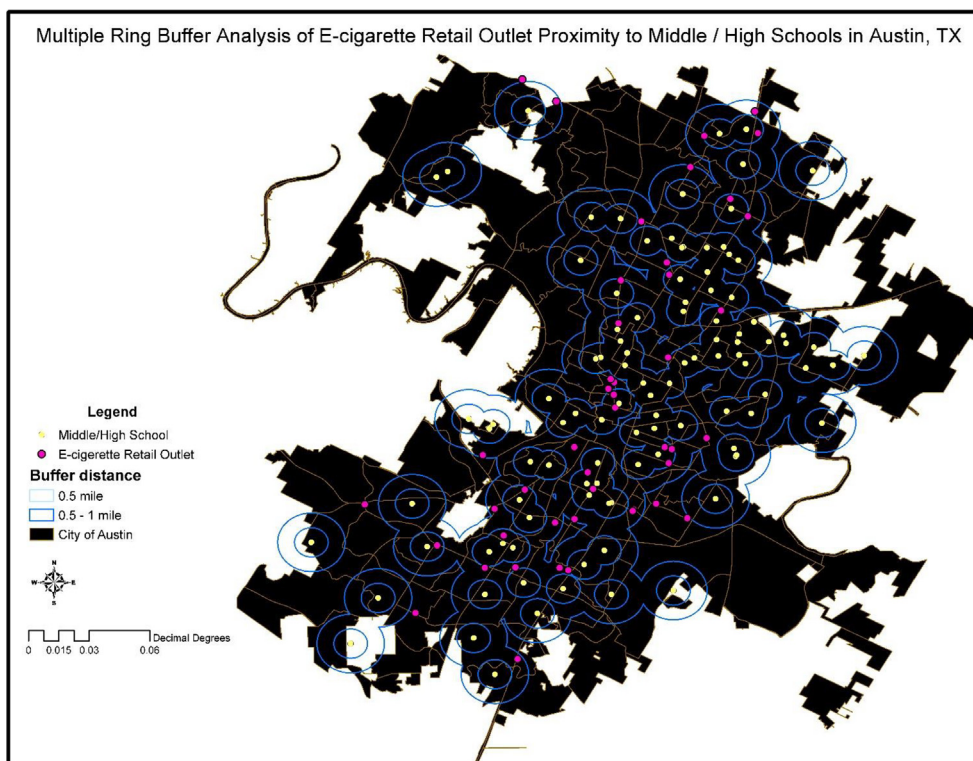


Fig 3. Multiple ring buffer analysis of vape shop proximity to middle and high schools in Austin, TX.

Table 2
Odds of vape shop presence relative to demographic characteristics of census tracts in Austin, TX (n = 200).

Characteristic	aOR [95% CI]	p
Families Living Below the FPL ^a	1.07 [1.010–1.125]	0.021
Total Population by Sex		
Female	1.00 [1.000–1.002]	0.072
Male	1.00 [0.998–1.000]	0.104
Age ^a		
10–14 y	0.76 [0.630–0.927]	0.006
15–19 y	0.99 [0.901–1.080]	0.769
20–24 y	0.97[0.912–1.033]	0.352
Race/ethnicity ^a		
Hispanic	1.01 [0.968–1.043]	0.794
Non-Hispanic White	1.00 [0.928–1.047]	0.644
Non-Hispanic Black	0.90 [0.815–0.997]	0.044
Other	0.96 [0.851–1.069]	0.451

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; FPL, federal poverty level.

shops within walking distance from schools, should be considered. Schools, particularly those in geographic regions that attract e-cigarette retailers, must be vigilant in preventing their students from accessing or using e-cigarettes. Such schools might consider amending their curriculum to include programs that shed light on the harms of e-cigarette use, particularly the dangers and adverse effects of nicotine exposure such as nicotine dependence.

4.1. Limitations

Our study was not without potential limitations. First, our search methodology was confined exclusively to vape shops and thus may not have provided a complete picture of the overall availability of e-cigarettes. E-cigarettes can also be purchased through other channels, such as online retailers and convenience stores. More so, we could not absolutely verify through a field-based inspection that shops identified

as vape shops sold only e-cigarettes and e-cigarette accessories. Second, our online search for vape shops ended in January 2017, and the population and practices of e-cigarette retailers in Austin may have changed since then. Third, our study did not account for private and vocational schools, as the TEA database collects data on public schools only.

Another potential limitation of our study is that we did not explore the effect of tobacco outlet density on our study outcomes. Bostean et al. [10] found a significant association between poverty and the presence of vape shops in census tracts; however, this relationship was lost when the author controlled for tobacco retail outlet density. In another study, Dai et al. [25] did not control for tobacco outlet density but still found no significant association between poverty and the presence of vape shops in census tracts in both urban and rural regions. Although an analysis of tobacco outlet density was beyond the scope of the present study, the potential interaction between tobacco outlet density and vape shop presence should be investigated in future analyses of this region.

5. Conclusion

The FDA has full regulatory oversight over all tobacco products including e-cigarettes [37]. This oversight presents a unique opportunity for more stringent surveillance of the practices of e-cigarette retailers. The findings of the present study reinforce the urgent need to take steps to curb the targeted marketing of tobacco products to adolescents. Moreover, our index study contributes to a growing body of literature pointing to the existence of socioeconomic disparities in the tobacco retail environment. Such evidence stresses the need to institute regulations and policies aimed at protecting these disadvantaged populations.

6. Human subjects approval statement

Study did not involve human participants.

Conflict of interest

None.

CRedit authorship contribution statement

Onyema Greg Chido-Amajuoyi: Writing - review & editing, Supervision. **Chamberline E. Ozigbu:** Writing - review & editing. **Kai Zhang:** Supervision.

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