Introduction

Tobacco retailer density refers to the concentration of tobacco retailers in a specific location; here defined as the number of retailers per 1,000 people. It is well established that proximity to a tobacco outlet is a risk factor for tobacco initiation and use. In 2012, the Surgeon General found that "neighborhoods that are more densely populated with stores selling tobacco may promote adolescent smoking, not only by increasing access, but also by increasing environmental cues to smoke."[1] Density also impacts cessation; ready availability of tobacco products in both the individuals' residential neighborhood and broader community activity spaces can hamper smoking cessation.[2]

In order to help reduce youth initiation and smoking rates, many U.S. cities have implemented tobacco-free zones near schools.[3] This strategy, or variations thereof, have been implemented outside of the United States as well: China, Turkey, and Ghana have tobacco sales restrictions related to educational institutions and, in 2003, India banned the sale of tobacco within 100 yards of educational institutions.[4] Another way to reduce density is to limit the total number of tobacco retailers permitted to operate in a community. Hungary serves as an example of this approach, allowing only one "National Tobacco Shop" for every 2,000 residents.[5]

Neither the state of Maryland nor any of its 24 local jurisdictions have laws limiting tobacco retailer density. However, Montgomery County is unique in that it does have laws that restrict manufacturer distribution. In 2020, the county enacted two bills that prohibited manufacturers from distributing specific tobacco products to retail stores near schools. The first, Bill 29-19, prohibited manufacturers from distributing any electronic cigarette to any retail store within 0.5 miles of any middle school or high school in the county.[6] The second, Bill 32-19, prohibited manufacturers from distributing any flavored electronic cigarette to any retail store within 0.5 miles of any elementary, middle, or high school, library, or recreational facility in the county.[7] In that same year, Montgomery County changed its zoning code so that a vape shop was required to

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[1] U.S. Department of Health and Human Services. Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2012.

[2] Shareck M, Datta GD, Vallée J, Kestens Y, Frohlich KL. Is Smoking Cessation in Young Adults Associated With Tobacco Retailer Availability in Their Activity Space? Nicotine Tob Res. 2020 Apr 17;22(4):512-521. doi: 10.1093/ntr/nty242. PMID: 30418634; PMCID: PMC7164576.

[3] Ackerman A, Etow A, Bartel S, Ribisl KM. Reducing the Density and Number of Tobacco Retailers: Policy Solutions and Legal Issues. Nicotine Tob Res. 2017 Feb;19(2):133-140. doi: 10.1093/ntr/ntw124. Epub 2016 Apr 28. PMID: 27127232; PMCID: PMC5234362.

[44] *Id.*

[5] *Id.*

[6] Codified at Montgomery County Code, Chapter 24, Health and Sanitation, § 24-15. https://codelibrary.amlegal.com/codes/montgomerycounty/latest/montgomeryco_md/0-0-0-132730

[7] Codified at Montgomery County Code, Chapter 24, Health and Sanitation, § 24-16. https://codelibrary.amlegal.com/codes/montgomerycounty/latest/montgomeryco_md/0-0-0-132738

be located a minimum of 0.5 miles from a middle or high school.[8] However, the zoning ordinance allows a vape shop to continue as a nonconforming use if a middle or high school is established within 0.5 miles of a pre-existing vape shop. Holistically, these laws mean that in Montgomery County there should be very few, if any, vape shops located near a middle or high school, no electronic smoking devices should be available for sale in any retail store that is within 0.5 miles of a middle or high school, and no flavored electronic smoking devices should be available for sale in a retail store that is within 0.5 miles of an elementary school. It is beyond the scope of this project to delve deeply into the efficacy of these laws, but it is noteworthy that Montgomery County has some of the lowest youth tobacco use rates in the state.

This study provides a current snapshot of tobacco retailer density in Maryland and considers the relationship between tobacco use rates and density. The Hilltop Institute at the University of Maryland, Baltimore County (UMBC), conducted all spatial analyses in this report.

Methodology

Data

Tobacco Retailer Locations

The Maryland Alcohol, Tobacco, and Cannabis Commission (ATCC) provided a list of tobacco retailers that was current as of October 2023. Retailers in this file were separated by the type(s) of tobacco product(s) they were licensed to sell, including cigarettes, OTP, and electronic smoking devices. The file contained a unique state-issued identification number for each retailer location, which allowed retailers licensed to sell more than one tobacco product at a single location to only be counted once in the analyses. The unduplicated list contained 6,425 retailers, though one was removed because it had a Florida address. The final list included 6,424 retailers. Using the Microsoft Bing Maps Application Programming Interface (API), retailer addresses were geocoded: i.e., find the point location (latitude and longitude), county, and census tract of each retailer.

High School Locations

A list of all public schools in Maryland as of the calendar year 2022 containing each school's name, address, and grade levels (elementary, middle, or high, or some combination of the three) was retrieved from the Maryland State Department of Education (MSDE) website.[9] This list was filtered to include only schools offering high school grade levels, and the 268 remaining schools' addresses were geocoded. Only high schools were included in this study because of constraints

[8] Montgomery County Zoning Ordinance, Chapter 59 of the Montgomery County Code, Division 3.5., Section 3.5.11. https://codelibrary.amlegal.com/codes/montgomerycounty/latest/montgomeryco_md_zone2014/0-0-0-1946

[9] Maryland State Department of Education. (2023). Public use data for download: NCES school directory. https://reportcard.msde.maryland.gov/Graphs/#/DataDownloads/datadownload/3/17/6/99/XXXX/2022

in separating middle and elementary schools. Figure 1 maps the locations of all licensed tobacco retailers and high schools in Maryland.

Adult Smoking Rates and Youth Tobacco Use Rates

Adult data comes from non-institutionalized Maryland residents ages 18 and older. County-level youth tobacco use and adult cigarette smoking rates came from the Maryland Department of Health's MD-IBIS Dataset Query System. This site allows public users to submit requests for excerpts from the Maryland Behavioral Risk Factor Surveillance System (BRFSS), Youth Risk Behavior Survey/Youth Tobacco Survey (YRBS/YTS). Specifically, we used the percentage of high school-aged youth (ages 15 – 18) who reported currently using any type of tobacco product and the percentage of adults who currently smoke cigarettes, by county[10]. The most recent data available at the time analyses were performed was from 2022 for adults and the 2020-2021 school year for youths. Age-adjusted rates were used for adult cigarette use while only crude rates were available for youth tobacco use.

County and Census Tract Population Estimates

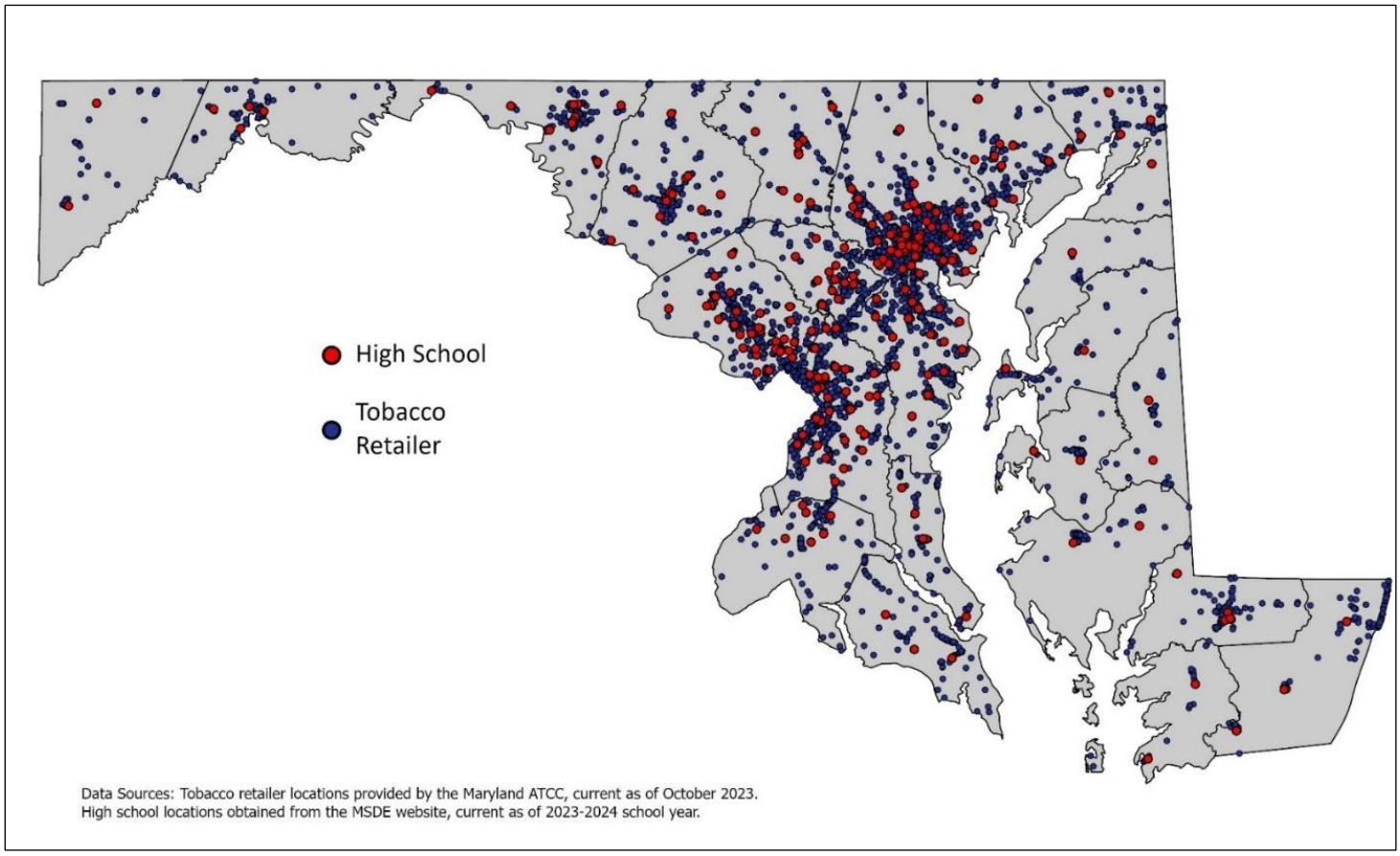
Data on county and census tract populations came from the American Community Survey (ACS) 2018 to 2022 5-year estimates. These files were downloaded from IPUMS's National Historical Geographic Information System (NHGIS) service.

[10] Current use for youths defined as smoking cigarettes or cigars or using smokeless tobacco or electronic vapor products in the past 30 days, and for adults as having smoked at least 100 cigarettes in their life AND currently smoke every day or some days.

Figure 1. Licensed Tobacco Retailers and High Schools

Methods

Hilltop created a series of tables presenting the percentages of adult cigarette smokers and youth tobacco users by county. Hilltop then used ArcGIS Pro to map the geographic distribution of these percentages.



Retailer locations were aggregated to find the number of retailers in each county. These counts were then divided by the ACS 5-year population estimates for the county and multiplied by 1,000 to find the number of retailers per 1,000 county residents. The same process was repeated to find the number of retailers per 1,000 census tract residents.

Hilltop also performed a “nearest neighbor” analysis to find the closest high school to each tobacco retailer. Then, the driving times in minutes between each retailer-school pair were found using the Microsoft Bing Maps API. Driving times for all pairs within a given census tract were aggregated, and the mean number of minutes between each retailer and the nearest high school was calculated for each census tract.

Hilltop also divided the state into two-square mile units, or grid cells, and found the mean drive times to the nearest high school for all retailers within each grid cell. Hilltop used grid cells because they are a standardized areal unit that allows results to be presented visually without distorting the relationship between the value being measured and the geography. Differences in mean driving times across the geographic units of analysis were categorized and then displayed on a map, with longer driving times represented by darker colors. Aggregating to a geography that differs in size across the study area, such as a census tract, means that rural areas with darker colors appear more prominently on the map and may draw attention disproportionate to the underlying data, such as the low retailer density in that same geography. Two square miles was chosen as the grid cell size because that is roughly the average distance between each retailer and the nearest high school.

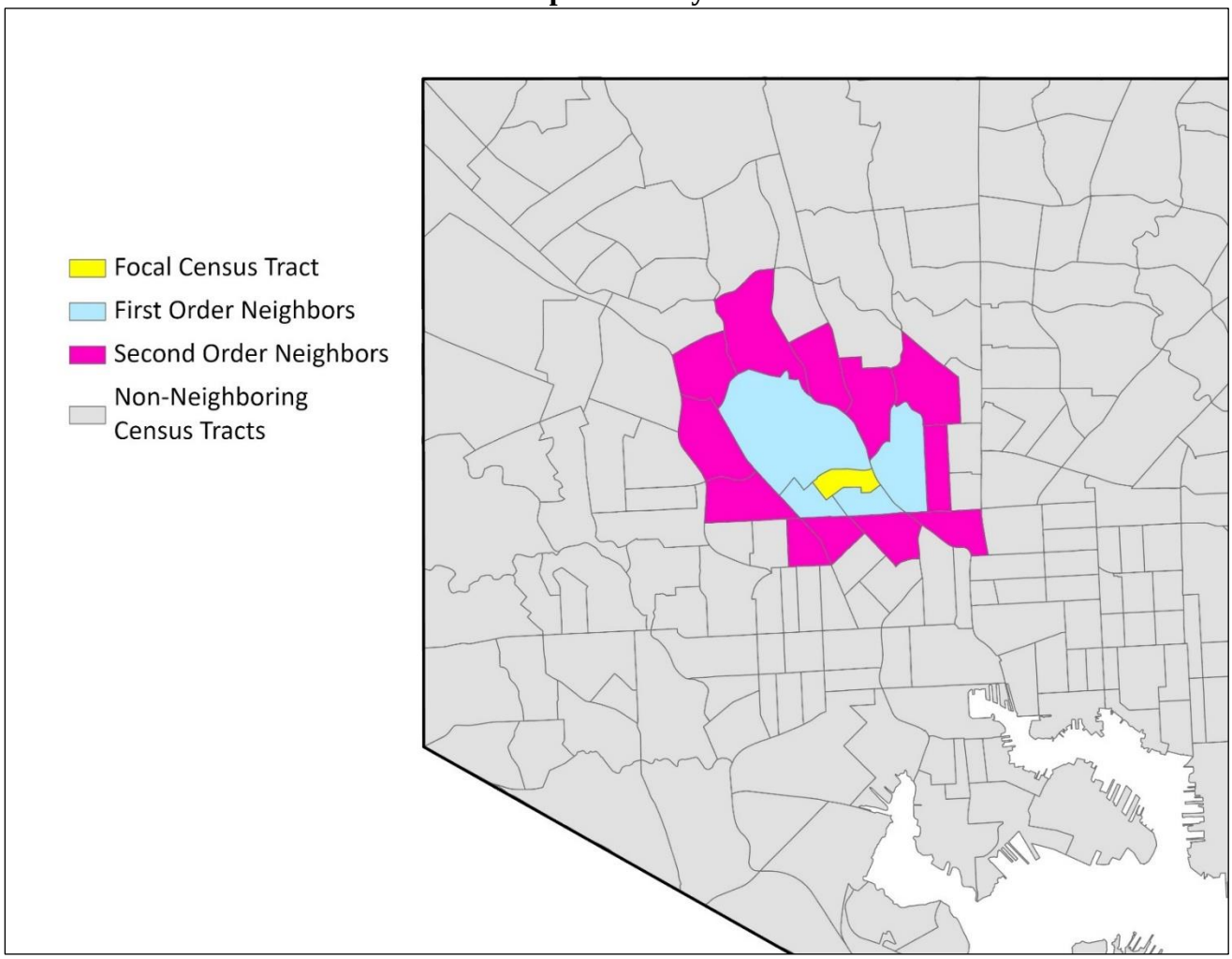
Statistical analyses were conducted to test for the presence of spatial autocorrelation (i.e., the tendency of nearby things to be similar) in the geographic distribution of retailers per 1,000 census tract residents. Specifically, local versions of the Getis-Ord G* (pronounced "G star") and Moran's I tests were used to identify clusters of census tracts with similarly high or low rates of retailers per population relative to the statewide average, as well as census tracts with a significantly higher or lower rate than the tracts they neighbored. Since these tests compare the value for each census tract, along with the values of its neighbors, to the overall value of the state, the first step was to define "neighbors."

Hilltop used two definitions of neighbor:

- "First order" neighbors are census tracts that share any length of border with a focal census tract.
- "Second order" neighbors include the first order neighbors of a focal census tract, as well as any other census tracts that share any length of border with the first order neighbors.

Figure 2 compares first and second order neighbors for a focal census tract in Baltimore City.

Figure 2. Visual Comparison of First and Second Order Definitions of Neighbors Used in Spatial Analyses



Neighbors can be defined in many ways, including using proximity or using distance. For instance, neighbors can be defined as all census tracts with a border within five miles of the central point of a focal census tract. Proximity was chosen for these analyses because, while there has been research suggesting that close proximity to tobacco retailers increases tobacco use, there is little research on the exact distance beyond which people are unwilling to travel for tobacco products.[11,12] Census tracts are, by design, much smaller and more tightly packed in urban areas, so deciding on a fixed distance to apply to all census tracts would have resulted in the creation of neighborhood units (i.e., groupings of neighboring census tracts) in urban areas containing many more census tracts and retailers than neighborhood units in rural areas, and some rural census tracts would likely have had no neighbors at all and would have been

[11] Purushothaman, V., Cuomo, R. E., Li, J., Nali, M., & Mackey, T. K. (2022). Association of tobacco retailer count with smoking population versus vaping population in California (2019). Archives of public health, 80(1), 42. https://doi.org/10.1186/s13690-022-00799-1

[12] Chuang, Y. C., Cubbin, C., Ahn, D., & Winkleby, M. A. (2005). Effects of neighbourhood socioeconomic status and convenience store concentration on individual level smoking. *Journal of Epidemiology and Community Health*, *59*(7), 568–573. https://doi.org/10.1136/jech.2004.029041

erroneously excluded from spatial analyses. By using a proximity-based definition of neighbor, all census tracts containing at least one retailer could be included in the analyses regardless of size.

Once the definition of neighbor was determined, a Z-score (a type of statistic) was calculated for each census tract to determine if there was a statistically significant difference in the number of retailers per 1,000 residents in the census tract relative the statewide average, while accounting for each census tracts' neighbors. Statistically significant Z-scores in these analyses indicated that, relative to the statewide average and while accounting for the values in neighboring census tracts, the unexpectedly higher or lower number of retailers per 1,000 residents in a census tract was extremely unlikely to have been due to random chance. The result is that each census tract is assigned one of three "cluster" values:

- High-value cluster indicated that the focal census tract was part of a cluster of census tracts with a ***higher-than-expected*** number of retailers per 1,000 population.
- Low-value cluster indicated that the focal census tract was part of a cluster of census tracts with a ***lower-than-expected*** number of retailers per 1,000 population.
- The focal census tract is not part of a cluster, indicating that the number of retailers per 1,000 population of it and its neighbors does not differ from the statewide average to a statistically significant degree.

The previous overview describes the basic mechanics of both the Getis-Ord G* and Moran's I tests. The Moran's I test then takes the additional step of assessing whether the value of each census tract also differs from the values of its neighbors. This test is useful for identifying outlier census tracts that on their own have much higher or lower values than surrounding geographies ***and*** are part of low- or high-value clusters identified in the Getis-Ord G* test. The Moran's I test assigned each census tract to one of five cluster types:

- Census tract with a ***high*** value surrounded by other census tracts with ***high*** values.
- Census tract with a ***high*** value surrounded by other census tracts with ***low*** values.
- Census tract with a ***low*** value surrounded by other census tracts with ***high*** values.
- Census tract with a ***low*** value surrounded by other census tracts with ***low*** values.
- Not part of a cluster, indicating that the number of retailers per 1,000 population of it and its neighbors does not differ from the statewide average to a statistically significant degree, and the focal census tract also does not differ from its neighbors to a statistically significant degree.

Census tracts with no tobacco retailers were excluded from the spatial analyses.

Results

Retailers

Table 1 shows the total unduplicated number of tobacco retailers in each county and the number of unduplicated retailers per 1,000 county population (retailer density). Nearly two-thirds (n = 4,172; 65.0%) of all licensed retailers were in one of five counties: Baltimore City (n = 1,147; 17.9%), Baltimore County (n = 933; 14.5%), Prince George's County (n = 857; 13.3%), Montgomery County (n = 661; 10.3%), and Anne Arundel County (n = 574; 8.9%). However, of these counties, only Baltimore City had a retailer density (1.96 per 1,000) that ranked in the top half of all counties in Maryland, while Montgomery County had the lowest retailer density (0.63 per 1,000).

Worcester County had the highest tobacco retailer density of 3.18 retailers per 1,000, despite only having the 10th most retailers overall (n = 168; 2.6%). This can be explained by Figure 3B, which shows the high concentration of retailers in Ocean City. Ocean City is a major tourist area, and the large number of retailers in such a small county is primarily due to the county catering to tourists and not full-time residents. If summer visitors were included in the total population, this retailer density number would decrease .

Of the 10 counties with the highest retailer density (from highest to lowest: Worcester, Baltimore City, Kent, Dorchester, Garrett, Talbot, Caroline, Queen Anne's, Cecil, and Allegany), only Worcester, Baltimore City, and Cecil had more than 100 retailers. This survey looks at retailer density per 1,000 people, but there are a number of ways to measure retailer density. A future direction of this research could be to measure retailer density by land area (square miles). Different results may be found with this measure of density, especially in counties with smaller populations and large land areas. Garrett County is one such example; it has only 47 retailers, but the licensed tobacco retailer locations per 1,000 population (retailer density) are high due to the lower population. Baltimore County has significantly more retailers and a larger population, so the licensed tobacco retailer locations per 1,000 population is lower than that of Garrett County. However, Garrett County and Baltimore County have similar land areas, 656 square miles and 598 square miles, respectively. If measuring retailer density by land area, these two counties would look different.

Table 1. Estimated Population, Total Number of Licensed Tobacco Retailers, and Number of Licensed Tobacco Retailers per 1,000 Population, by County

County	Estimated Population, 2022	Number of Licensed Tobacco Retailer Locations	Licensed Tobacco Retailer Locations per 1,000 Population
Allegany	68,161	83	1.22
Anne Arundel	588,109	574	0.98
Baltimore	850,737	933	1.10
Baltimore City	584,548	1,147	1.96
Calvert	93,244	91	0.98
Caroline	33,320	46	1.38

County	Estimated Population, 2022	Number of Licensed Tobacco Retailer Locations	Licensed Tobacco Retailer Locations per 1,000 Population
Carroll	173,225	160	0.92
Cecil	103,876	127	1.22
Charles	167,035	165	0.99
Dorchester	32,557	54	1.66
Frederick	273,829	249	0.91
Garrett	28,856	47	1.63
Harford	261,059	218	0.84
Howard	332,011	238	0.72
Kent	19,289	32	1.66
Montgomery	1,056,910	661	0.63
Prince George's	957,189	857	0.90
Queen Anne's	50,316	68	1.35
Somerset	24,672	30	1.22
St. Mary's	113,814	123	1.08
Talbot	37,663	52	1.38
Washington	154,645	182	1.18
Wicomico	103,815	119	1.15
Worcester	52,827	168	3.18
TOTAL	6,161,707	6,424	1.04

Figure 2 shows a map of retailer density by county, while Figure 3A maps retailer density at the census tract level. These two maps show that the high number of retailers per population observed in Worcester County is primarily due to the concentration of retailers in the northeast corner of the county, where, for example, the census tract containing Ocean City has 31.1 retailers per 1,000 population. Similarly, Baltimore City has several census tracts with some of the highest retailer densities in the state, specifically across the central region of the city. These high density census tracts subsequently drive up the retailer rate for the entire city. Worcester County and Baltimore City examples are shown more clearly in Figure 3B.

Figure 2. County Map of Licensed Tobacco Retailers per 1,000 County Population

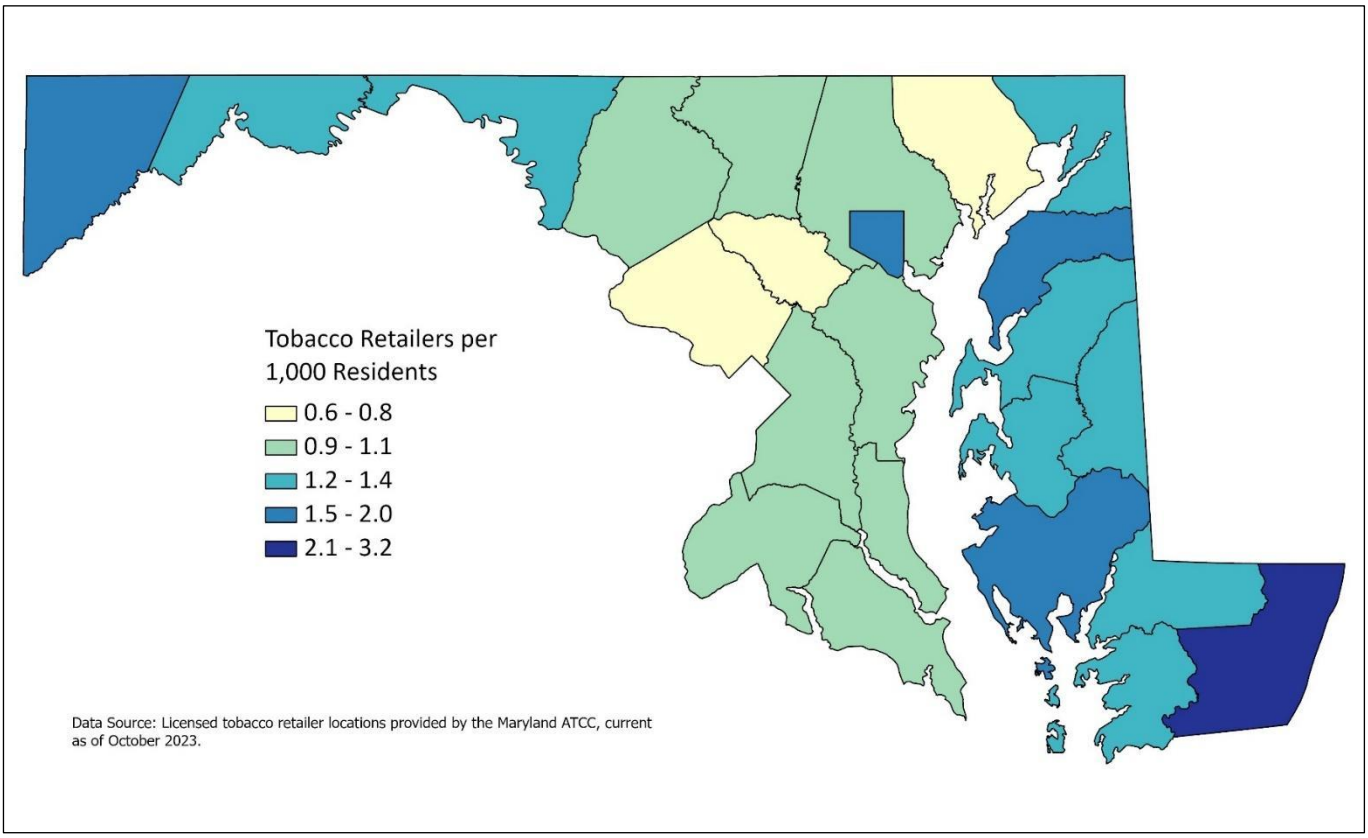


Figure 3A. Census Tract Map of Licensed Tobacco Retailers per 1,000 Census Tract Population

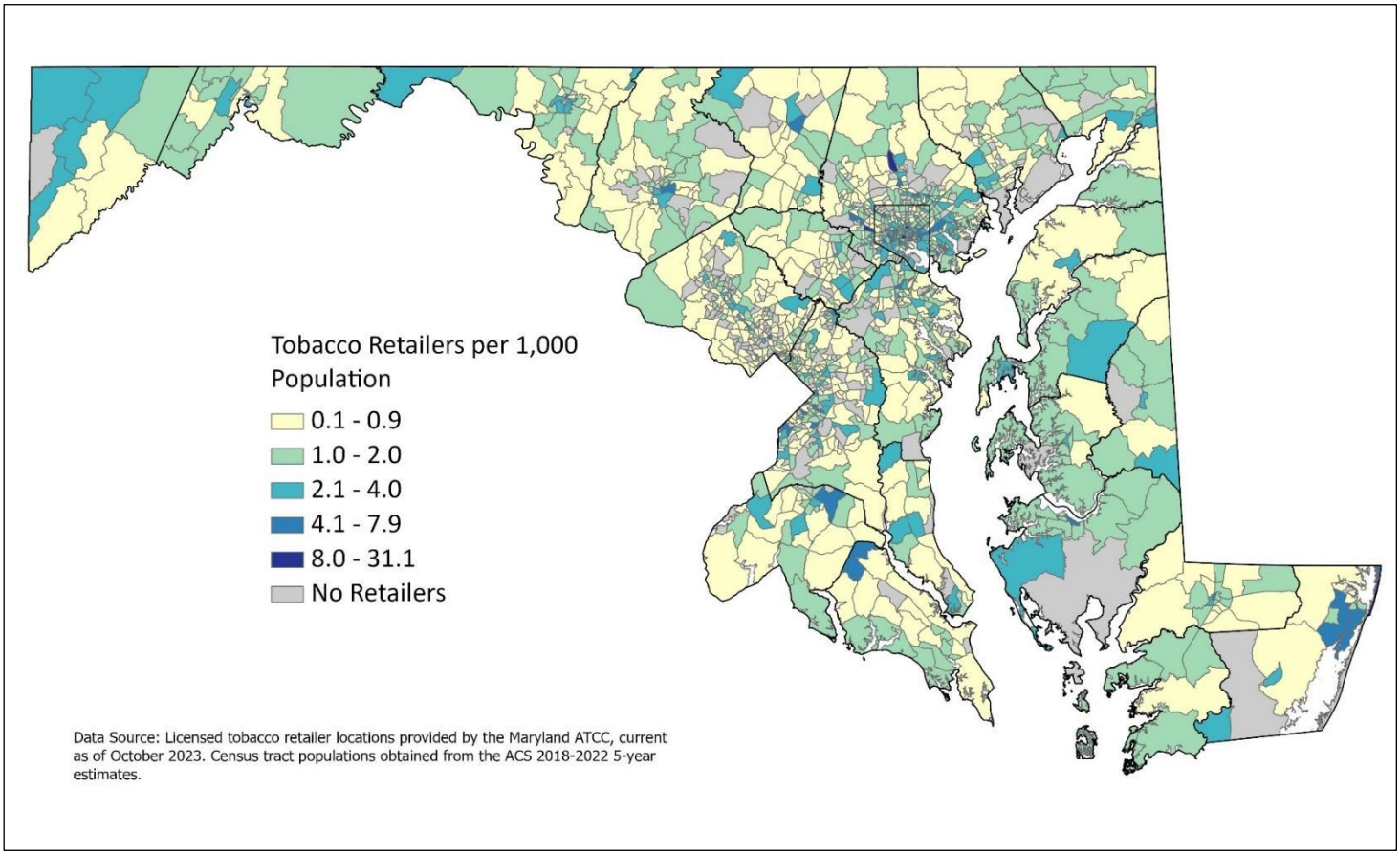
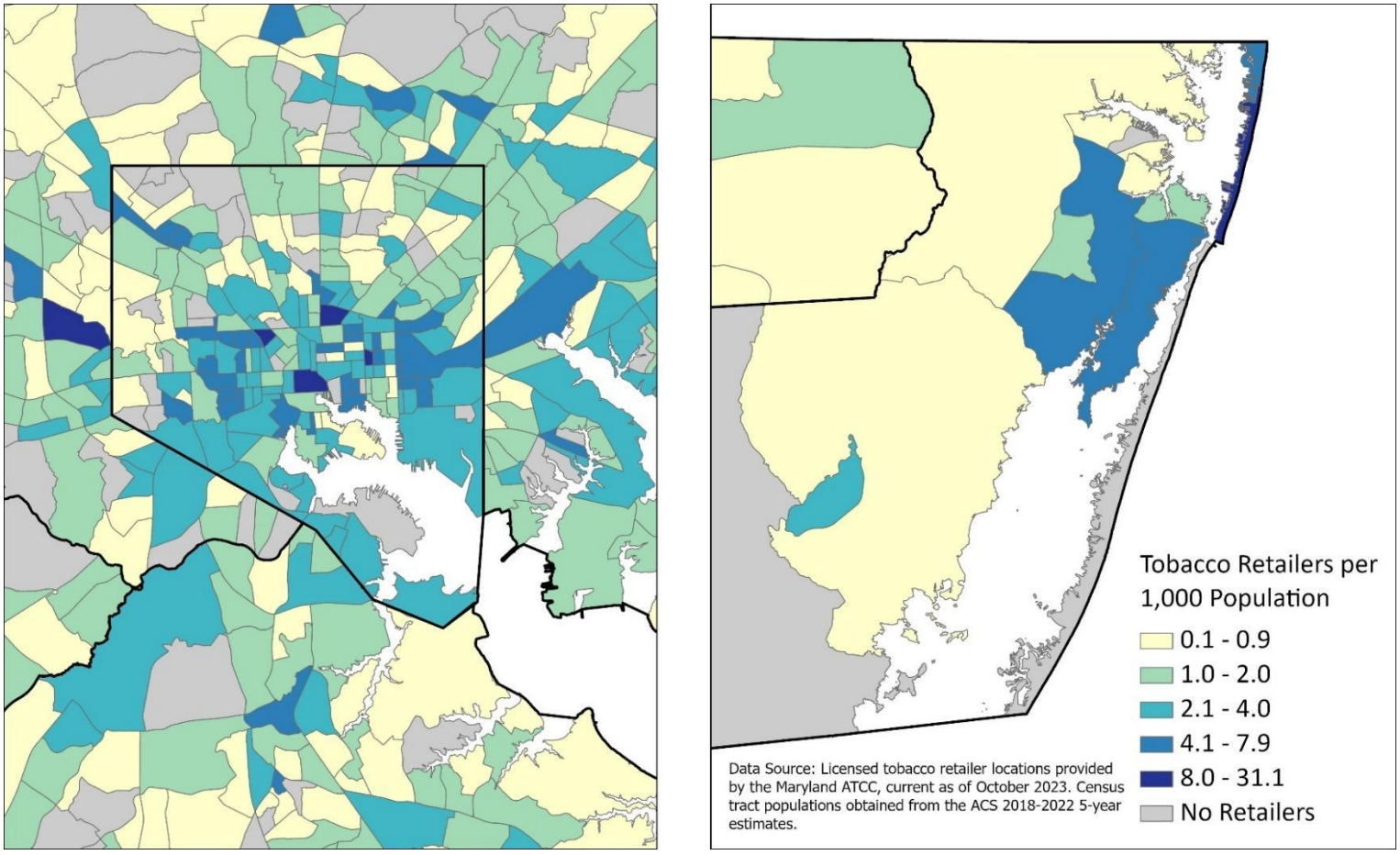


Figure 3B. Census Tract Map of Licensed Tobacco Retailers per 1,000 Census Tract Population, Baltimore City (Left) and Worcester County (Right)



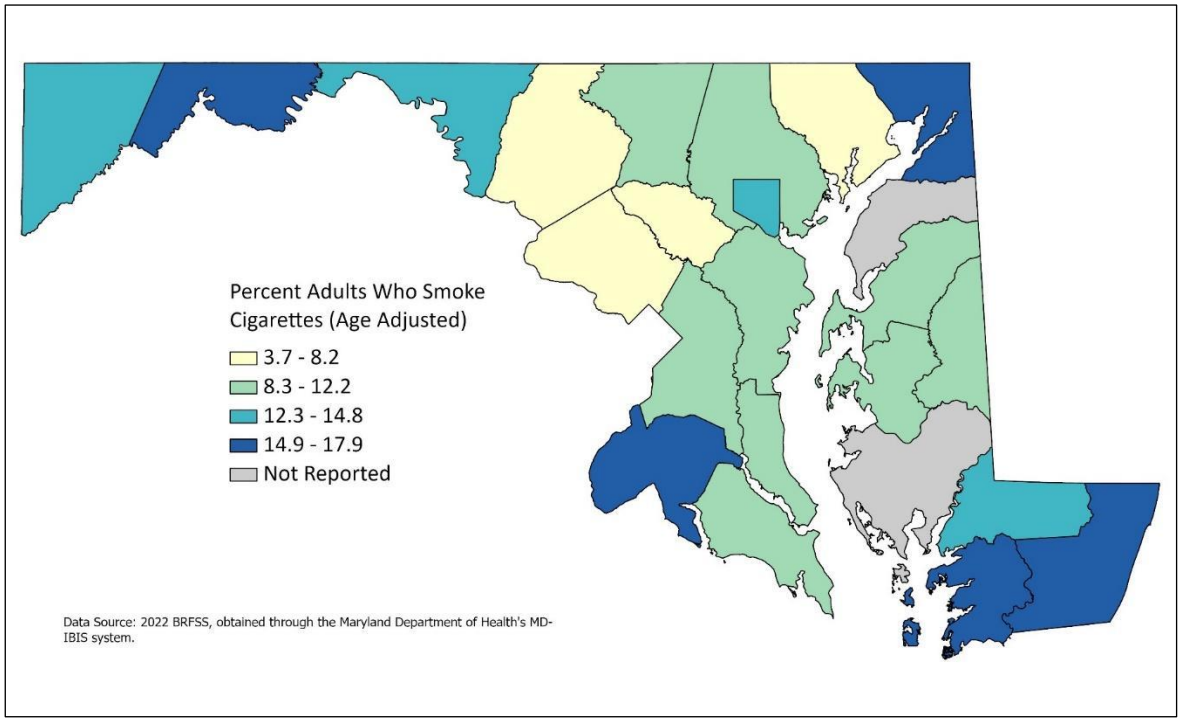
Adults

Table 2 shows the percentage of adults who reported being current cigarette smokers, by county. Current cigarette use among adults ranged from a low of 3.7% in Howard County to a high of 17.9% in Somerset County (data were not reported in the BRFSS for Dorchester and Kent Counties due to unreliable estimates). Figure 4 visualizes the county-level rates among adults and closely mirrors Figure 2, showing that adult smoking rates are higher in counties with larger retailer density.

Table 2. Age-Adjusted County-Level Adult Smoking Rates as Reported to the 2022 BRFSS

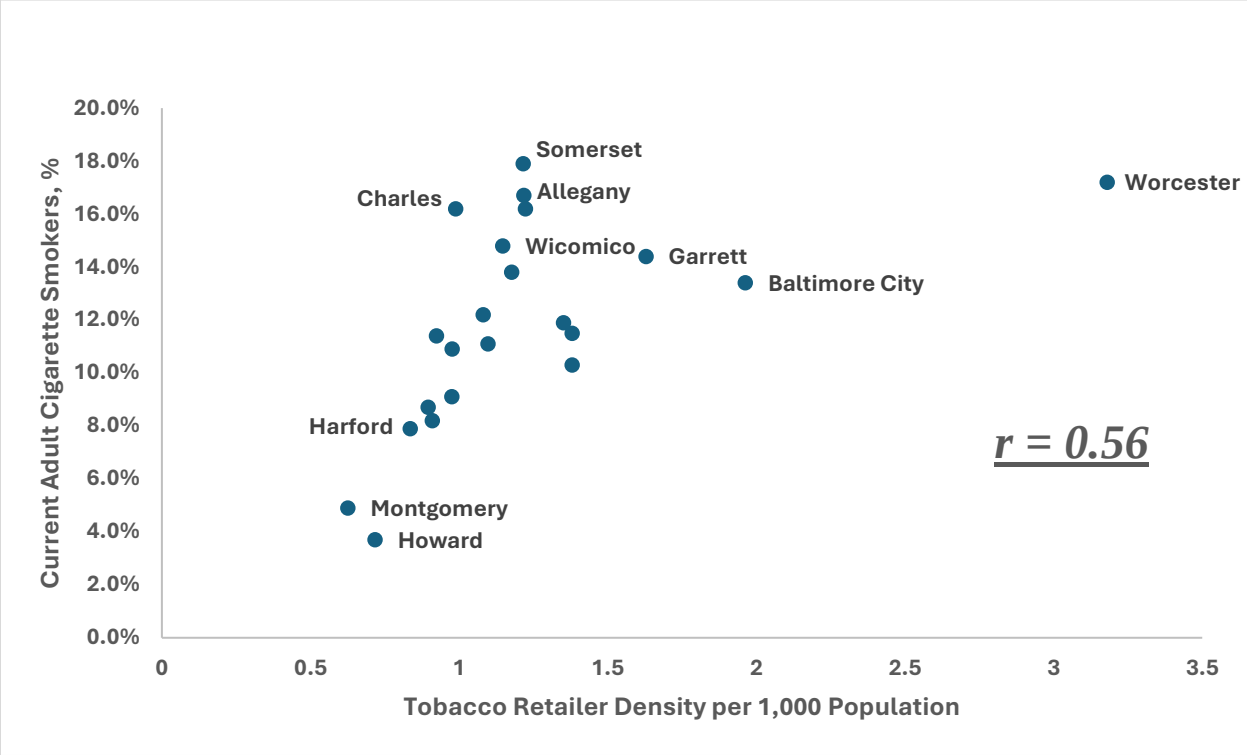
County	Percent of Adults who Reported Being Current Cigarette Smokers
Allegany	16.7%
Anne Arundel	10.9%
Baltimore	11.1%
Baltimore City	13.4%
Calvert	9.1%
Caroline	11.5%
Carroll	11.4%
Cecil	16.2%
Charles	16.2%
Dorchester	Not Reported
Frederick	8.2%
Garrett	14.4%
Harford	7.9%
Howard	3.7%
Kent	Not Reported
Montgomery	4.9%
Prince George's	8.7%
Queen Anne's	11.9%
Somerset	17.9%
St. Mary's	12.2%
Talbot	10.3%
Washington	13.8%
Wicomico	14.8%
Worcester	17.2%
TOTAL	9.8%

Figure 4. Age-Adjusted County-Level Adult Smoking Rates as Reported to the 2022 BRFSS



A scatter plot comparing the estimated percentage of adults in each county who reported being current cigarette smokers at the time of survey response and the number of tobacco retailers per 1,000 county population is shown in Figure 5. A Pearson's correlation coefficient (*r*) of 0.56 was calculated, indicating a fairly strong correlation between adult cigarette use and tobacco retailer density.

Figure 5. Scatter Plot Comparing Estimated Percentage of Current Adult Cigarette Users and Tobacco Retailers per 1,000 Population in Each County.



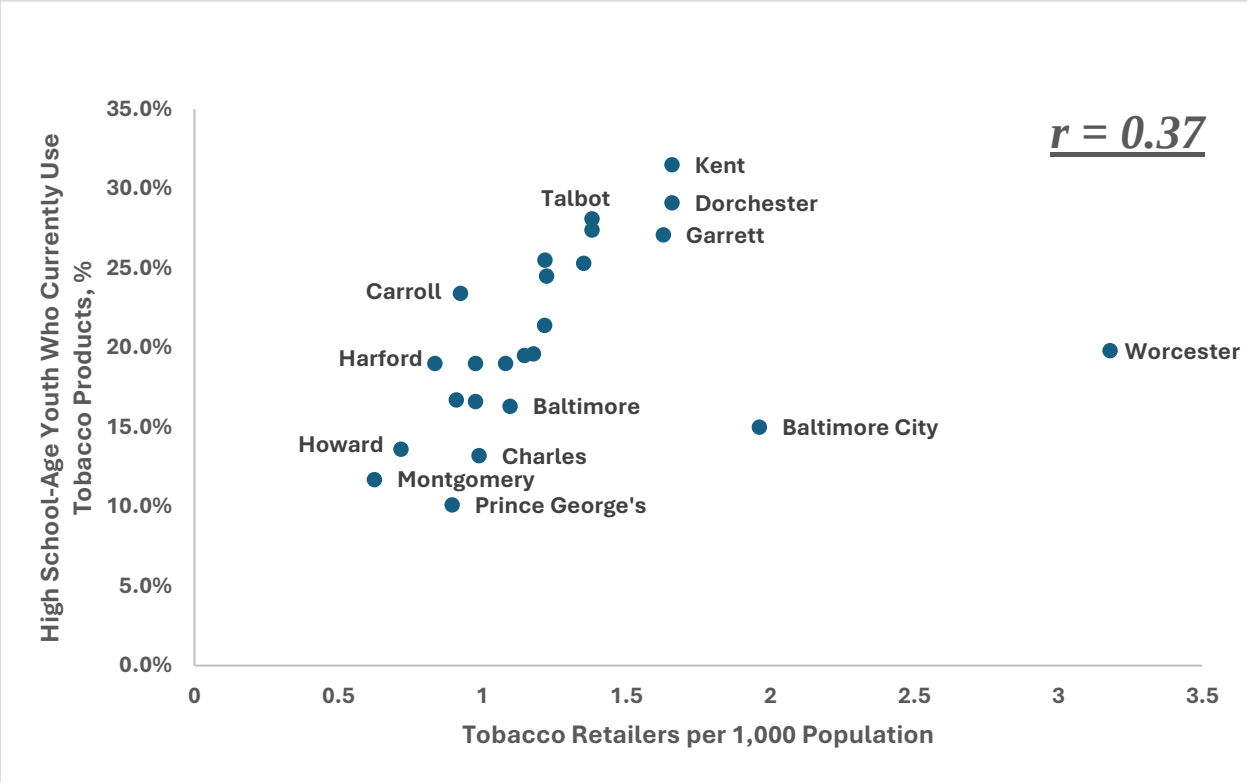
Youth

Table 3 shows the percentage of high school-aged youth who reported currently using any type of tobacco product, by county. Tobacco use among high schoolers varied widely across counties, ranging from a high of 31.5% in Kent County to a low of 10.1% in Prince George's County. Howard County again ranked among the lowest for youth tobacco use, with 13.6% of high schoolers estimated to be current users of any tobacco products. Figure 5 visualizes the county-level rates among youth.

There is no clear correlation between retailer proximity to high school and youth use. For example, Baltimore City has the highest retailer density of all jurisdictions with retailers so close to the high schools that some are on the same block and a 15% current high school tobacco product usage rate. Compare that to Caroline County with a high retailer density but those retailers are not near the two county high schools, even still the percent of high school students who reported being current tobacco product users was much higher than that of Baltimore City.

A moderate correlation (r = 0.37) was found between retailer density and youth tobacco use, as seen in Figure 6. Furthermore, Figures 2 and 7 show that counties with the highest retailer density and highest rates of youth tobacco use are generally the rural counties in the eastern and western parts of the state.

Figure 6. Scatter Plot Comparing Estimated Percentage of Current High School Age Tobacco Users and Tobacco Retailers per 1,000 Population in Each County.



Higher tobacco product use seems to occur in rural counties. Garrett, Kent, Caroline, Talbot, and Dorchester counties have the highest current youth tobacco product use rate followed by Queen Anne's, Cecil, Carroll, and Allegany. There are multiple possible explanations for this, further research could be conducted on factors like average income, education levels, and unemployment rates in these counties, all of which can relate to higher tobacco product usage. These counties generally also have lower populations and can mean decreased services and health communication. The only outlier is Charles County which has a rural designation but falls into the lowest bracket for youth tobacco use. This could be due to the county's proximity to Prince George's County, northern Virginia, and Washington, DC.

Table 3. Crude County-Level Youth Tobacco Use Rates as Reported to the School Year 2020-2021 YRBS/YTS

County	Percent of High Schoolers who Reported Being Current Users of Any Tobacco Products
Allegany	25.5%
Anne Arundel	19.0%

County	Percent of High Schoolers who Reported Being Current Users of Any Tobacco Products
Baltimore	16.3%
Baltimore City	15.0%
Calvert	16.6%
Caroline	27.4%
Carroll	23.4%
Cecil	24.5%
Charles	13.2%
Dorchester	29.1%
Frederick	16.7%
Garrett	27.1%
Harford	19.0%
Howard	13.6%
Kent	31.5%
Montgomery	11.7%
Prince George's	10.1%
Queen Anne's	25.3%
Somerset	21.4%
St. Mary's	19.0%
Talbot	28.1%
Washington	19.6%
Wicomico	19.5%
Worcester	19.8%
TOTAL	15.6%

Figure 7. County-Level Youth Tobacco Use Rates as Reported to the School Year 2020-2021 YRBS/YTS BRFSS

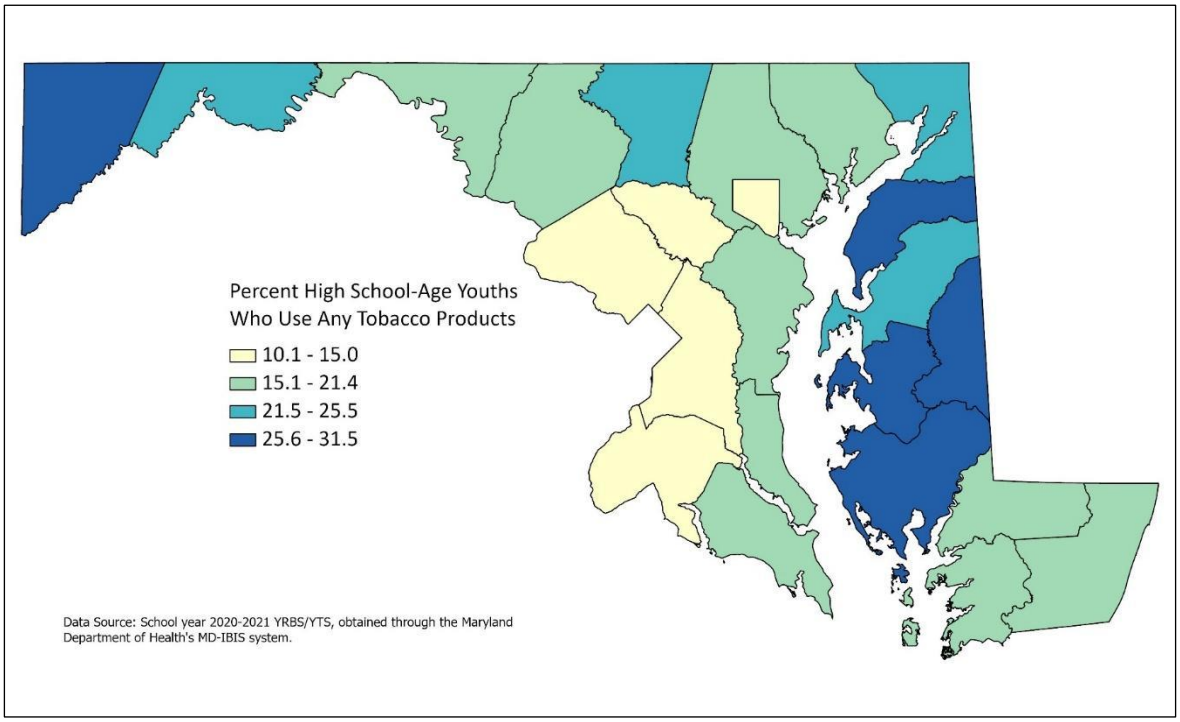


Figure 8 shows the mean drive times in minutes between every retailer and the nearest high school by county. Table 3 shows the mean driving times and driving distances in miles between each retailer and the nearest high school by county. Retailers in Kent (time = 14.12 minutes, distance = 8.89 miles), Worcester (time = 11.48 minutes, distance = 6.67 miles), and Garrett (time = 10.84 minutes, distance = 7.20 miles) Counties had the longest driving times and furthest distances on average to the nearest high school. All other counties had average driving times below ten minutes, and only three others (Caroline, St. Mary's, and Queen Anne's) had average distances longer than five miles.

Figure 8. Map of Mean Drive Times Between Every Licensed Tobacco Retailer and the Nearest High School, Aggregated to the County of the Retailer

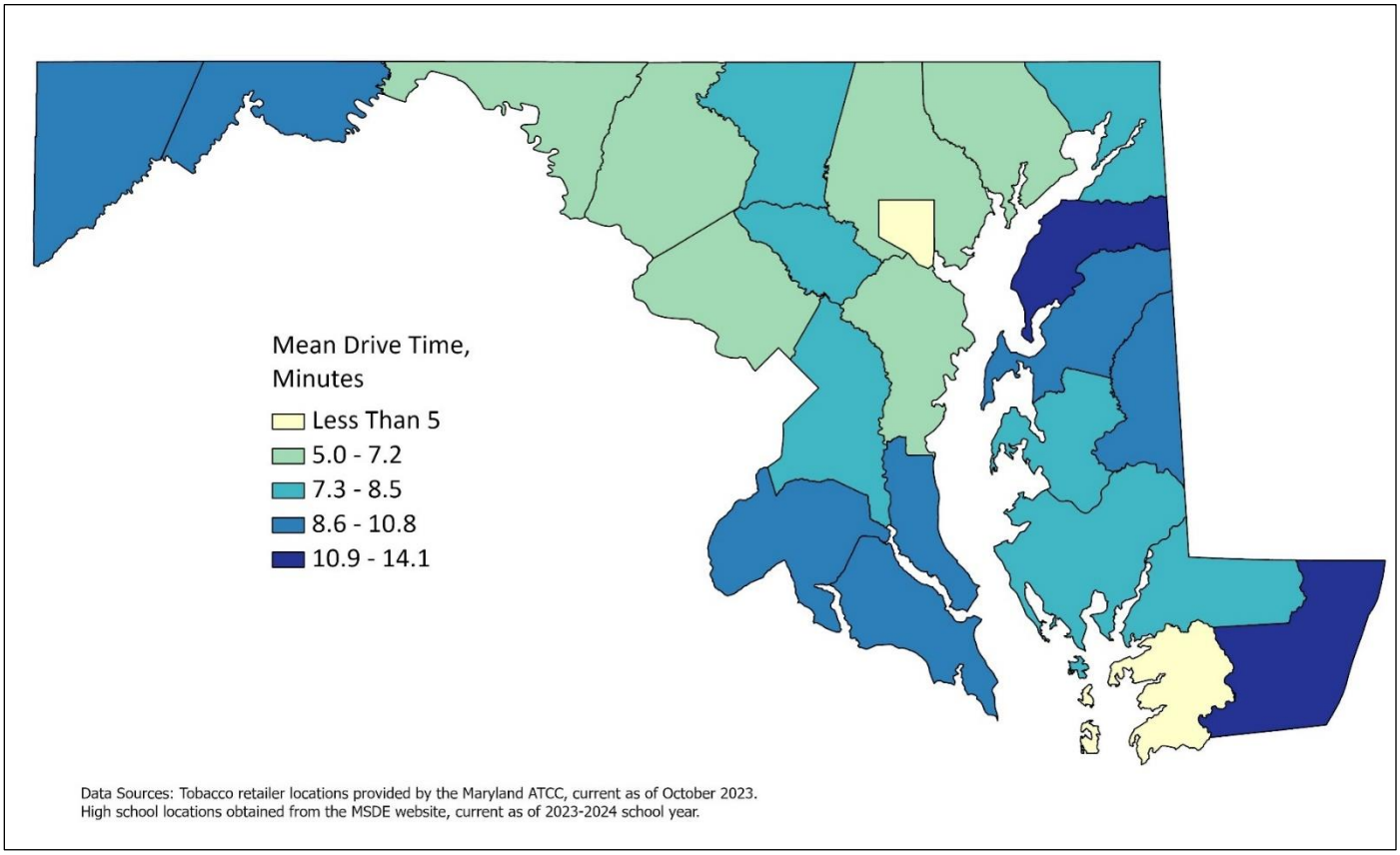


Table 3. Mean Driving Time and Driving Distance Between Every Licensed Tobacco Retailer and the Nearest High School, Aggregated to the County of the Retailer

County	Mean Driving Time, Minutes	Mean Driving Distance, Miles
Allegany	8.96	4.33
Anne Arundel	6.63	2.42
Baltimore	6.03	1.89
Baltimore City	4.92	1.13
Calvert	9.00	4.53
Caroline	9.75	5.81
Carroll	8.47	3.65
Cecil	7.96	3.74
Charles	9.05	4.43
Dorchester	8.02	4.09
Frederick	7.20	2.83
Garrett	10.84	7.20
Harford	6.94	2.84

County	Mean Driving Time, Minutes	Mean Driving Distance, Miles
Howard	8.08	2.97
Kent	14.12	8.89
Montgomery	6.65	1.96
Prince George's	7.43	2.14
Queen Anne's	8.83	5.36
Somerset	4.82	2.41
St. Mary's	9.85	5.75
Talbot	7.61	3.39
Washington	6.55	2.36
Wicomico	8.01	3.66
Worcester	11.48	6.67
TOTAL	**6.97**	**2.58**

Figure 9 shows average driving times aggregated for each census tract, while Figure 10 shows a map of the average drive time between each retailer in two-square mile units (i.e., grid cells) to the nearest high school. As seen in previous figures, urbanized areas such as Baltimore City and the parts of Montgomery and Prince George's Counties that surround Washington, DC, tended to have the most retailers, as evidenced by fewer gray areas. However, the driving time from retailers within each census tract and grid cell to the nearest high school appears, on average, to have been longer for most areas in Montgomery and Prince George's Counties than in Baltimore City. This holds true in most other counties, indicating that Baltimore City's retailers are, on average, closer to high schools (and one another) than retailers in other counties.

Figure 9. Map of Mean Drive Times Between Every Licensed Tobacco Retailer and the Nearest High School, Aggregated to the Census Tract of the Retailer

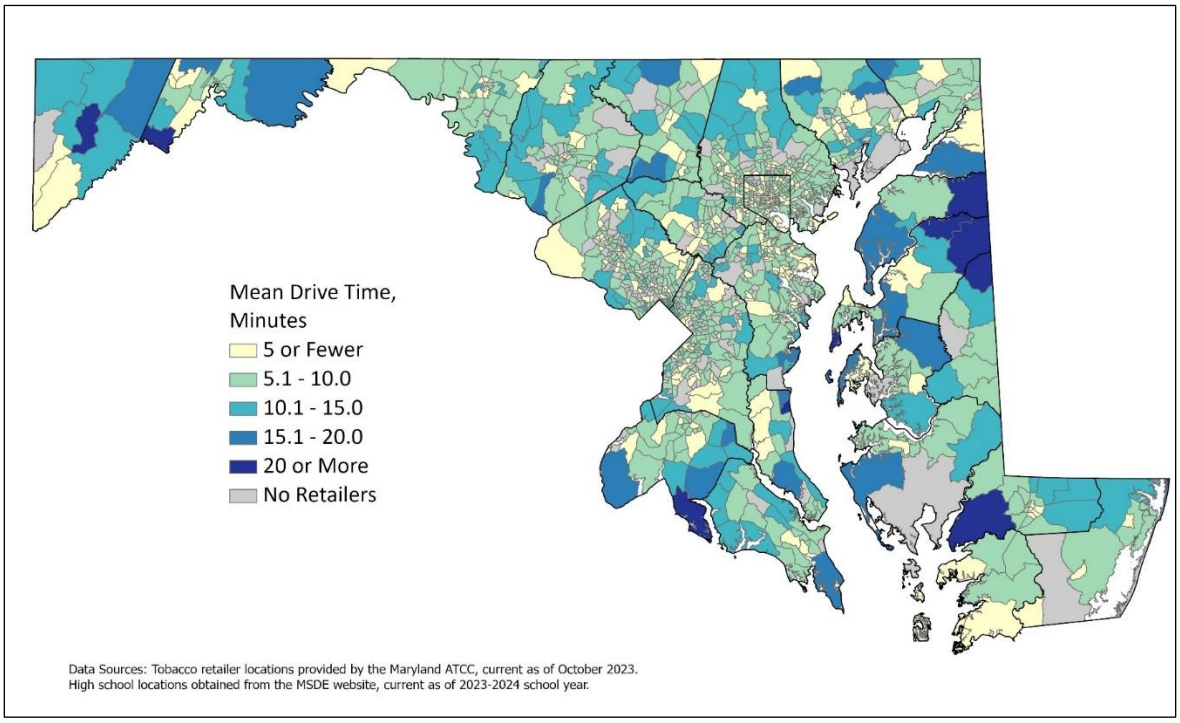
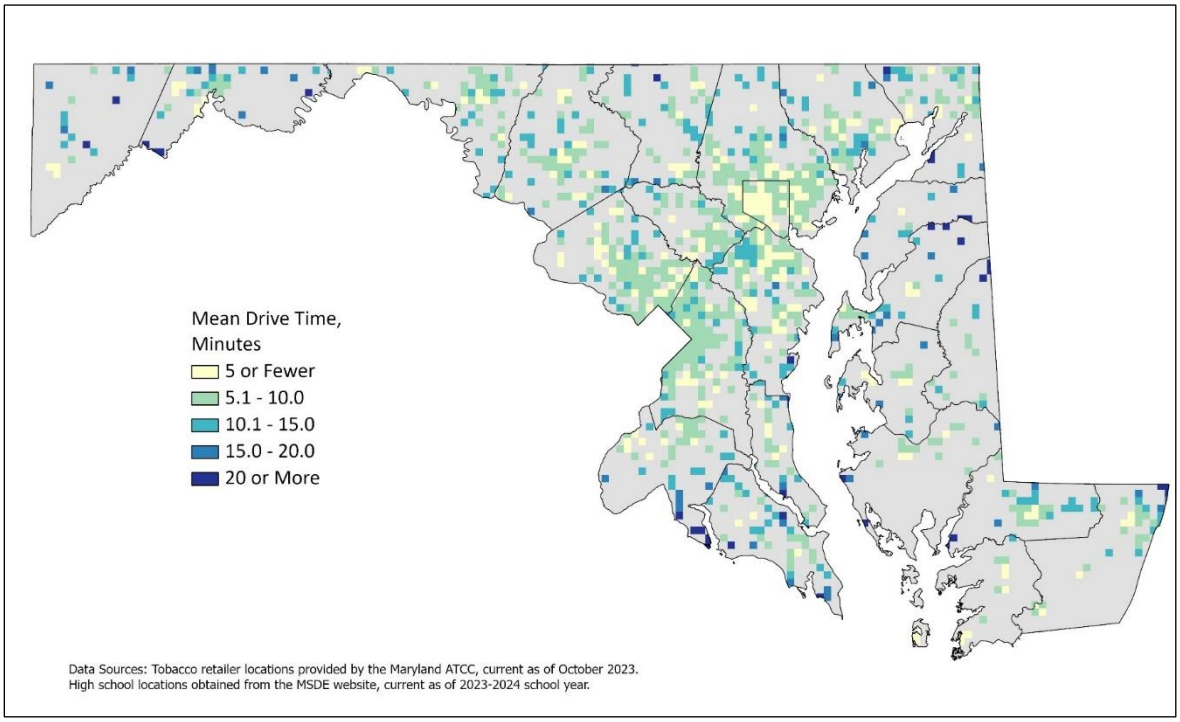


Figure 10. Map of Mean Drive Times Between Every Licensed Tobacco Retailer and the Nearest High School, Aggregated to the Two Square Mile Grid Cell of the Retailer



Figures 11 and 12 present the results of analyses to identify clusters of census tracts with higher-than-expected numbers of retailers per 1,000 population using a first order definition of neighbor. In Figure 10, the results of the Getis-Ord G* first order neighbor analysis, census tracts colored blue had a number of retailers per 1,000 population that was considered much lower than the statewide value of 1.04, while red census tracts had much higher values of retailers per 1,000 population. Despite the high number of retailers overall in Montgomery and Prince George's County, there were sizable clusters of census tracts with low number of retailers per population, with smaller clusters also found in nearby Frederick, Carroll, Howard, Anne Arundel, and Calvert Counties. Central Baltimore City had a large swathe of census tracts with higher numbers of retailers per 1,000 population than the rest of the state.

Figure 12 shows the results of the Moran's I analysis that aims to identify not only clusters of census tracts with high or low values relative to the statewide average but also outlier census tracts that have higher or lower values than neighboring tracts. Red and blue census tracts have essentially the same meaning in this map as in Figure 11 (high values surrounded by other high values [HH] and low values surrounded by other low values [LL]). Yellow and teal census tracts are considered outliers among their neighbors: yellow census tracts are those that have low values but are surrounded by tracts with high values (LH), while the teal tracts are high values surrounded by lower values (HL). There are numerous HL outlier census tracts in Figure 12 that were identified as single low-value clusters (i.e., clusters of one) in Figure 11. This occurs because the value of the isolated census tract is high relative to its neighbors, but when the value is combined with the values of neighboring census tracts, the resulting mean is lower than the statewide mean, and the difference is statistically significant. In effect, the relatively high value of the single census tract is washed out by the lower values of the neighboring census tracts in the more global Getis-Ord G* analysis. The same explanation can also be applied to the LH census tracts that were identified by the Getis-Ord G* analysis as part of a cluster of census tracts with high values.

Figure 11. Map Showing the Results of the Getis-Ord G* Analysis Using a First Order Definition of Neighbor to Identify Clusters of Census Tracts with High or Low Values of Retailers per 1,000 Population

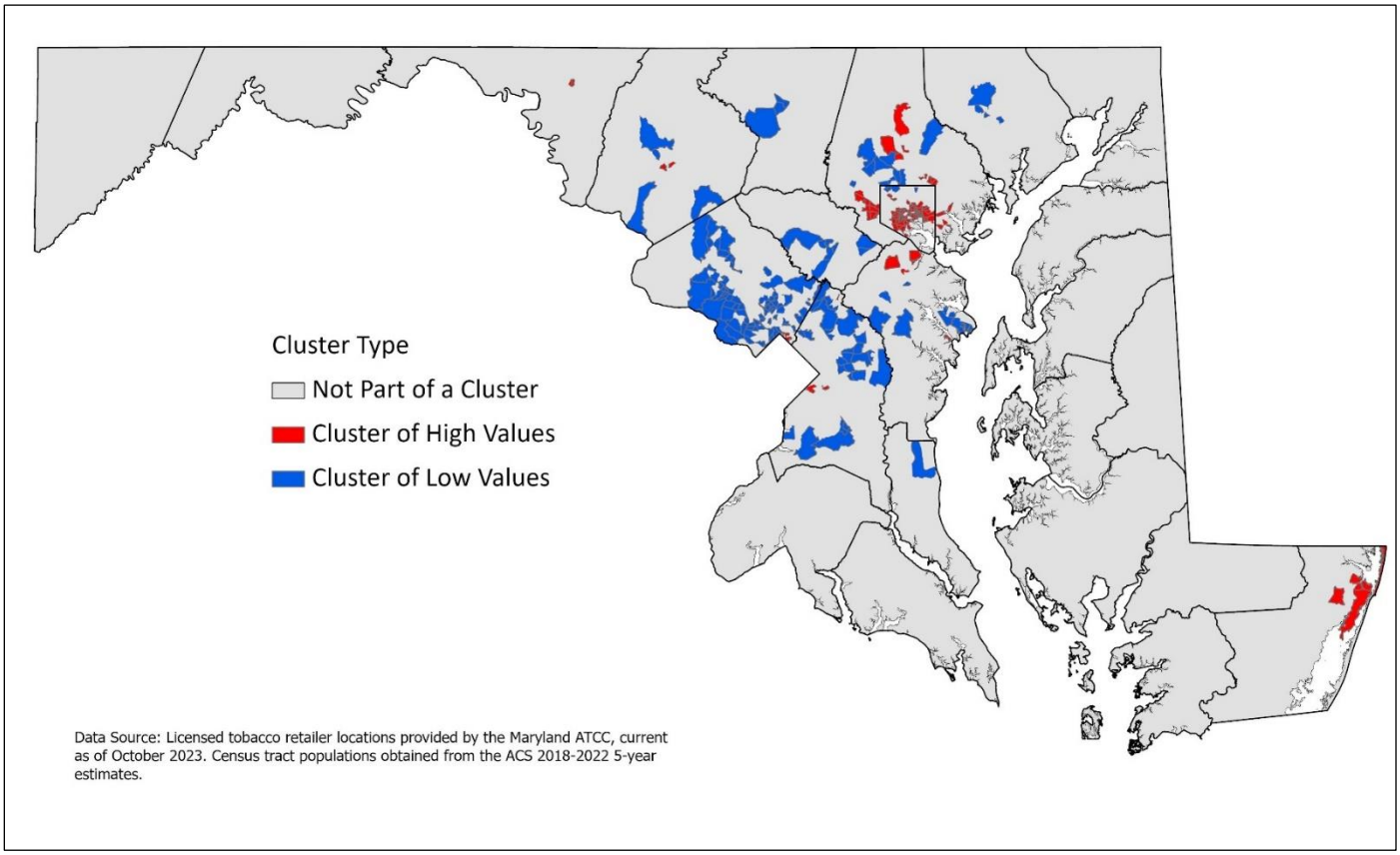
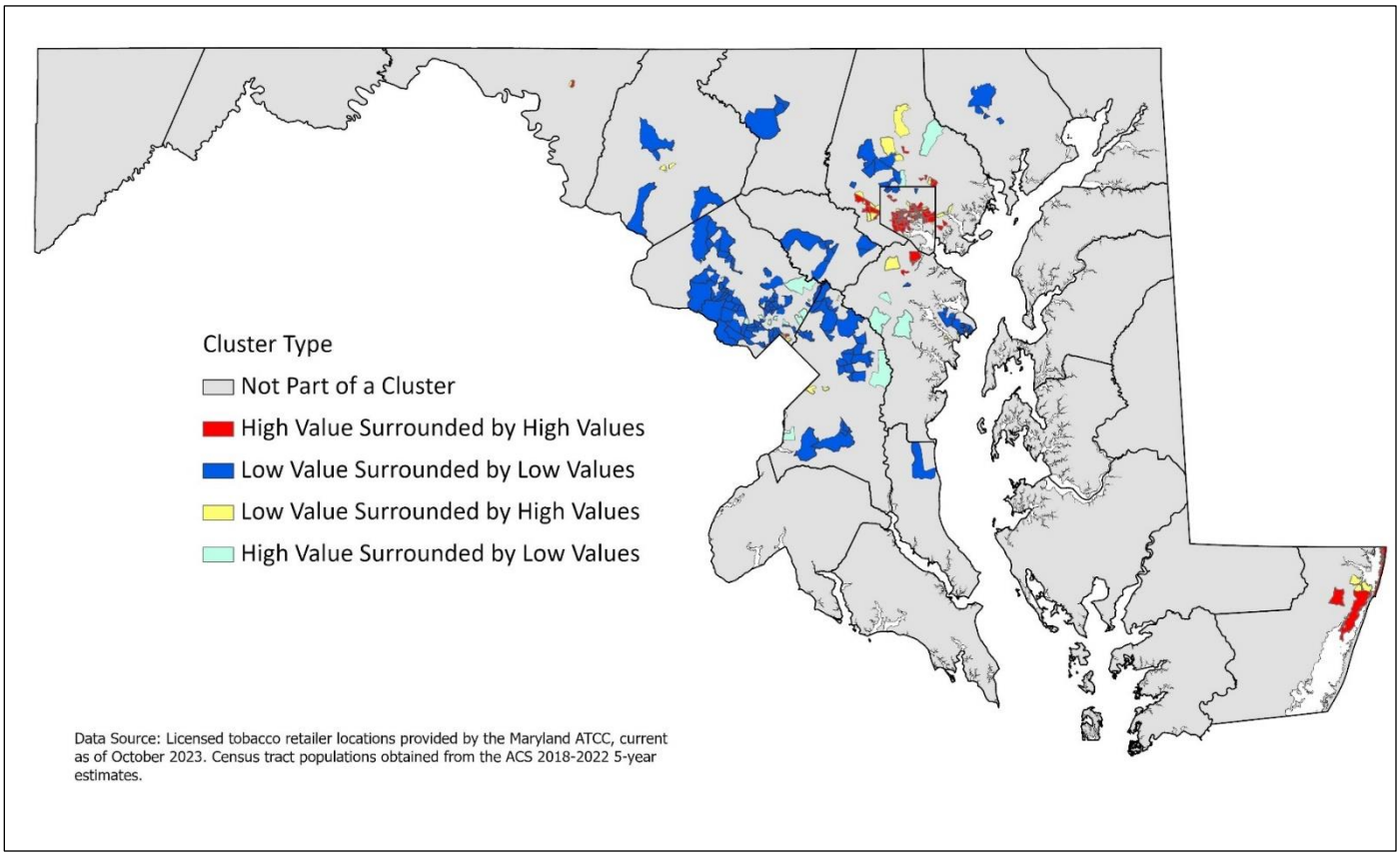


Figure 12. Map Showing the Results of the Local Moran's I Analysis Using a First Order Definition of Neighbor to Identify Clusters of Census Tracts with High or Low Values of Retailers per 1,000 Population



Figures 13 and 14 present the results of the Getis-Ord G* and Moran's I analyses using the second order definition of neighbor. Larger clusters of census tracts with both high and low values were identified when each census tract was analyzed with more neighbors, though the clusters identified covered much of the same general areas as the clusters in Figures 11 and 12 above.

To that point, perhaps more notable than the clusters themselves is the fact that they are predominantly located in the central part of the state. Most census tracts identified as being part of a cluster of either high or low values, or an outlier (i.e., high value surrounded by low values, or low value surrounded by high values), are located in six counties (Baltimore City, Baltimore County, Howard County, Anne Arundel County, Montgomery County, and Prince George's County) when using both the first order (91.7%) and second order (92.8%) definitions of neighbor. The census tracts containing Ocean City and surrounding areas made up a sizable high-value cluster when a first order definition of neighbor was used but diminished considerably with the second order definition, likely due to the much lower values of retailers per 1,000 population in the census tracts further inland.

Figure 13. Map Showing the Results of the Getis-Ord G* Analysis Using a Second Order Definition of Neighbor to Identify Clusters of Census Tracts with High or Low Values of Retailers per 1,000 Population

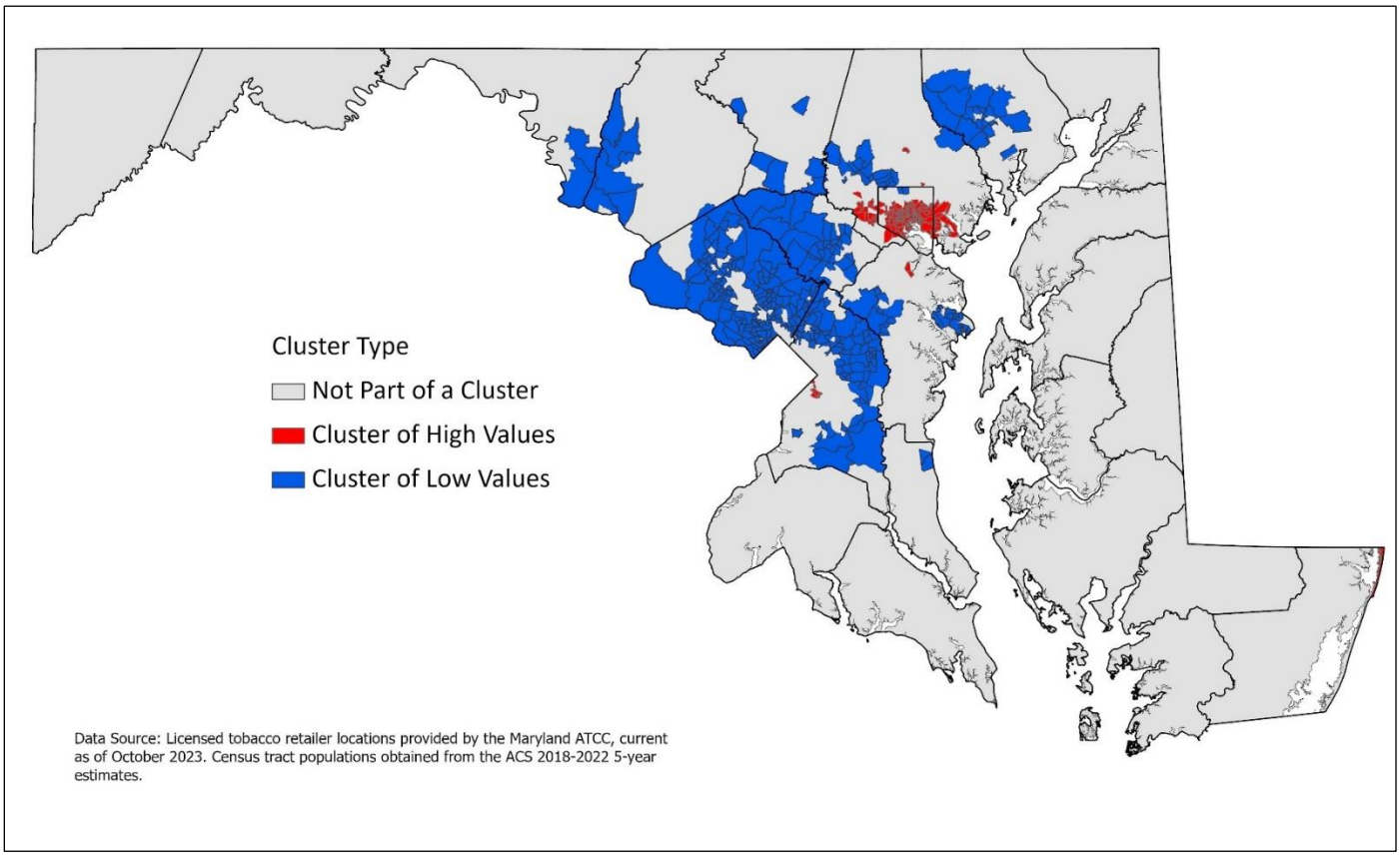
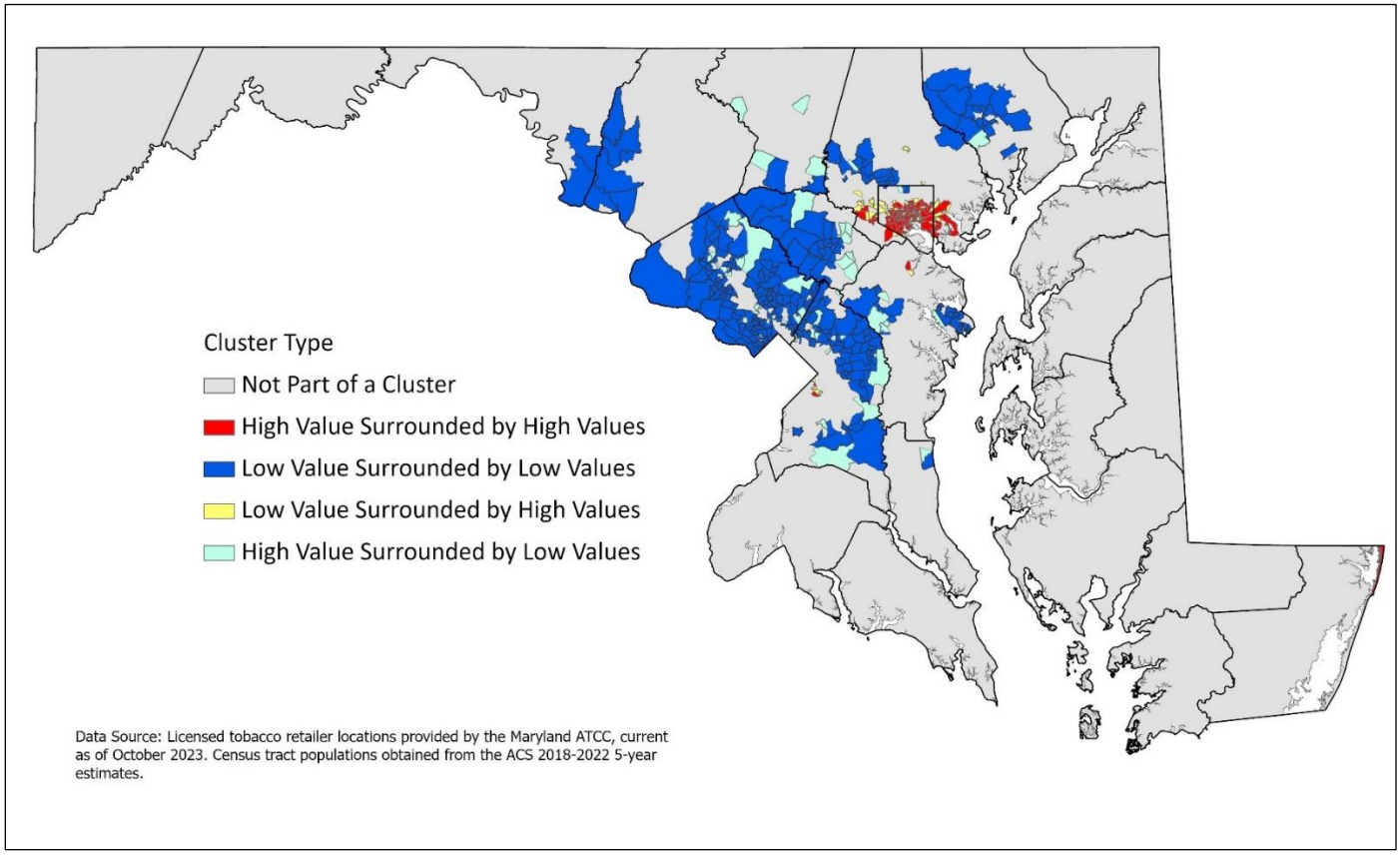


Figure 14. Map Showing the Results of the Local Moran's I Analysis Using a Second Order Definition of Neighbor to Identify Clusters of Census Tracts with High or Low Values of Retailers per 1,000 Population



Summary of Findings

This report described the findings of various descriptive and spatial analyses intended to explore the distribution of tobacco retailers in Maryland, their proximity to high schools, and the geographic distribution of tobacco usage. The key findings can be summarized as follows:

- Current cigarette use among adults ranged from a low of 3.7% in Howard County to a high of 17.9% in Somerset County. Tobacco use among high schoolers ranged from a high of 31.5% in Kent County to a low of 10.1% in Prince George's County.
- Nearly two thirds (n = 4,172; 65.0%) of all licensed retailers (N = 6,424) were in one of five counties: Baltimore City (n = 1,147; 17.9%), Baltimore County (n = 933; 14.5%),

Prince George's County (n = 857; 13.3%), Montgomery County (n = 661; 10.3%), and Anne Arundel County (n = 574; 8.9%).

- Worcester County had the highest retailer density (3.18), but the majority of these appeared to be concentrated in and around Ocean City. Of the 10 counties with the highest retailer density rates, only 3 had more than 100 retailers.
- On average, driving times from retailers to the nearest high school were shortest in Baltimore City. Mean drive times in Montgomery and Prince George's Counties, the counties with the 3rd and 4th highest counts of retailers, were longer despite the relatively high number of retailers. Future analyses, such as spatial regression models, would be useful for identifying possible relationships between tobacco retailers' proximity to high schools and other social and environmental factors. These analyses also included all retailers licensed to sell any tobacco products, so future work could also stratify by type of tobacco product.
- Spatial analyses identified clustering of census tracts with both low and high numbers of retailers per 1,000 population. More than 90% of the census tracts comprising these clusters were located in 6 counties: Baltimore City, Baltimore, Howard, Anne Arundel, Montgomery, and Prince George's Counties. Results of these analyses change depending on how each census tracts' neighbors are defined. Two definitions were used here, and while the overall conclusions were largely unchanged with both definitions, the sizes of the clusters changed considerably. Additional analyses are recommended for testing and comparing the neighbor definitions used here as well as other definitions to determine which is/are most appropriate.
- Correlations were found between tobacco retailer density and both rates of adult cigarette use and youth tobacco use. The correlation was stronger for adult cigarette use ($r = 0.56$) but was still moderate for youth tobacco use ($r = 0.37$).
- These analyses were exploratory and descriptive and should not be used to address questions of association or causation. Future analyses could incorporate external data on public sources, such as the ACS used here, and non-public sources, such as claims data, to explore relationships between area factors and health outcomes.