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ABSTRACT

INTRODUCTION: In 2019, the state of Massachusetts signed into law the first statewide sales restrictions of flavored ENDS/tobacco products for both physical and online shops in response to a previous executive order to curb E-Cigarette, or Vaping Product, Use Associated Lung Injury (EVALI) cases that were surging throughout the nation.

METHODOLOGY: This study obtained licensure data from the Massachusetts Department of Revenue, to observe the changes in retail licensure comparing the pre ban (October 2018-August 2019) and post ban periods (October 2020- August 2021). A series of linear regression tests were conducted on both periods using census tract data to explore potential associations with sociodemographic covariates, including median age, median household income, and population proportion by gender, age, and race/ethnicity groups.

RESULTS: Analysis of the Massachusetts post-ban period (October 2020-August 2021) found that new tobacco retail licenses issued decreased by 52.9% (n = 968) when compared to the pre-ban period (October 2018-August 2019) of 1831. A significant positive association was discovered between change in new retailer count and proportion male population (2.48 ± 1.05, $P = .018$) as well as proportion Hispanic population (1.19 ± .25, $P < .001$) at the census tract level.

CONCLUSION/DISCUSSION: Our analysis indicates that, following the temporary MA flavor sales ban, the total number of licenses decreased, though decreases were more pronounced for new licenses when compared to continuing licenses. Higher increases in new tobacco retailer density were significantly associated with concentration of male and Hispanic populations.

KEYWORDS: electronic cigarette delivery system, vape shops, Massachusetts, flavor ban, retail density, minority communities

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Implications:

- While existing studies on the Massachusetts flavor ban examine sales data, no study has examined and compared licensure data from the pre- and post-ban period to assess the potential impact of the policy on tobacco retail density.
- This study detected a significant decrease in the number of licenses issued for new tobacco stores (52.9%) and a slight decrease in the number of licenses issued for total number of tobacco stores (5.8%).
- Future studies should investigate the implementation of a state-wide tobacco control policy and its effect on local policies and retailer density placement, including among minority communities.

Introduction

Measuring the potential impact of tobacco control policies is essential to the success of tobacco and nicotine use prevention, particularly in the context of progressive state or local policies and ordinances that address marketing and sale of these addictive products. State and local tobacco control policies are very diverse and vary in scope and application. For example, regulations mandating health-related warnings on several forms of tobacco products serve to remind users of the dangers associated

Data Availability Statement included at the end of the article

with smoking and can therefore prevent new smokers from initiating.[1-7] Other effective regulatory strategies include incremental tax increases on cigarettes and electronic cigarettes to increase their cost, which in turn decreases overall affordability and appeal for consumers; health promotion and education initiatives to communicate the negative consequences associated with nicotine; cessation programs to assist users looking to quit; and increasing the minimum purchase age to limit youth and young adult exposure and uptake.[8-12] However, in order for tobacco control policies to be effective, policies targeting a wide range of tobacco products must occur, such as requiring tobacco retail licensing (TRLs) or directly regulating the sale of tobacco and nicotine delivery products.[13]

Recently, states and local municipalities have introduced new regulations to combat growing rates of vaping.[14-17] This includes instituting flavor bans for different tobacco and vaping products that include flavors for menthols, mints, and other flavors often attractive to youth (e.g., desserts, fruits, etc.). To combat these attractive and addictive products, there exist statewide bans that prohibit the sale of flavored products within their respective jurisdiction. States that recently enacted flavor bans include California, Massachusetts, New Jersey, Rhode Island, and South Dakota.[18-20] Furthermore, major cities have also banned flavored products, including Chicago, New York City, San Jose, and San Francisco.[21-23] Despite the potential of these policies to curb tobacco and nicotine use, only a few studies have attempted to quantify the potential impact of these bans based on restricting product marketing or tobacco and nicotine product sales. For example, a 2022 study found an increase in cigarette sales from bordering states outside of Massachusetts once the comprehensive menthol flavor ban was in effect.[24,25] In addition, another study in 2022 found that the total revenue of retail shops in Massachusetts decreased following the menthol flavor ban when comparing to prior years.[24,25] Several studies have also focused on a measuring the potential impact of a ban in a single retail location or examining the economic and product sales impact on retailers statewide.[26,27]

Tobacco control policies that restrict a product's availability are expected to impact sales and revenue due to lowered availability of restricted product primarily at point-of-sale. However, potential unevenness in consequent store closures may unintentionally worsen existing tobacco-related health disparities.[28,29] Importantly, previous studies have found that individuals who reside in a neighborhood with a higher tobacco retailer density were at higher risk of initiating smoking.[28,29] Further, communities with greater concentrations of African American or Hispanic residents were more likely to be disproportionally affected by these increases in smoking initiation.[30,31] While state-wide tobacco control policies, such as flavor restrictions, are critical public-health tools aimed at limiting access, the impact of these policies on local retail density, issuing and renewing tobacco licenses, business conditions, and health disparities requires further study.

In 2019, the state of Massachusetts implemented a temporary four month (September 24, 2019 – January 25, 2020) statewide ban, both in-store and online, that prohibited the sale, manufacture, and distribution of all electric nicotine delivery system (ENDS) products, excluding medically prescribed marijuana products.[32,33] The temporary ban was in response to a rising number of national cases involving electronic cigarette, or vaping, product use-associated lung injury (EVALI), which raised significant public health concerns about the dangers associated with vaping.[34] Studies that have examined the impact of the temporary ban have identified non-compliant sellers[35,36] and also found that the temporary ban had a direct influence on revenue losses for tobacco retailers.[25,27] Eventually, the temporary ban was signed into law as House Bill No. 4196 ("An Act Modernizing Tobacco Control") in November 2019, but only banned the sale of flavored tobacco products, including menthol and e-cigarettes (versus all ENDS during the temporary ban), and also imposed a 75% excise tax on nicotine-containing vaping products.[37,38] Hence, the Massachusetts temporary ban and subsequent permanent flavor ban represents a natural tobacco control policy experiment that can be further assessed for impacts on the tobacco and vaping retail landscape.

Therefore, this study aims to assess whether the 2020 Massachusetts flavor ban law (House Bill No. 4196), which took effect on June 1, 2020, has led to a change in the number of tobacco retail establishments as measured by tobacco retail licenses. We also aim to assess how the location of tobacco and vaping retailer hotspots may have changed or migrated after the ban was enacted, and specifically assess whether retail density rates increased in communities with greater minority population representation or other socio-demographic characteristics. Results from this study can provide needed insights into the immediate impact of flavored sales bans on retail availability and potential changes in retail store distribution across different communities within the state.

Methods

Data collection

A list of licensed tobacco retailers from January 2018 through December 2021 was obtained from the Massachusetts state government Department of Revenue Cigarette and Tobacco Forms and Legal Documents website.[39] The licensed tobacco retailer list included information on: (a) newly licensed tobacco retailers; (b) renewed licensed retailers; and (c) non-renewed retailers. The list also provides detailed licensure information on a retailers' location and operating business names, which specifically included: (i) license number; (ii) owner name; (iii) business name; (iv) retailer address; and (v) date of license commencement. MA tobacco retailer licenses are applicable to all tobacco and ENDS product retailers, are valid for two years, and expire on September 30th of each even year (e.g., 2018, 2020). To obtain the exact longitude and latitude coordinates of all licensed stores, we used the Google geocode application

programming interface (API version 3.49) and GeoPy client for geocoding in Python 3.7. For each store, the "Sales Street", "Sales City", "State", and "Zip" were appended into one string as the input for the Google geocode API. To attain optimal accuracy in geo coordinates, we utilized two tools to conduct a comparative analysis: Google API and GeoPy. The dataset included a total of 8290 available addresses, out of which 7740 were successfully located by both Google API and GeoPy. For 538 addresses, only Google API was able to locate their geo locations, whereas for 2 addresses, only GeoPy was successful. The remaining 10 addresses could not be located by either tool.

In order to examine the reliability of Google API results and GeoPy results the Cohen's kappa statistic was calculated to assess inter-rater reliability.[40] Kappa coefficient k is calculated as follows:

$$k = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)}$$

Cohen's kappa for geolocation between tools was .8039, indicating good agreement. Based on our analysis, we opted to proceed with using the results from Google API to maintain consistency within the dataset."

In order to further classify licenses as either existing (i.e., continuing) or new, we cross-referenced retailers' names and business addresses as follows: (1) comparing the licensure list from 10/01/2018 – 09/30/2020 with the licensure list from 10/01/2016 – 09/30/2018; and (2) comparing the licensure list from 10/01/2020 – 12/31/2021 with the licensure list from 10/01/2018 – 09/30/2020. In order to compare the volume and distribution of tobacco retailers before and after the 2020 flavor ban, identical time periods from a two-year time frame were chosen, as licenses are valid for two years and expire September 30th of each year ending in an even digit.[41] Licenses for existing stores are renewed by June 30th of the year of expiry. A store was classified as a "renewed" or "existing" store if a store in the current licensure list existed in the previous licensure list. If a store in the licensure list of interest could not be found in the previous licensure list, it was considered a "new" store. Lists for "new" and "existing" retailers were compiled for the two time periods of pre- and post-ban periods. The pre-ban period included October 2018-August 2019 and the post-ban period included October 2020-August 2021.

Data for population, age, gender, race, ethnicity, and median household income were obtained from the American Community Survey (2019 five-year estimates) at the census tract level for the state of Massachusetts.

Data analysis

Using the latitude and longitude coordinates corresponding to each of the retailer addresses, point coordinates were plotted on a Massachusetts base map in ArcGIS. By aggregating point coordinates to census tract polygons, the number of retailers for each census tract was obtained for each of the pre-post time periods: (i) October 2018-August 2019 (pre-ban) and (ii) October 2020-August 2021 (post-ban). The number of total, renewed, and new retailers was obtained by census tract. Changes in number of existing/renewed retailers and new retailers between the pre- and post-ban periods were also calculated by census tract. An adjusted linear regression backward selection model was used to determine if the change in new retailer count was significantly associated with sociodemographic covariates such as tract-level median age, median household income, and population proportion by gender, age, and race/ethnicity groups.

All dependent and independent variables were treated as continuous variables. Non-percentage continuous independent variables were divided by 100,000 to scale up effect estimates. All statistical analyses were conducted using SPSS version 27. A P-value of $< .05$ was considered statistically significant. Spatial clusters of high values (hot spots) and low values (cold spots) for tobacco retailers adjusted for population were mapped using the optimized hot spot analysis tool in ArcGIS v10.7.1 (Esri: Redlands, CA) for both pre- and post-ban periods. Specifically, the Getis-Ord Gi* statistic was calculated using this tool, and corresponding z-scores were mapped. Geographically weighted regression (GWR) was used to map residuals of the adjusted regression model using population normalized change in retailer count to verify spatial fit, and Anselin Moran's I test was used to determine if regression residuals were spatially random.

Results

A total of 7458 tobacco retail licenses were issued during October 2018-August 2019 (pre-flavor ban period), and a total of 7026 tobacco retail licenses were issued during October 2020-August 2021 (post-flavor ban period), representing an overall 5.8% decline in licenses. While the number of existing retailers that were issued renewed licenses increased by 9.5% (5627 during October 2018-August 2019 and 6163 during October 2020-August 2021), the number of new tobacco retail licenses issued decreased by 52.9% (1831 during October 2018-August 2019 and 863 during October 2020-August 2021).

During October 2018-August 2019, Nantucket County had the highest total tobacco retailer license density (n = 22, 196.22 per 100,000 population), followed by Dukes County (n = 27, 154.91 per 100,000), and Barnstable County (n = 318, 148.94 per 100,000). Similarly, during October 2020-August 2021, Nantucket County had the highest total tobacco retailer license density (178.38 per 100,000 population), followed by Dukes County (143.43 per 100,000), and Barnstable County (138.17 per 100,000). The largest decrease in total tobacco retail density was observed in Nantucket County (17.84 per 100,000 population), followed by Hampden County (12.86 per 100,000 population), and Suffolk County (12.48 per 100,000 population). Overall, the decrease in total tobacco retail license density across counties in the state of Massachusetts was 7.78 per 100,000 population.

During October 2018-August 2019, Dukes County had the highest new tobacco retailer license density (n = 10, 57.37 per 100,000 population), followed by Hampden County (n = 201, 43.07 per 100,000), and Barnstable County (n = 84, 39.34 per 100,000). However, during October 2020-August 2021, Nantucket County had the highest new tobacco retailer license density (35.68 per 100,000 population), followed by Hampden County (20.57 per 100,000), and Bristol County (18.64 per 100,000). The largest decrease in new tobacco retail density was observed in Dukes County (51.66 per 100,000 population), followed by Barnstable County (26.23 per 100,000 population), and Hampden County (22.50 per 100,000 population). Overall, the decrease in new tobacco retail license density across counties in the state of Massachusetts was 17.15 per 100,000 population.

A visualization of *z*-scores across Massachusetts revealed clustering of high *z*-scores (hot spots) for the normalized change in counts of new tobacco retailers between October 2018-August 2019 (see Figure 1) and October 2020-August 2021 (see Figure 2). Statistically significant hotspots for new tobacco retailers were observed around Hampden County and Barnstable County during October 2018-August 2019. While the Hampden County hotspot for new tobacco retailers persisted, the hotspot observed within Barnstable County disappeared in the post-ban period. Decreasing new tobacco retailer density was observed overall, especially in Dukes County (decreased by 51.66 per 100,000 population), Barnstable County (decreased by 26.23 per 100,000 population), and Hampden County (decreased by 22.50 per 100,000 population).

Massachusetts has 1478 census tracts and the average retail density of total tobacco stores was 122.89 per 100,000 during October 2018-August 2019 and 114.70 per 100,000 during October 2020-August 2021. The average retail density of existing tobacco stores that were issued renewed licenses was 90.80 per 100,000 during October 2018-August 2019 and 98.91 per 100,000 during October 2020-August 2021. The average retail density of new tobacco stores was 32.08 per 100,000 during October 2018-August 2019 and 15.79 per 100,000 during October 2020-August 2021. After including sociodemographic covariates in multivariable models (age, gender, race, ethnicity, household income, and census tract population), change in new retailer count was significantly associated with proportion of male population, proportion of Hispanic population, and median household income. There was a significant positive association between pre-post change in new retailer count and proportion male population (2.48 ± 1.05, $P = .018$) as well as proportion Hispanic population (1.19 ± .25, $P < .001$) at the census tract level. A significant inverse association was observed between change in new retailer count and median household income per $100,000 (-.39 ± .13, $P = .004$). See Table 1 for all model effect sizes. Using geographically weighted regression (GWR), residuals for the adjusted regression model were mapped at the census tract level (see Figure 2). Overpredictions (darkest shade) and underpredictions (lightest shade) were randomly distributed and no clustering of over- and/or underpredictions was observed. Similarly, no evidence of statistically significant spatial autocorrelation was observed (Morans I = .015, $P = .183$).

Discussion

Our study found a slight overall decrease (5.8%) in the number of total licenses for tobacco retailers during the two-year license renewal period after the statewide flavor ban that took effect on June 1, 2020. These results suggest that Massachusetts House Bill No. 4196 may have contributed to reducing the overall number of tobacco retail shops. The observed pronounced decrease in new licenses issued (52%), compared to the observed increase in license renewals (9.5%), suggests that this new law decreased active retail of tobacco products predominantly by discouraging new entrants rather than affecting established businesses. These patterns were observed broadly across the state, with every county in the state of Massachusetts experiencing a decrease in the number of new tobacco retail licenses and associated retail density, equating to an average of 17.15 shops per 100,000 population in the post-ban period compared to 31.23 shops per 100,000 population in the pre-ban period.

However, while the pattern in licensure changes were broadly observed, the intensity of these changes was not uniformly distributed across the state, with the highest decrease in licenses occurring in Dukes County, Barnstable County, and Hampden County, who had previously reported the highest number of new tobacco retailer licenses issued in the pre-ban period. This pattern suggests that, in addition to impacts from the new state law, changes in licensure may be driven by underlying market forces, specifically regional saturation of tobacco product vendors. Further Massachusetts communities with higher proportions of male and Hispanic populations experienced statistically significant increases in new tobacco retail licenses compared to communities with different sociodemographic characteristics, while median household income was inversely associated with an increase in retailers. This may indicate differences in price elasticity for nicotine vaping between demographic groups and/or disproportionate demand for flavored products between these groups.

Between the pre- and post-ban periods, the SARS-CoV-2 (COVID-19) virus rapidly spread across the country. On March 23, 2020, Massachusetts Governor, Charlie Baker declared all non-essential businesses to cease in-person operations.[42] This order is expected to have potentially impacted the entry of new tobacco retail shops to the Massachusetts tobacco/vaping market. However, retailers often operate online storefronts while also having physical addresses, and these retailers would still be required to carry a state license to sell tobacco/vaping products.[43] Furthermore, the Paycheck Protection Program established by the CARES Act made federal money available to mitigate the financial impact of the COVID-19 pandemic on existing businesses.[44] Therefore, while the COVID-19 pandemic may have suppressed vaping retailer

Table 1. Linear regression model for change in new tobacco retailer count adjusting for covariates at the census tract level, Massachusetts.

PARAMETER	ESTIMATE	SE	*P*-VALUE
Intercept	-.01	.61	.982
% Male	2.48	1.05	.018
% Hispanic	1.19	.25	<.001
% Black	.36	.28	.193
Median age	.70	.60	.205
Median household income (per $100,000)[a]	-.39	.13	.004

[a]Independent variables were divided by 100,000 to scale up effect estimates. All independent variables are expressed as count or percentage except median household income which is expressed in US dollars.

activity during this time period, the impact of the pandemic may have been mitigated by online business modalities and availability of government business relief and subsidies for existing businesses. Future studies should assess the degree to which vaping retailers utilized these avenues in response to pandemic-related pressures and how it impacted business decisions to start or continue tobacco retailing.

Overall, the statewide Massachusetts flavor ban appears to have had some impact on introducing supply-side constraints for tobacco products overall, but in particular served to strongly dissuade entry of new retailers vs shutting down already-established retailers. Our study also identified that tobacco retailer density appears to have concentrated in areas with higher proportions of male and Hispanic residents post-ban, necessitating further study into the extent to which legal bans may worsen existing disparities in retail access to tobacco products and how to mitigate these effects. This finding is consistent with previous literature which identified minority neighborhoods as having disproportionally higher density of tobacco retail outlets, resulting in easier physical access to tobacco products in these communities.[31,45] The optimal design of sales bans to dissuade access to tobacco products without worsening disparities raises important research questions for implementation scientists which were not addressed by this analysis but should be undertaken by further comparative research on distinct implementations of product bans of this nature. Future studies should also monitor tobacco use prevalence rates in Massachusetts minority communities to identify potential downstream effects of flavor bans on tobacco use and behavior, including poly-use and product transitions. To our knowledge, this is the first study that analyzes retailer density pre and post a subnational flavor ban through use of licensure data.

Limitations

There are certain limitations to this study. First, this study only evaluated the potential impact of the Massachusetts's Flavor Ban in connection to retailer license status; however, additional analysis on sales and tax revenue data would need to be examined to establish a more complete assessment of the ban's economic impact on both the tobacco retail industry and the overall retail market in these communities. Also, the licensure data did not include information on the type of store (tobacco or vape or tobacco and vape) or online presence of the physical stores. Additionally, counties, cities and other municipalities in Massachusetts may have passed specific local or municipal anti-tobacco laws which exerted spatially uneven pressure on tobacco retailer licensure renewal or new retailer entrants. Future studies should investigate the impact of both local ordinances and state legislation to evaluate the effect on the existing tobacco retail environment and registration of new tobacco retail shops. Some specific licensure data were manually inspected and cleaned during the matching process. Seven retail storefronts required manual correction for fixing typos or spelling out abbreviations in order to be matched. In addition, data collected and analyzed falls within the time period during which, the COVID-19 pandemic could have potentially impacted the renewing of existing or opening of new tobacco/vaping retail stores. Also, this study did not assess any concurrent policy changes that could have potentially had an additive effect on the licensing of new or existing tobacco retail stores. Finally, licensure data sometimes contained multiple businesses having the same address (e.g., those in a retail outlet plaza), as additional location information on lot number was not available in the original files, these retail points were aggregated to a single address. Overall, while the study explores the potential impact of the sales ban on tobacco retail density along with sociodemographic disparities, establishing causality is not possible owing to the ecological study design.

Author contributions

Matthew Nali: Conceptualization, Methodology, Writing – Original draft preparation. Vidya Purushothaman: Methodology, Formal Analysis, Writing- Original draft preparation, Review & Editing. Zhuoran Li: Data Curation, Software. Raphael Cuomo: Conceptualization, Methodology, Supervision, Funding Acquisition. Tim Mackey: Conceptualization,

Methodology, Writing-Review & Editing, Supervision, Funding Acquisition.

Data Availability Statement

Data is publicly available from the Massachusetts state government Department of Revenue Cigarette and Tobacco Forms and Legal Documents website.

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