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Supplement Article

Flavored Tobacco Sales Restrictions and Youth E-cigarette Behavior: Impact by Tobacco Retailer Density in Diverse Communities in California

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Abstract

Introduction: Factors that impact flavored tobacco sales restriction (flavor restrictions) effectiveness on youth e-cigarette behavior are unclear. Tobacco retailer density (retailer density) is a health equity issue with greater retailer density in high-minority, low-income areas. We examined the association between flavor restrictions and youth e-cigarette behavior by retailer density across diverse communities in the California Bay Area.

Aims and Methods: We analyzed data from the California Healthy Kids Survey using a difference-in-differences (DID) strategy. We compared pre- and post-policy changes in e-cigarette access and use one-year post-implementation among high school students in the Bay Area with a flavor restriction (n = 20 832) versus without (n = 66 126). Separate analyses were conducted for students in cities with low and high retailer density, with a median cutoff of 3.3 tobacco retailers/square mile.

Results: Students with high retailer density were more likely to identify as a minority and have parents with lower education. Among students with low retailer density, flavor restrictions were associated with 24% lower odds in the pre- to post-policy increase in ease of access relative to unexposed students (DID = 0.76, 95% CI: 0.58, 0.99). Among students with high retailer density, flavor restrictions were associated with 26% higher odds in ease of access (DID: 1.26, 95% CI: 1.02, 1.56) and 57% higher odds of current use (DID = 1.57, 95% CI: 1.31, 1.87).

Conclusions: Flavor restrictions had positive impacts on youth e-cigarette access in low, but not high retailer density cities. From a health equity perspective, our results underscore how flavor restrictions may have uneven effects among vulnerable groups.

Implications: In diverse communities in the California Bay Area, our results suggest a protective association between flavored tobacco sales restrictions and youth access to e-cigarettes in low, but not high tobacco retailer density cities one-year post-implementation. These results underscore how flavor restrictions may have uneven effects, and when implemented in high retailer density areas, may disproportionately place already vulnerable groups at heightened exposure to e-cigarette use and access. In high retailer density areas, additional tobacco control efforts may need to be included with flavor restriction implementation, such as increased education, youth prevention and cessation programs, policies to reduce tobacco retailer density, or stronger tobacco retailer enforcement or compliance monitoring.

Introduction

The U.S. Surgeon General declared youth e-cigarette use an epidemic, as current electronic cigarette (e-cigarette) use in the past 30 days among high school students more than doubled between 2017 (9.5%) and 2019 (22.5%).[1,2] Although use decreased to 14% in 2022, e-cigarettes are still the most used tobacco product among youth.[3] Among current e-cigarette users, 85% of high school students reported a preference for flavored e-cigarettes.[4] Youth who use e-cigarettes are three times more likely to initiate cigarette smoking, the leading cause of preventable death.[5,6]

Flavored tobacco sales restrictions (flavor restrictions) have been implemented to reduce youth access to e-cigarettes and other tobacco products. A comprehensive systematic review found moderate to strong evidence that flavor restrictions reduce the sale and retail availability of tobacco products, but only moderate quality evidence that they were associated with decreased tobacco use in the general population.[7] Among youth, there has been inconsistent evidence on the association between flavor restrictions and tobacco use with some,[8–10] but not all studies[11–13] reporting a protective impact. No association was found between flavor restrictions and youth e-cigarette use one-year post-policy in our recent research in the California Bay Area.[11] Potential explanatory factors are that ease of access to e-cigarettes and using cannabis in an e-cigarette increased. Since the evidence has not been consistent, there may be community factors that impact the effectiveness of flavor restrictions.

The effectiveness of flavor restrictions in different communities may depend on tobacco retailer density (retailer density), the number of tobacco retailers in a given area, which is higher in high-minority and low-income areas.[14–17] Youth who live in cities with high retailer density may have more

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exposure to tobacco marketing and increased opportunities to purchase tobacco, which may impact youth tobacco access and use.[14] Retailer density may also impact youths' beliefs about tobacco availability and enforcement.[18]

San Francisco implemented one of the first comprehensive flavor restrictions (that prohibit the sale of all flavors in all tobacco products in all locations) in the nation in January 2019 and nearby cities in the California Bay Area followed with similar policies. For example, Oakland implemented a flavor restriction that excluded adult-only stores in July 2018 and removed this exclusion in May 2020. As of April 2023, 122 municipalities in California have implemented flavor restrictions that regulate the sale of flavored tobacco products in some manner, with 73 passing comprehensive flavor restrictions.[19] In this current study, we stratify the results of our previous study[11] by retailer density to examine differences in the association between flavor restrictions and e-cigarette use in cities with high and low retailer density. The same data, exposure (flavor restrictions), outcomes (ever and current e-cigarette use and access to e-cigarettes), and covariates from our prior work were used.[11]

Methods

Data Source

The California Healthy Kids Survey (CHKS) is a comprehensive survey administered to students attending middle and high schools (grades 9 and 11) in California. Although most schools participate once every two years, schools are on different two-year cycles so that data is collected every year. Participation is voluntary, confidential, and passive parental consent was obtained. Student response rate was 88% in 2017/18 and 91% in 2019/20.[20] According to the CHKS survey administrators, a majority of completed surveys for the Spring 2020 data were administered in-person before school closures due to COVID-19.

To create the retailer density variable, data for each school's city from the CHKS was merged with data on the number of tobacco retailers in each city, obtained from the 2018 California Department of Tax and Fee Administration,[21] and land area in square miles for each city, obtained from the 2010 Census.[22]

Since all cities with a flavor restriction that met our inclusion criteria (see below) were in the San Francisco Bay Area, we restricted the analysis to nine counties in the Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma). We restricted the data to students attending public high schools or K-12 schools (n = 157 606), who were not missing information on current e-cigarette use (n = 134 604), and reported that they answered all or most of the questions honestly (n = 129 658). Cities with flavor restrictions that were not implemented in 2018/2019 or did not have CHKS data in both 2017/2018 and 2019/2020 were excluded, for a final sample size of 86 958.

Exposure to Flavor Restrictions

Students were classified as exposed to a flavor restriction if their school was in a city with a flavor restriction implementation date (enforcement or effective date) during the 2018/2019 school year, or the summer before or after (July 2018–August 2019). Seven cities met these criteria, resulting in 20 832 students classified as exposed to flavor restrictions. The unexposed group included students living in cities in the Bay Area without a flavor restriction implemented before June 2020 (n = 66 126). County flavor restrictions only applied to unincorporated areas and were excluded. Additional information about the cities with flavor restrictions is available in the Supplemental section of our original publication, including a table, timeline, and map.[11]

Outcome Variables: E-cigarette Use

The main outcome variable was current e-cigarette use. The questions changed slightly over time to account for the introduction of JUUL. From 2017 to 2019, the question was "During the past 30 days, on how many days did you use electronic cigarettes, e-cigarettes, or other vaping device such as Juul (added in 2018/2019), e-hookah, hookah pens, or vape pens." In 2019/2020, each question was shortened to ask about "vape products," which were defined at the beginning of the question as "Electronic devices like vape pens, e-cigarettes, e-hookah, hookah pens, e-vaporizers, tanks, pods, or mods used to inhale a vapor." We coded respondents who reported ≥1 days as currently using e-cigarettes and 0 days as not currently using e-cigarettes.

Information on ever e-cigarette use was obtained from the question "During your life, how many times have you used the following…Electronic cigarettes, e-cigarettes, or other vaping device such as e-hookah, hookah pens, or vape pens?" Response options (0, 1, 2, 3, 4–6, or 7 or more) were dichotomized as ever (>=1 time) or never used (0 times).

To capture ease of access to e-cigarettes, students were asked "How difficult is it for students in your grade to get any of the following if they really want them [E-cigarettes (electronic) or vaping device]?" Students who responded with "very easy" were compared with those who responded with "fairly easy," "fairly difficult," "very difficult," or "don't know."

Tobacco Retailer Density

Retailer density was calculated by dividing the number of tobacco retailers in each city by the land area in square miles. We created a two-category variable, using the median value (3.3) as the cut-point, so that there was approximately an equal sample size in each group. Supplementary Table 1 shows the population characteristics in high and low retailer density cities and Supplementary Figure 1 shows a map of the cities with flavor restrictions that were categorized as high and low retailer density.

Covariates

Student level covariates included gender (male, female), grade (9th or 11th), term (fall or winter), race/ethnicity (Hispanic, Non-Hispanic (NH) Asian/Pacific Islander, NH Black, NH White, and NH mixed race), parents' education (did not finish high school, graduated from high school, attended some college, graduated from college, or don't know), and type of home (a home with a parent, a relative or friends home, or a foster home, hotel, shelter, or other).

Statistical Analysis

As with our prior work,[11] we leverage a quasi-experimental method, known as difference-in-differences (DID). In contrast with our previous approach, we stratify our analyses by retailer density. We estimate separately by each retailer density group (low: <3.3 and high: >=3.3), how pre- to post-changes in our outcomes for youth exposed to a flavor restriction

differ versus pre- to post-changes for youth not exposed to a flavor restriction. Thus, our DID approach allows us to capture the association between flavor restrictions and outcomes when the flavor restriction is implemented in a high or low retailer density setting. We also statistically tested for an interaction between flavor restrictions and each outcome by retailer density by including a 3-way cross product interaction term in each adjusted model between year (2019/2020 or 2017/2018), exposure group (flavor restriction: yes or no), and retailer density (low or high). We used logistic regression models, adjusted for covariates and clustering of students within schools using SAS version 9.4 survey procedures (SAS Institute, Cary, NC).

Several sensitivity analyses were conducted. Adjusted DID estimates were calculated for the association between flavor restrictions and each outcome, stratified by retailer density with a cutoff of 2.3 and 4.3 retailers per square mile (Supplementary Tables 2a and 2b). In addition, we considered controlling for sexual orientation to increase the precision of the DID estimate, but it had high levels of missingness/declined to state responses (22.5% had missing data across all low retailer density cities with a flavor restriction). Therefore, we ran a sensitivity check and included sexual orientation with a "missing/declined to state" category and the results remained consistent.

Results

Across both years combined, an estimated 24.0% of students were exposed to a flavor restriction. Approximately half of the students were male, in the 11th grade, and had parents with a college education. The most common race/ethnic group was Hispanic (35.7%), followed by NH White (26.9%), and NH Asian/Pacific Islander (21.5%). As shown in Table 1, students in survey year 2019/2020 had a slightly higher percentage of parents who were college graduates and a higher

Table 1. Sample Characteristics by Year and Tobacco Retailer Density Among Youth in the Bay Area, CHKS 2017/2018 and 2019/2020

	Percent in each year				Percent in each retailer density (retailers/ square mile)		
	Total sample size	2017/2018 n = 46 535	2019/2020 n = 40 423	p-value	Low retailer density <3.3, n = 45 021	High retailer density >=3.3, n = 41 937	p-value
Number of cities	40	40	40	NA	25	15	NA
Flavor restriction	20,832	24.6	23.2	.48	17.0	31.4	.19
Male	43,087	50.0	49.8	.72	49.8	50.0	.54
11th grade	39,558	45.8	45.1	.44	46.2	44.8	.19
Parents education				**.03**			**<.01**
< High school	10,320	11.8	12.0		9.5	14.5	
High school	11,668	13.7	13.2		12.4	14.6	
Some college	10,305	12.4	11.3		12.1	11.6	
College graduate	44,989	51.5	52.4		56.8	46.7	
Don't know	9,368	10.6	11.1		9.2	12.5	
House type				.25			**<.01**
Home with a parent	80,596	92.8	93.2		94.1	91.7	
Relative or friends' home	4,304	5.1	4.8		3.9	6.1	
Foster, hotel, shelter, or other	1,813	2.1	2.0		2.0	2.2	
Fall term	52,118	54.5	66.1	**.03**	59.1	60.8	.88
Race/ethnicity				.18			**<.01**
Hispanic/ Latino	30,510	35.0	36.5		33.7	37.8	
NH Asian/ Pacific Islander	18,343	21.7	21.2		17.3	25.9	
NH Black	4,040	5.0	4.5		4.4	5.0	
NH White	22,997	27.1	26.6		32.1	21.4	
NH Mixed	9,585	11.2	11.2		12.5	9.8	

Bolded p-values were statistically significant ($p < .05$).

percentage that were surveyed in the Fall term, compared with the 2017/2018 school year. Students in cities with high retailer density compared with low retailer density had a higher percentage of parents with lower levels of education, living in a friend's or relative's home (6.1% vs. 3.9%), and identifying as Hispanic (37.8% vs. 33.7%), or NH Asian/Pacific Islander (25.9% vs. 17.3%). Cities with high retailer density (compared with cities with low retailer density) had almost double the median population density, with a lower percent of NH whites and people under the age of 21, but had similar median incomes and the same median number of high schools (Supplementary Table 1). Cities with high retailer density also had 54% higher median number of tobacco retailers, 38% higher median tobacco retailer density (per 10 000 people), and nearly double the median tobacco retailers within 1000' of a school.

The population characteristics of students exposed to a flavor restriction was different in cities with low and high retailer density (Table 2). In low retailer density cities, there was a *greater* percentage of exposed students compared with unexposed students whose parents were college graduates (73.5% vs. 53.4%). There was a *lower* percentage of students exposed to flavor restrictions who were Hispanic (23.2% vs. 35.8%), NH Black (1.2% vs. 5.1%), and who lived in a friend or relative's home (2.3% vs. 4.2%). In high retailer density cities, there was a *lower* percentage of students exposed to flavor restrictions whose parents were college graduates compared with unexposed students (32.4% vs. 53.1%), and a *higher* percentage of exposed students who were Hispanic (40.6% vs. 36.6%), NH Black (12.2% vs. 1.8%), and lived in a friend or relative's home (8.3% vs. 5.1%). There was a lower percentage of exposed students who took the survey in the Fall (13.7% vs. 82.5%).

We tested whether the association between flavor restrictions and e-cigarette behavior differed by retailer density. There was a significant interaction for current e-cigarette use ($p = <.01$) and ease of access to e-cigarettes ($p = <.01$), but not for ever e-cigarette use ($p = .24$). Results stratified by retailer density are described below.

Current E-cigarette Use

In cities with low retailer density, the adjusted odds of current e-cigarette use decreased pre- to post-policy among students exposed to a flavor restriction (aOR: 0.78, 95% CI: 0.60, 1.01) and unexposed (aOR: 0.89, 95% CI: 0.77, 1.03), but these decreases were not statistically significant (Table 3). Adjusted DID estimates showed that the pre- to post-policy difference in the odds of current e-cigarette use among students exposed to a flavor restriction relative to those unexposed to a flavor

Table 2. Sample Characteristics by Tobacco Retailer Density and Flavor Restrictions Among Youth in the Bay Area, CHKS 2017/2018 and 2019/2020

	Tobacco retailer density (retailers/square mile)					
	Low retailer density <3.3 (n = 45 021)			High retailer density >=3.3 (n = 41 937)		
	Flavor restriction	No Flavor restriction	p-value	Flavor restriction	No Flavor restriction	p-value
Sample size	7,654	37,367		13,178	28,759	
Number of schools	6	35		20	18	
Number of cities	4	21		3	12	
Number of tobacco retailers/city (median)	27	41		377	51	
Population/city (median)	66,573	69,567		425,097	79,074	
Male	49.7	49.8	.81	50.6	49.8	.32
11th grade	45.4	46.3	.58	44.6	44.8	.90
Parents education						
< High school	5.7	10.2	**<.01**	21.4	11.4	**<.01**
High school	7.9	13.3		17.4	13.3	
Some college	7.1	13.2		11.3	11.8	
College graduate	73.5	53.4		32.4	53.1	
Don't know	5.8	9.9		17.4	10.3	
House type						
Home with a parent	95.8	93.8	**.03**	89.1	92.9	**<.01**
Relative or friends' home	2.3	4.2		8.3	5.1	
Foster, hotel, shelter, or other	1.9	2.0		2.5	2.0	
Fall term	69.4	57.0	.56	13.7	82.5	**<.01**
Race						
Hispanic/Latino	23.2	35.8	**.01**	40.6	36.6	**<.01**
NH Asian/Pacific Islander	19.8	16.8		26.6	25.6	
NH Black	1.2	5.1		12.2	1.8	
NH White	43.8	29.6		11.1	26.1	
NH Mixed	12.0	12.6		9.6	9.9	

Bolded p-values were statistically significant ($p < .05$).

Table 3. Percent of Youth With Each Outcome by Flavor Restriction Exposure Category and Tobacco Retailer Density, CHKS 2017/2018 and 2019/2020

	Pre-policy 2017/2018	Post-policy 2019/2020	OR (95% CI) (n=86,958)	DID (95% CI)	*p*-value	aOR* (95% CI) (n=84,450)	aDID* (95% CI)	*p*-value
a. Current e-cigarette use								
Retailer density								
Low retailer density <3.3 retailers/ square mile (n = 45 021)								
Exposed	14.8	11.6	0.76 (0.60, 0.96)	0.86 (0.65, 1.15)	0.31	0.78 (0.60, 1.01)	0.88 (0.66, 1.17)	0.37
Unexposed	11.8	10.5	0.88 (0.76, 1.03)			0.89 (0.77, 1.03)		
High retailer density >=3.3 retailers/ square mile (n = 41 937)								
Exposed	7.9	10.9	1.4 (1.3, 1.6)	**1.6 (1.4, 2.0)**	**<.01**	1.54 (1.36, 1.74))	**1.57 (1.31, 1.87)**	**<.01**
Unexposed	14.2	12.6	0.87 (0.76, 1.0)			0.98 (0.86, 1.12)		

	Pre-policy 2017/2018	Post-policy 2019/2020	OR (95% CI) (n = 85 877)	DID (95% CI)	*p*-value	aOR* (95% CI) (n = 83 450)	aDID* (95% CI)	*p*-value
b. Easy access to e-cigarettes								
Retailer density								
Low retailer density <3.3 retailers/ square mile (n = 44 463)								
Exposed	41.5	43.7	1.1 (0.86, 1.4)	0.75 (0.56, 1.0)	0.05	1.17 (0.93, 1.47)	**0.76 (0.58, 0.99)**	**0.04**
Unexposed	34.5	43.7	1.5 (1.2, 1.7)			1.54 (1.33, 1.77)		
High retailer density >=3.3 retailers/ square mile (n = 41 414)								
Exposed	23.6	36.7	1.9 (1.7, 2.1)	**1.3 (1.1, 1.6)**	**<.01**	2.05 (1.72, 2.43)	**1.26 (1.02, 1.56)**	**0.04**
Unexposed	34.6	43.2	1.4 (1.3, 1.6)			1.63 (1.42, 1.86)		

	Pre-policy 2017/2018	Post-policy 2019/2020	OR (95% CI) (n = 85 803)	DID (95% CI)	*p*-value	aOR* (95% CI) (n = 83 351)	aDID* (95% CI)	*p*-value
c. Ever e-cigarette use								
Retailer density								
Low retailer density <3.3 retailers/ square mile (n = 44 482)								
Exposed	23.5	22.0	0.92 (0.79, 1.06)	0.94 (0.78, 1.13)	0.49	0.95 (0.81, 1.11)	0.96 (0.80, 1.16)	0.66
Unexposed	23.3	22.8	0.98 (0.87, 1.09)			0.99 (0.89, 1.10)		
High retailer density >=3.3 retailers/ square mile (n = 41 321)								
Exposed	19.1	21.2	1.14 (1.01, 1.29)	1.13 (0.96, 1.33)	0.13	1.22 (1.05, 1.41)	1.10 (0.93, 1.30)	0.25
Unexposed	24.9	25.0	1.00 (0.91, 1.11)			1.10 (1.00, 1.22)		

*Adjusted for gender, grade, parent's education, house type, term, and race/ethnicity
The sample sizes for the adjusted analyses reflect missing data.
OR=odds ratio
DID = difference-in-difference estimate
a = adjusted
Bolded DID estimates and p-values were statistically significant ($p < .05$).

restriction was also not statistically significant (aOR: 0.88, 95% CI: 0.66, 1.17).

In cities with high retailer density, there was an increase in the adjusted odds of current e-cigarette use pre- to post-policy among students exposed to a flavor restriction (aOR: 1.54, 95% CI: 1.36, 1.74) and no change among unexposed students (aOR: 0.98, 95% CI: 0.86, 1.12). Adjusted DID estimates show a pre- to post-policy increase in the odds of current e-cigarette use among students exposed to a flavor restriction relative to those unexposed to a flavor restriction (aOR: 1.57, 95% CI: 1.31, 1.87). Although there was a greater increase in e-cigarette use among students exposed to a flavor restriction, the post-policy prevalence of e-cigarette use in exposed and unexposed students was not statistically different, 10.9% (flavor restriction) and 12.6% (nonflavor restriction).

Ease of Access to E-cigarettes

In cities with low retailer density, there was no significant change in the adjusted odds of ease of access to e-cigarettes pre- to post-policy among students exposed to a flavor restriction (aOR: 1.17, 95% CI: 0.93, 1.47) and a significant increase among unexposed students (aOR: 1.54, 95% CI: 1.33, 1.77) (Table 3). Adjusted DID estimates show that the pre- to post-policy increase in ease of access was smaller in students exposed to a flavor restriction compared with unexposed students (aOR: 0.76, 95% CI: 0.58, 0.99).

In cities with high retailer density, there was an increase in the adjusted odds of access to e-cigarettes pre- to post-policy among exposed (aOR: 2.05, 95% CI: 1.72, 2.43) and unexposed students (aOR: 1.63, 95% CI: 1.42, 1.86). Adjusted DID estimates show a greater pre- to post-policy increase among students exposed to a flavor restriction relative to those unexposed to a flavor restriction (aOR: 1.26, 95% CI: 1.02, 1.56). Although the pre- to post-policy increase was greater in students exposed to a flavor restriction, this group had a lower prevalence of ease of access to e-cigarettes compared with unexposed students both pre-policy (23.6% vs. 34.6%) and post-policy (36.7% vs. 43.2%).

Ever Use of an E-cigarette

In cities with low retailer density, we did not detect a significant pre- to post-policy change in the odds of ever using an e-cigarette among exposed (aOR: 0.95, 95% CI: 0.81, 1.11) and unexposed students (aOR: 0.99, 95% CI: 0.89, 1.10) (Table 3). Furthermore, the adjusted DID estimate showed no significant association between flavor restrictions and e-cigarette use (aOR: 0.96, 95% CI: 0.80, 1.16) in low retailer density cities. On the other hand, in cities with high retailer density, there was a significant pre- to post-policy increase in the adjusted odds of ever e-cigarette use among students exposed (aOR: 1.22, 95% CI: 1.05, 1.41) and unexposed (aOR: 1.10, 95% CI: 1.00, 1.22) to flavor restrictions. However, adjusted DID estimates show that in high retailer density areas, the pre- to post-policy increase in the odds of ever e-cigarette use was not statistically different among students exposed to a flavor restriction relative to those unexposed to a flavor restriction (aOR = 1.10, 95% CI: 0.93, 1.30).

Results from the sensitivity analysis using different retailer density cut-points of 2.3 and 4.3 retailers per square mile were consistent with results using the retailer density cut-point of 3.3, except for the outcome of ease of access to e-cigarettes using the 2.3 cut-point (Supplementary Tables 2a and 2b). There was no association between flavor restrictions and ease of access to e-cigarettes among low or high retailer density cities using the 2.3 cut-point. However, using the 3.3 and 4.3 cut-points there was a similar protective association between flavor restrictions and ease of access to e-cigarettes among low retailer density cities and an increase in ease of access among high retailer density cities.

Discussion

This is one of the first studies to examine the association between flavor restrictions and youth e-cigarette use by retailer density. Among cities with low retailer density in the Bay Area of California, ease of access to e-cigarettes increased significantly less from pre- to post-policy in youth exposed to flavor restrictions, compared to unexposed youth. Among cities with high retailer density, flavor restrictions were associated with an increase in ease of access and current use of e-cigarettes. Results also showed that in high retailer density cities (compared with low retailer density cities), youth were more likely to be from racial and ethnic minority groups and tended to have parents with a lower level of education. From a broader equity perspective, our results underscore how flavor restrictions can have uneven and unintended effects, and when implemented in high retailer density areas, can disproportionately place already vulnerable groups at heightened exposure to e-cigarette use and access.

There are several reasons for why there may be a protective association between flavor restrictions and ease of access to e-cigarettes in low, but not high retailer density cities. Tobacco retailers are one of the main venues for tobacco marketing, which increases the likelihood that youth are exposed to pro-tobacco messages that can impact tobacco use.[23] In addition, youth that live in low retailer density cities have fewer actual and perceived opportunities to purchase tobacco, which may impact youth tobacco access and use.[14] Results from a study in California youth suggested that greater retailer density was associated with greater perceived availability of cigarettes and with lower perceived enforcement of underage tobacco policies.[18] Thus, youth in low retailer density cities may have less exposure to tobacco marketing and fewer opportunities to access tobacco products.

There are many different strategies for limiting the number of tobacco retailers including limiting the overall number of retailers, restricting retailers from operating near each other, restricting retailers from being located near schools, and prohibiting certain retailer types (ie, pharmacies) from selling tobacco.[24] We defined retailer density as the number of tobacco retailers per square mile, as this was similar to a strategy used by San Francisco. In January 2015, San Francisco capped the number of tobacco retailers to 45 per supervisorial district, which resulted in an 8% decrease in tobacco retailers.[25] A review of retailer density approaches found that all tobacco retailer reduction strategies examined demonstrated actual or predicted reductions in retailer density.[26] Choosing an effective strategy often depends on the community characteristics and goals. A recent article describes the importance of including the retail environment as part of a comprehensive approach to tobacco control.[27,28]

Few studies have examined the association between flavor restrictions and tobacco use in different settings.[9,12] In Massachusetts, the impact of flavor restrictions on youth tobacco use in two different towns was examined, compared with a control town without a flavor restriction. There was an overall protective association between flavor restrictions and tobacco use, but the association was weaker among youth from the town closer to Rhode Island, a state that still sold flavored e-cigarettes, compared with the town further away.[9] Consistent with this finding, a systematic review of interventions to prevent tobacco sales to minors found that retailer interventions may not work if neighboring cities have different policies.[29] In another study, there was no overall association between flavor restrictions and e-cigarette use in a longitudinal cohort study of young adults in Los Angeles, CA.[12] However, they found that flavor restrictions were associated with a pre- to post-policy increase in e-cigarette use among dual e-cigarette and cigarette users at baseline. Given that youth who use cigarettes

may be more vulnerable to e-cigarette use and addiction, overcoming this co-occurring risk of dual use may be beyond what flavor restrictions can plausibly influence and, instead, may require more targeted and intensive individual level interventions. These findings suggest that the implementation of flavor restrictions may need to consider the use of other tobacco products or proximity to towns without a flavor restriction.

Our results showing that youth in high retailer density cities had a higher percent of racial and ethnic minority groups and lower parental education is consistent with prior research.[14–17] In the U.S., neighborhoods with a greater proportion of Black residents and adults living below the poverty level lived in areas with a higher retailer density (number of retailers per 1000 people).[17] Neighborhoods with lower income also have more tobacco marketing, which has been associated with tobacco use.[30] In addition, flavor restrictions and other tobacco control policies are less likely to be implemented in areas with racial and ethnic minority groups.[12,31,32] Flavor restrictions are also more likely to be implemented in areas with existing tobacco control policies.[31] Indeed, among cities with high tobacco retailer density, we found lower baseline e-cigarette use in youth exposed to a flavor restriction compared to unexposed youth. These inequities in retailer density, tobacco marketing, and where tobacco control policies are implemented could further exacerbate health disparities in tobacco use and tobacco-related diseases.

Limitations

Only seven cities with flavor restrictions were included due to data availability. Thus, we used the median retailer density value as a cut-off so that there would be an approximately equal number of cities with flavor restrictions and sample size in each stratification group. Sensitivity analyses conducted using a cut-point of 2.3 and 4.3 produced mostly consistent results. If we had more cities with flavor restrictions, we could have tested different cut-off values.

Although we stratified our results by retailer density, there could be other stratification factors that would also result in a difference in association between flavor restrictions and e-cigarette use, as there were substantial differences in population and retailer characteristics between cities with high and low retailer density. Cities with high retailer density had a higher population density, number of tobacco retailers, retailer density (retailers per 10 000 people), number of retailers within 1000 feet of a school, and were likely closer to cities without a flavor ban. Cities with high retailer density had a lower percent of the population that was White race/ethnicity and that was younger than the legal age to purchase tobacco, 21 years. We used retailer density as a stratification factor because previous literature has shown that retailer density is associated with increased tobacco access and use.[14,18]

These results may be considered preliminary as they included only seven cities in the Bay Area with flavor restrictions, and only one-year post-policy implementation time. Future research is needed with more policies and longer follow-up time. We also did not include any information on strength of enforcement of flavor restrictions, which is typically at the local level and likely differs between cities. The Policy Evaluation Tracking System, a database maintained by the American Nonsmokers Rights Foundation, is in the process of coding flavor restrictions based on their enforcement mechanisms and the data will be available for future research studies. Future research may also consider the impact of the California state flavor restriction, which was implemented in late December 2022.[33]

Conclusion

Flavor restrictions are implemented in communities with a variety of different demographic and tobacco control characteristics. Therefore, it is important to examine the impact of flavor restrictions in different contexts and how they shape health outcomes. In diverse communities in the California Bay Area, our results suggest a protective association between flavor restrictions and access to e-cigarettes in low, but not high retailer density cities one-year post-implementation. Thus, the effectiveness of flavor restrictions may depend on retailer density, as youth who live in cities with high retailer density may be exposed to more tobacco marketing, have more opportunities to purchase tobacco products, or weaker tobacco retailer compliance with policies. As retailer density is known to be a health equity issue with greater retailer density in high-minority, low-income areas, these groups may not be receiving the full benefits from flavor restrictions, furthering inequities in tobacco use. High retailer density areas may need additional tobacco control efforts, such as increased education, youth prevention and cessation programs, policies to reduce tobacco retailer density, or stronger tobacco retailer enforcement or compliance monitoring.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Declaration of Interests

None declared.

Data Availability

The California Healthy Kids Survey is available by request: https://calschls.org/reports-data/

Author Contributions

Melanie Dove (Conceptualization [Equal], Data curation [Equal], Formal analysis [Equal], Investigation [Equal], Methodology [Equal], Validation [Equal], Writing—original draft [Equal]), Kevin Gee (Conceptualization [Equal], Investigation [Equal], Methodology [Equal], Writing—review & editing [Equal]), and Elisa Tong (Conceptualization [Equal], Investigation [Equal], Methodology [Equal], Writing—review & editing [Equal])

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