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A statewide study of disparities in local policies and tobacco, vape, and cannabis retail environments

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ABSTRACT

The current study: (1) assesses sociodemographic disparities in local policies related to tobacco and cannabis retail, and (2) examines the cross-sectional association between policy strength and retailer densities of tobacco, e-cigarette (vape), and cannabis retailers within California cities and county unincorporated areas (N = 539). We combined (a) American Community Survey data (2019 5-year estimates), (b) 2018 tobacco, vape, and cannabis retailer locations from a commercial data provider, (c) 2017 tobacco and vape retail environment policy data from American Lung Association, and (d) 2018 cannabis policy data from California Cannabis Local Laws Database. Conditional autoregressive models examined policy strength associations with sociodemographic composition and retailer density in California jurisdictions. Jurisdictions with larger percentages of Black and foreign-born residents had stronger tobacco and vape policies. For cannabis policy, only income had a small, significant positive association with policy strength. Contrary to hypothesis, tobacco/vape policies were not significantly associated with retailer density, but cannabis policy strength was associated with lower cannabis retailer density (relative rate = 0.58, 95% Uncertainty Interval 0.47–0.70)—this effect was completely driven by storefront bans. Thus, storefront cannabis bans were the only policy studied that was associated with lower cannabis retailer density. Further research is needed to understand policies and disparities in retail environments for tobacco, vape, and cannabis, including data on the prospective association between policy implementation and subsequent retailer density, and the role of enforcement.

1. Introduction

Retail environments and policies related to tobacco and cannabis have substantially changed in recent years in the United States (US) (Meng et al., 2022; Smart & Pacula, 2019). For example, e-cigarette specialty retailers, called vape stores, are now a common part of the tobacco retail landscape (Berg et al., 2020; Giovenco et al., 2016; Sussman et al., 2015) in addition to other tobacco retailers such as tobacco shops, liquor stores, convenience stores, etc. Moreover, cannabis retailers have emerged in localities that permit them. As of April 2023, 22 states had legalized non-medical cannabis use, and three states had no public cannabis access program (National Conference of State Legislatures, 2023). There is also significant diversity in local-level cannabis policies in states such as California, where jurisdictions are permitted to ban cannabis retail altogether, or to implement policies that are more stringent, and in some cases less stringent than state law (Padon et al., 2022).

Presence and strength of local tobacco and cannabis control policies (e.g., licensing, zoning, retailer caps or bans) may affect retail environment disparities. Ample evidence shows that retail environments affect health behaviors (Lee et al., 2022; Lipperman-Kreda et al., 2014; Valiente et al., 2021), thus are a potential pathway linking place-based economic disparities and place-based substance use disparities (Pearce et al., 2011). For example, tobacco retailer exposure increases tobacco

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use risk for all ages (Clemens et al., 2020; Lee et al., 2022), particularly youth (Mistry et al., 2022; Robertson et al., 2016). It is therefore important to understand the role of policy in shaping retail environment disparities. A large literature documents greater densities of "unhealthy" retailers (e.g., tobacco, alcohol, fast food, cannabis) in socioeconomically disadvantaged and predominantly minority neighborhoods (James et al., 2014; Trangenstein et al., 2020; Wheeler et al., 2020; Yu et al., 2010). Some studies find tobacco retail environment disparities by nativity—a Chicago study found a positive correlation between retailer density and percentage foreign-born (Novak et al., 2006), and a California study found a positive association with percentage foreign-born Latinx (Bostean et al., 2021). A study of 80 tobacco control programs found that affluent localities were more likely to adopt tobacco retail environment policies (Combs et al., 2019)—notably, the first two US cities to ban tobacco sales within city limits, both in California (Action on Smoking and Health, 2021), are among the top 2.5% most affluent in the state (U.S. Census Bureau, 2014).

Researchers know less about the extent to which varying policy strength contributes to disparities. Since local policies, such as retailer licensing ordinances, may increase equity (Lawman, 2019), scholars and policymakers must understand: (a) factors driving the strength of local policies that regulate the retail environments for unhealthy products, particularly community sociodemographic composition, and (b) whether policy strength is in turn associated with density of retailers.

This study is the first to examine local policies in three product domains (tobacco, vape, cannabis), and how policy strength is associated with retail environments for these products. Using data for California cities and counties, we address two primary questions: (1) Are racial/ethnic, nativity, and socioeconomic status (SES) composition of jurisdictions associated with the strength of tobacco and cannabis control policies?; and, (2) Is policy strength in each domain associated with retailer density for that domain? We test the following hypotheses: 1. Sociodemographically disadvantaged jurisdictions have weaker local policies related to tobacco, vape, and cannabis retail environments; 2. Greater local policy strength in each domain is associated with lower retailer density in the respective domain.

We extend the literature in several ways. First, in examining these three domains we provide a more holistic view of the retail landscape than most studies focusing on only tobacco or cannabis. Given their increase in recent years (Golden et al., 2021), we include vape stores, a specialty retailer whose primary business code is e-cigarette specific and may have lounge areas (Sussman et al., 2015), separately from other tobacco retailers (e.g., tobacco shops, convenience stores, gas stations). Although there may be some overlap between retailers—e.g., vape-and-smoke shops (Sussman et al., 2021), tobacco or vape stores that sell CBD, a hemp-derived product that can be sold without a cannabis retailer license (Berg et al., 2020), and cannabis shops sell vape devices—in California, retailers must have a license to sell either cannabis or tobacco and cannot sell both in the same location (Proposition 64, 2016). *De facto*, however, there are loopholes (Leas, 2021) and non-compliance with regulations about cannabis-derived products and tobacco sales (Berg et al., 2023).

Second, we assess sociodemographic and policy strength disparities, controlling for ecological confounders. Because we focus on retailer density, we examine the association between density and strength of local policies that directly impact retailer density—e.g., local retail licensing requirements or regulations requiring a minimum distance between retailers and sensitive use sites.

2. Methods

2.1. Data

We examined all California jurisdictions (N = 539; 481 cities and 58 county unincorporated areas that are not part of cities and thus subject to county regulations). Sociodemographic data came from American Community Survey (2015–2019 5-year estimates). Policy strength data for tobacco and vape came from American Lung Association (ALA) 2017 State of Tobacco Control Grades (American Lung Association, 2017) and cannabis policy from the California Cannabis Local Laws Database, based on laws passed on or before December 31, 2018 (Silver et al., 2020).

Retailer locations were purchased from commercial data provider DataAxle, used in prior studies (Siahpush et al., 2010). We included "verified" locations of retailers that were open in 2018 (confirmed with multiple phone calls throughout the year) based on primary industry codes (NAICS 445120, 445310, 447110, 447190, and 453991 for tobacco retailers, including tobacco shops, gas stations, beer, wine, and liquor stores, convenience stores, wine stores– SIC 599306 for vape shops, and SIC 512227 for medical and non-medical cannabis shops). We eliminated duplicates, excluded PO Box addresses, and ensured that the vape and tobacco store lists were mutually exclusive, which resulted in 20,986 tobacco shops, 318 vape shops, and 326 cannabis shops operating in 2018.

The one-year lag between the policy measures for tobacco and vape, and retailer locations (2018 retailers, 2017 policy measures for tobacco and vape), accounts for the fact that it takes time for retail environment to change in response to policy implementation. Although adult-use cannabis sale became legal in California on 1/1/2018, nearly 70% of jurisdictions that allowed storefront cannabis retailers in 2018 had adopted relevant regulations by 2017 (Silver et al., 2020). This study was deemed exempt from human subjects review by the Chapman University Institutional Review Board.

2.2. Measures

2.2.1. Retail environment policy strength

Tobacco policy strength (0–5) variable was created specifically for this study, using data from the local license category of the ALA report (for details, see American Lung Association, 2017). We summed the tobacco retail license strength (0–4) and retailer location restrictions (0–1) measures. See Supplementary Table 1 for details. The retailer location restriction measure assesses whether the jurisdiction restricts tobacco retailers within a certain distance of parks and/or schools, or of other retailers, or caps/limits the number of licenses that can be issued. *Vape policy strength* (0–6) uses the same variables as tobacco and adds whether e-cigarettes/vapes are explicitly included in the local licensing requirements (0–1). *Cannabis policy strength* (0–6) sums five dichotomous variables assessing strength of local retail environment policies compared with state policies (ban of storefront retailers, retailer cap, retailer minimum distance (buffer) from schools, from other sensitive use sites, or from other retailers; 0 = no policy, less strict or same as state; 1 = policy stricter than state). Jurisdictions (cities/county unincorporated areas) that ban cannabis storefronts were given the strictest score of 6. Policy variables are coded such that higher numbers indicate more stringent policies.

2.2.2. Retailer density

We calculated the number of tobacco, vape, and cannabis stores within each jurisdiction, and standardized per 100 miles of roadway within the jurisdiction (Bostean et al., 2021; Gruenewald et al., 2006). Studies commonly standardize by population or roadway (Holmes et al., 2014; Lee et al., 2022); we use roadway because retailers generally cannot locate where there is no roadway.

2.2.3. Sociodemographic composition

We examined the percentages of non-Latinx Black, Latinx, and Asian populations to examine racial/ethnic disparities; we also included the percentage of foreign-born, given the moderating impact of nativity on ethnic disparities in exposure to alcohol and tobacco retailers in California (Bostean et al., 2021). Percentage unemployed and median household income examined income-related disparities (education was

not included because of high [r = 0.9] collinearity with Latinx).

2.2.4. Control variables

Potential confounders included the percentage of the population under age 18 (Giovenco et al., 2016), population density per square mile of jurisdiction, percent urban using Census Urban Areas (Schleicher et al., 2016), percent commercial zoning (Theobald and Merenlender, 2014), and city vs. county (0 = incorporated city, 1 = county remainder/unincorporated).

2.3. Statistical analyses

We examined sample descriptive statistics, then bivariate correlations among key study variables. To test hypotheses, we used Bayesian conditional autoregressive (CAR) Poisson models (Besag et al., 1991; Blangiardo & Cameletti, 2015). This approach accounts for unexplained spatial autocorrelation, which introduces bias in uncorrected analyses (Carlin & Louis, 2000), and controls for overdispersion similarly to zero-inflated methods (Lord et al., 2005). Models were estimated using the "BYM2" variant of the CAR model (Riebler et al., 2016), computed within the R-INLA package version 21.02.23 (Rue et al., 2009) using R version 4.0.3 (R Core Team, 2020). Two variants of the spatial Poisson model were computed across three domains (tobacco, vape and cannabis): (1) predicting counts of retail policies enacted in each jurisdiction, (2) explaining counts of tobacco, vape, and cannabis retailers within each jurisdiction, with roadway miles as the expectation. Tables present relative rates and upper and lower limits for 95% Uncertainty Intervals (UI), which are interpreted similarly to confidence intervals. Cannabis analyses excluded four localities missing cannabis policy data. Jurisdictions with cannabis storefront bans (n = 390) had a mean of 0.99 retailers (range 0 – 20, standard deviation = 1.9) operating in 2018. These retailers may have been granted a one-time exemption, been operating illegally, or local bans may have been implemented after stores opened. Thus, we conducted cannabis regressions with all jurisdictions (N = 535), and separate regressions excluding jurisdictions with bans (n = 145), to examine whether the policy strength effect was driven by storefront bans. Policy variables were standardized in models predicting retailer density. Based on prior evidence about potential differences by both race/ethnicity and nativity (Bostean et al., 2021), we tested for interactions between percentages of foreign-born and percentages of Latinx and Asian populations (predominant California immigrant groups), respectively; we mean-centered variables involved in the interaction to facilitate interpretation. All models exhibited unexplained spatial autocorrelation, with the conditional autoregressive random effect accounting for at least 60% of total residual variance across models. Thus, spatial models are needed to account for this departure from randomly distributed residuals. Findings were robust to different retailer definitions (tobacco shops only versus a wider variety of tobacco retailers), to inclusion of both verified and pre-verified (licensees that never opened or permanently closed at some point during this period) versus only verified retailers, and to controlling for population count as an indicator of jurisdictional policy capacity (not presented here) instead of population density.

3. Results

Table 1 presents the characteristics of California cities and counties. Across the state, the mean tobacco policy strength was 1.2 and mean vape retail environment policy strength was 1.5, both with large standard deviations. Mean cannabis policy score was 5.0 (range 0–6) for all jurisdictions, and 2.3 (range 0–5) for only jurisdictions allowing storefronts. Mean retailer density (per 100 miles of roadway within the jurisdiction) was 1.4 for tobacco (range 0–20.5), 0.4 for vape stores (range 0–4.2), and 0.4 for cannabis retailers (range 0–11.2). Supplementary Figs. 1–3 visualize the policy and retail environments for tobacco, vape, and cannabis throughout the state.

Table 1
Socio-demographic descriptives, policy strength, and retailer density of California (US) cities and unincorporated county areas (N = 539).

	Median	Mean	SD	Min	Max
Policy strength retail env (higher = more stringent policy)					
Tobacco	0.0	1.2	1.9	0.0	5.0
Vape	0.0	1.5	2.2	0.0	6.0
Cannabis	6.0	5.0	1.8	0.0	6.0
Retailer density (per 100 roadway miles)					
Tobacco retailer	10.9	12.3	9.7	0.0	82.0
Vape store	0.0	0.2	0.4	0.0	3.4
Cannabis retailer	0.0	0.1	0.5	0.0	7.5
Sociodemographic composition					
Non-Latinx Black (%)	1.8	3.5	4.7	0.0	39.7
Latinx (%)	30.3	36.0	25.1	2.9	99.0
Asian (%)	5.6	10.8	13.3	0.0	67.4
Foreign-born (%)	20.7	22.2	12.0	0.3	56.8
Unemployed (%)	5.6	6.2	3.2	0.0	23.7
Mean Household Income ($10,000 s)	8.9	10.9	6.4	3.5	52.7
Control variables					
Under age 18 (%)	22.8	23.1	5.6	0.2	38.9
Population density (100 s persons/sq. mile) [a]	1.9	2.0	1.3	0.0	9.1
% Urban	82.0	70.1	34.3	0.0	100.0
% Commercial land use	7.6	8.6	7.9	0.0	83.8
County unincorporated area	0.0	0.1	0.3	0.0	1.0

Notes: Retailer data purchased from commercial data provider for verified locations open in 2018. Policy strength data for tobacco and vape came from American Lung Association (ALA) 2017 State of Tobacco Control Grades, and cannabis policy scores from the Public Health Institute 2019 California Local Cannabis Laws Database (CLCLD). Sociodemographic data come from American Community Survey 5-year estimates (2015–2019). Cannabis policy measure (N = 535 due to missing data for 4 cities). [a]Population density is population normalized by jurisdiction area and rounded to a tenth, thus the areas with very small populations are shown as zero in this table, although all jurisdictions have residents.

Bivariate correlations (Table 2) show stronger policies in all three domains were generally positively correlated with percentages of residents who are Black, Asian, foreign-born (with the exception that percentage Black is negatively associated with cannabis policy strength). Unemployment was negatively, and median household income positively, correlated with cannabis policy strength (Supplemental Table 2 provides further detail.). Stronger tobacco and vape policies were associated with higher tobacco and vape shop densities, respectively, while stronger cannabis policy was associated with lower cannabis retailer density.

Conditional autoregressive Poisson regressions predicting policy strength assessed the independent effects of these sociodemographic variables while accounting for spatial dependence in policy strength. Table 3 presents relative rates (RR) from fully adjusted models. For tobacco, adjusted models showed stronger policies in areas with larger percentages of Black (RR = 1.06, 95% UI = 1.02 – 1.10) and foreign-born residents (RR = 1.09, 95% UI = 1.04 – 1.15); Latinx and Asian percentages were not associated with policy strength and there was no interaction between nativity and race/ethnicity. Thus, for each percentage point increase in Black residents, there was a 1.06 times higher policy strength, and for a one percentage point increase in foreign-born composition there was a 1.09 times higher policy strength. Patterns were similar for vape retail environment policies. Larger percentages of Black and foreign-born residents (RR = 1.06 and 1.10, respectively) were associated with stronger vape retail environment policies. Cannabis policy strength was significantly associated with median household income, with 1% stronger cannabis policies for every $10,000 increase in area-level household income. However, when examining only jurisdictions without cannabis storefront bans (N = 145), which have policy strength ranging from 0 to 5, there were no statistically significant associations with city sociodemographic composition. In sum, findings provide partial support for Hypothesis 1, showing stronger cannabis

Table 2
Pairwise correlations between policy strength, retailer density, and key sociodemographic variables (California cities and unincorporated areas; N = 539).

	Tobacco policy	Vape policy	Cannabis policy	Tobacco shop density	Vape shop density	Cannabis shop density	Non-Latinx Black	Latinx	Asian	Foreign-born	Unemployment Rate
Tobacco policy	1.00										
Vape policy	0.99*	1.00									
Cannabis policy	−0.06	−0.07	1.00								
Tobacco shop density	0.19*	0.19*	−0.07	1.00							
Vape shop density	0.11*	0.11*	0.00	0.19*	1.00						
Cannabis shop density	0.10*	0.11*	−0.23*	0.33*	−0.05	1.00					
Non-Latinx Black	0.19*	0.19*	−0.09*	0.04	0.03	0.08	1.00				
Latinx	0.05	0.04	−0.03	0.06	−0.05	−0.11*	0.10*	1.00			
Asian	0.12*	0.11*	0.16*	0.04	0.18*	−0.05	0.08	−0.28*	1.00		
Foreign-born	0.22*	0.22*	0.10*	0.19*	0.11*	−0.08	0.09*	0.48*	0.59*	1.00	
Unemployment Rate	−0.04	−0.04	−0.16*	−0.38*	−0.13*	−0.07	0.14*	0.46*	−0.33*	0.01	1.00
Household Income	0.04	0.03	0.22*	−0.10*	−0.02	−0.04	−0.15*	−0.50*	0.33*	0.00	−0.45*

Notes: Asterisk denotes statistical significance at < 0.05 alpha level. Retailer data purchased from commercial data provider for verified locations open in 2018. Policy strength data for tobacco and vape came from American Lung Association (ALA) 2017 State of Tobacco Control Grades, and cannabis policy scores from the Public Health Institute 2019 California Local Cannabis Laws Database (CLCLD). Sociodemographic data come from American Community Survey 5-year estimates (2015–2019). Cannabis policy measure (N = 535 due to missing data for 4 cities).

Table 3
Predicting retail environment policy strength in California cities and county unincorporated areas, 2017 & 2018[b]: Relative rates from BYM Poisson models.

	Tobacco (N = 539)			**Vape (N = 539)**			**Cannabis (N = 535)**			**Cannabis[a] (N = 145)**		
		95% Uncertainty Interval			95% Uncertainty Interval			95% Uncertainty Interval			95% Uncertainty Interval	
	Median	LL	UL	Median	LL	UL	Median	LL	UL	Median	LL	UL
Key independent variables												
% Black (non-Latinx)	**1.06**	1.02	1.10	**1.06**	1.02	1.11	1.00	0.99	1.01	1.01	0.98	1.03
% Latinx	0.99	0.96	1.02	0.99	0.96	1.02	1.00	0.99	1.00	1.00	0.98	1.02
% Asian	1.02	0.96	1.08	1.02	0.95	1.08	1.00	0.99	1.02	1.03	0.98	1.09
% Foreign-born	**1.09**	1.04	1.15	**1.10**	1.04	1.17	0.99	0.98	1.00	0.98	0.94	1.02
% Foreign-born*% Latinx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
% Foreign-born*% Asian	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
% Unemployed	0.98	0.91	1.06	0.98	0.90	1.06	0.99	0.97	1.00	1.00	0.96	1.05
Mean Household Income ($10,000 s)	1.00	0.95	1.04	0.99	0.94	1.04	**1.01**	**1.00**	**1.02**	1.05	1.00	1.09
Control variables												
% Under age 18	0.95	0.91	1.00	0.95	0.90	1.00	1.01	1.00	1.02	1.01	0.97	1.04
Population density (100 s per roadway mile)	**1.42**	1.12	1.81	**1.46**	1.13	1.89	0.98	0.93	1.03	0.99	0.86	1.13
% Urban	0.99	0.94	1.04	0.99	0.94	1.04	1.01	1.00	1.02	1.01	0.99	1.05
% Commercial land use	0.99	0.97	1.02	0.99	0.96	1.02	1.00	1.00	1.01	1.01	0.99	1.02
County unincorporated area (ref = incorporated cities)	1.97	0.82	4.84	1.95	0.76	5.10	1.03	0.85	1.24	1.29	0.77	2.18
Intercept	**0.19**	0.04	0.77	**0.20**	0.04	0.93	**4.07**	3.06	5.40	1.02	0.39	2.56

policies in socioeconomically advantaged areas and this is driven by bans.

Turning to fully adjusted models predicting retailer density (Table 4), tobacco policy strength was not a statistically significant predictor of jurisdiction-level tobacco retailer density net of sociodemographic and ecological controls, nor was vape policy strength associated with vape shop density. However, stricter cannabis retail policy was associated with lower cannabis retailer density (RR = 0.58, 95% UI = 0.47 – 0.70). Thus, Hypothesis 2, that policy strength is inversely associated with retailer density, is only supported for cannabis. We also examined only jurisdictions that allowed storefronts. No statistically significant association between policy strength and cannabis retailer density was found, suggesting that the association between cannabis policy strength and density is driven entirely by storefront bans.

To examine sensitivity of the results to different retailer definitions, Supplemental Table 3 shows the results from models predicting retailer density, including only tobacco shops (rather than the expanded tobacco retailers including gas stations, convenience stores, and beer/wine/liquor stores), and including both verified and pre-verified locations of all three retailers (which may overestimate density in some locations). Results were similar. Thus, our results—that cannabis storefront bans are associated with cannabis retailer density, but that tobacco and vape density-related policies are not significantly associated with tobacco and vape shop density—are robust to the inclusion of pre-verified retailers and to changes in the tobacco retailers included.

4. Discussion

This study examined associations between place-level sociodemographic composition, strength of retail environment-related policies for tobacco, vape, and cannabis, and density of tobacco, vape, and cannabis retailers throughout California. Two major findings speak to our hypotheses: (1) higher percentages of Black and foreign-born residents

Table 4
Predicting retailer density (by roadway) in California cities and county unincorporated areas, 2018: Relative rates from BYM Poisson models.

	Tobacco (N = 539)			Vape (N = 539)			Cannabis (N = 535)			Cannabis[a] (N = 145)		
		95% Uncertainty Interval			95% Uncertainty Interval			95% Uncertainty Interval			95% Uncertainty Interval	
	Median	LL	UL	Median	LL	UL	Median	LL	UL	Median	LL	UL
Policy strength [a]	1.04	0.96	1.12	1.02	0.88	1.17	**0.58**	0.47	0.70	1.79	0.96	3.43
Control variables												
% Black (non-Latinx)	0.99	0.98	1.01	0.99	0.96	1.02	**1.04**	1.00	1.09	**1.12**	1.03	1.24
% Latinx	**1.01**	1.00	1.02	0.99	0.97	1.02	0.98	0.94	1.01	0.96	0.89	1.03
% Asian	1.02	1.00	1.05	1.02	0.98	1.06	0.98	0.91	1.06	0.90	0.73	1.10
% Foreign-born	**1.03**	1.01	1.05	1.01	0.97	1.05	1.04	0.97	1.10	1.02	0.86	1.19
% Foreign-born*% Latinx	**1.00**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
% Foreign-born*% Asian	**1.00**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01
% Unemployed	**0.96**	0.92	1.00	**0.91**	0.84	0.98	0.95	0.85	1.06	1.06	0.88	1.29
Mean Household Income ($10,000 s)	**0.91**	0.88	0.94	**0.93**	0.88	0.98	0.95	0.87	1.02	0.90	0.69	1.10
% Under age 18	1.01	0.99	1.03	1.02	0.98	1.07	0.99	0.93	1.05	1.01	0.90	1.15
Population density (100 s per roadway mile)	**1.47**	1.34	1.61	1.10	0.95	1.29	**1.35**	1.04	1.76	**1.99**	1.24	3.27
% Urban	**1.03**	1.01	1.05	**1.05**	1.01	1.10	1.02	0.95	1.09	1.01	0.90	1.15
% Commercial land use	1.00	0.99	1.02	1.01	0.98	1.03	1.01	0.97	1.05	1.04	0.97	1.12
County unincorporated area (ref = incorporated cities)	**0.13**	0.09	0.20	**0.09**	0.04	0.21	**0.20**	0.07	0.64	**19.23**	2.69	191.66
Intercept	1.17	0.58	2.36	0.74	0.18	2.89	0.38	0.05	2.68	0.22	0.00	10.72

were independently associated with stronger tobacco and vape policies, and higher household income was associated with stronger cannabis policies, and (2) cannabis storefront bans were negatively associated with cannabis retailer density, but tobacco and vape policy strength were not significantly associated with retailer densities. These findings do not suggest that stronger tobacco/vape local licensing and location restrictions are ineffective in reducing retailer density; rather, given that these associations were cross-sectional, they merely indicate that a jurisdiction's decision to implement these policies is not associated with sociodemographic make-up of its residents.

The finding that proportionally larger Black and foreign-born populations were associated with stronger tobacco and vape policies may seem counterintuitive given prior research documenting worse retail environments in minority neighborhoods. However, these communities have historically shown more support for tobacco control policies (Osypuk & Acevedo-Garcia, 2010; Rose et al., 2015). Moreover, strong local coalitions (African American Tobacco Control Leadership Council, 2023) advocate for policies to counteract targeting of these communities by Big Tobacco, and the California Department of Public Health makes explicit efforts to address targeting and inequities caused by Big Tobacco (UNDO- End Tobacco Damage Now, 2022).

Further, cannabis policy was stronger in cities with higher median household income. This is particularly important in light of California's equity grant program, announced in 2022, intended to help "level the playing field for communities that were negatively or disproportionately impacted by cannabis criminalization," (Purcell, 2022). Future research should examine the impacts of this and other new cannabis programs on retail environments and health equity.

Our second finding, that policy strength was significantly associated only with cannabis retailer density (driven by storefront bans)—not tobacco or vape shop density—reveals a paradox whereby some areas have stronger tobacco retailer licensing policies, but these places do not have statistically significantly lower tobacco or vape shop density than places with weaker policies. To be clear, these results do not suggest that policies are ineffective at changing retail environments. There are several factors to consider when interpreting these results. First, the cannabis policy measure includes several policies related to retail environment (e.g., retailer caps, distance from sensitive use sites) and storefront bans as the strongest policy. The tobacco and vape policy measures are mostly based on the presence/strength of a local retailer licensing requirement due to limitations of available tobacco/vape-related data on similar retail environment-related policies.

The fact that tobacco and vape policy measures were not significantly associated with retailer densities may indicate that despite strong licensing ordinances (Jacobson et al., 1997), penalties for non-compliance are not severe enough to result in store closure, or fees remain insufficient to cover administration and enforcement. It could be that a strong local licensing ordinance is not a sufficiently strong barrier to curb the number of retailers, or that despite a strong licensing ordinance there is ineffective enforcement of non-compliant retailers. A review of Tobacco 21 local policies passed before 2019 found that few included enforcement components (Dobbs et al., 2021). Further research should examine whether other retail environment policies are more closely associated with tobacco retailer/vape shop density.

It is also possible that some of these tobacco/vape retailers were operating illegally. A strength of this study is using data from a commercial provider rather than state license data, so that our sample may include retailers operating without a license. State inspection data from 2018 to 2019 show 12,288 inspections which resulted in 92 tobacco product seizures (CDTFA, 2023), though we are unable to assess what proportion were unlicensed. If there are substantial numbers of unlicensed retailers, this suggests that enforcement is crucial to changing retail environments; simply having a licensing requirement is not enough. This highlights the need for on-going surveillance of retail environments.

Another plausible explanation is that tobacco or vape licensing measures are enacted in response to growing retailer presence rather than enacted proactively. It takes time for the retail environment to change following policy implementation, and it can be difficult to close retailers once open (Lawman et al., 2020). In San Francisco the number of tobacco licenses decreased by 8% in the first 10 months after implementation of a policy restricting density, but it is projected to take 10–15 years to achieve the desired 45 retailer district cap (Bright Research Group, 2016). More recent San Francisco data show that land use zoning is the primary correlate of closure of retailers following implementation of a retailer density ordinance (Vyas et al., 2020). Further, some localities may provide one-time exemptions for certain retailers, contributing to slower change in density. Therefore, the one-year lag between our policy and retailer data for tobacco and vape may be insufficient to capture the full longer-term effects of policy. Future studies could include the number of years since policy implementation to understand how duration of policy is associated with retail environment.

Finally, although areas with larger foreign-born populations have stronger tobacco policies, areas with only average size foreign-born Latinx and Asian populations have higher than average tobacco

retailer density (while cities with larger immigrant Latinx and Asian populations have lower retailer density). This isn't surprising considering Latinx immigrants have among the lowest smoking rates in the US (Berardi et al., 2021). More research is needed, however; a recent California study found greater density of tobacco retailers in census tracts with larger proportions of foreign-born Latinx and no association with the proportion of foreign-born Asian residents (Bostean et al., 2021), despite foreign-born Asian men having high smoking prevalence (Baluja et al., 2003). This may reflect the broader array of tobacco retailers included in this study, and differing levels of aggregation between the studies (an aspect of the Modifiable Areal Unit Problem, discussed below, common in geographic studies (Fotheringham & Wong, 1991)). For vape shop density, cities with higher income and higher unemployment had lower vape density, suggesting that income and unemployment may have differing associations with vape shop environment, perhaps because vape shops tend to be small businesses that may locate where rents are lower. Future research should explore whether socioeconomic inequality (beyond independent SES measures) is associated with retail environment, given prior research finding associations of inequality with health outcomes (Wilkinson & Pickett, 2006).

For cannabis, when examining all jurisdictions, higher income areas had stronger policies, which are associated with lower retailer density. However, when examining only places without bans, there were no significant associations with sociodemographic composition, and cannabis policy strength did not predict cannabis retailer density. This suggests that storefront bans are the most effective policy for reducing cannabis retailer density. Further, larger percentages of foreign-born are associated with higher cannabis retailer density. These findings highlight the need for localities, especially those with lower income and more foreign-born residents, to take proactive measures to ensure that retail commerce of harmful products does not concentrate in communities of immigrants, lower-income, or racial/ethnic minorities.

Findings should be interpreted in the context of several limitations. Although we used lagged data for tobacco and vape policies and retailer locations (and used policy and retailer data from the same year for cannabis, but most jurisdictions had already passed relevant policies), the lack of longitudinal data prevents us from examining causal relationships. The dynamic environment is a limitation of this cross-sectional study, and highlights the need for on-going surveillance of the retail environments. As with other spatial studies that examine area-level characteristics, our findings could be susceptible to the Modifiable Areal Unit problem, which can yield different associations when aggregating data to different geographic areal units (Fotheringham & Wong, 1991). Because local policies are implemented at the local level, we used the most appropriate and geographically nuanced unit of aggregation suitable for this study. Finally, this study focused on verified tobacco retailers and vape shops, and therefore excludes some locations that were not fully verified by the commercial data provider, indicating that they may not have operated for the full year in 2018. However, our data source potentially includes unlicensed locations which are unavailable through the California state license listing. Thus, study strengths include using statewide data to examine three types of retailers and using spatial analyses to account for spatial dependence.

Future research should explore whether local-level policies are associated with sub-locality retail environments. For example, it may be that density within specific areas (e.g., certain neighborhoods or areas around schools) are more correlated with these policies than overall local-level retailer density. Additionally, while this study focused on policies related directly to retail environment for tobacco, vape, and cannabis, multiple policies (such as tobacco excise taxes and clean air policies) are often implemented at the same time (Matthay et al., 2022); thus, future studies should include consideration of the co-implementation of related policies including those that may be indirectly associated with retailer density such as restrictions on flavored products.

5. Conclusions

Local policies such as local licensing requirements, zoning regulations, permit caps, and other means of regulating the retail environment remain key strategies for the tobacco endgame (Kong and King, 2021). From an equity perspective, while it is encouraging that we document higher tobacco and vape policy strength in cities with larger Black and foreign-born populations, attention should also be paid to retailer densities within localities; some research shows that retailer closures following policy implementation may be predominantly in areas with non-minority residents (Vyas et al., 2020). Moreover, our findings suggest that strong licensing ordinances may be necessary but not sufficient, at least in the very short-term, or may take substantial time to change tobacco and vape retail environments. Strategies may be more impactful when multiple strategies are implemented together. Efforts to decrease inequities related to the long history of Big Tobacco targeting disadvantaged communities must go beyond policy implementation to enforcement (Kong and King, 2021). Importantly, for emerging products including cannabis, proactive policymaking to shape retail environments before retailer density increases to concerning levels, may be more effective than reactive policymaking in response to alarmingly high levels of retailer density.

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CRediT authorship contribution statement

Georgiana Bostean: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing. **William R. Ponicki:** Methodology, Formal analysis, Writing – review & editing. **Alisa A. Padon:** Data curation, Methodology, Writing – review & editing. **William J. McCarthy:** Methodology, Writing – review & editing. **Jennifer B. Unger:** Funding acquisition, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Figures with some of the data are available as an ArcGIS StoryMap entitled, "Retail environments for tobacco, vape, & cannabis in CA", available at the following link: https://storymaps.arcgis.com/stories/af7e38752ec94911bb9939850fdb7ed9.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.

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