

# BMJ Open Modelling retailer-based exemptions in flavoured tobacco sales restrictions: national estimates on the impact of product availability

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## ABSTRACT

**Objectives** More than 250 US localities restrict sales of flavoured tobacco products (FTPs), but comprehensiveness varies, and many include retailer-based exemptions. The purpose of this study is to examine resulting changes in the US retail environment for FTPs if there was a hypothetical national tobacco control policy that would prohibit FTP sales in all retailers except (1) tobacco specialty stores or (2) tobacco specialty stores and alcohol outlets.

**Design and setting** A cross-sectional analysis of the FTP retail environment in every US Census tract (n=74 133). FTP retailers (n=3 10 090) were enumerated using nine unique codes from a national business directory (n=296 716) and a national vape shop directory (n=13 374).

**Outcome measures** We assessed FTP availability using static-bandwidth and adaptive-bandwidth kernel density estimation. We then calculated the proportion of FTP stores remaining and the mean density of FTP retailers under each policy scenario for the overall population, as well as across populations vulnerable to FTP use.

**Results** Exempting tobacco specialty stores alone would leave 25 276 (8.2%) FTP retailers nationwide, while exempting both tobacco specialty stores and alcohol outlets would leave 54 091 (17.4%) retailers. On average, the per cent remaining FTP availability per 100 000 total population was 7.1% for a tobacco specialty store exemption and 18.1% for a tobacco specialty store and alcohol outlet exemption. Overall, density estimate trends for remaining FTP availability among racial/ethnic populations averaged across Census tracts mirrored total population density. However, estimates varied when stratified by metropolitan status. Compared with the national average, FTP availability would remain 47%–49% higher for all racial/ethnic groups in large metropolitan areas.

**Conclusions** Retailer-based exemptions allow greater FTP availability compared with comprehensive policies which would reduce FTP availability to zero. Strong public policies have the greatest potential impact on reducing FTP availability, particularly among urban, and racial/ethnic minority populations.

## Strengths and limitations of this study

- This study used a comprehensive national retailer database supplemented with vape shop retailers to model the remaining availability of retail outlets selling flavoured tobacco products under two hypothetical policy scenarios with national retailer-based exemptions.
- Compared with many existing studies, this research more appropriately controlled for the underlying population distribution when generating density estimates and further stratified results by urbanicity to better examine geographical inequities.
- Additional density estimates were generated for different sociodemographic groups to assess potential disparities among populations vulnerable to flavoured tobacco use and marketing.
- This study is cross-sectional and cannot evaluate changes over time.
- While this study examined two of the more commonly proposed retailer exemptions, other retailer-based exemptions exist and warrant further research.

## INTRODUCTION

The availability of flavoured tobacco products (FTPs) has been associated with increased rates of initiation and progression to regular tobacco use in the USA.<sup>1,2</sup> Further, those using FTPs, especially menthol-flavoured cigarettes, are less likely to quit and are more nicotine-dependent than those who do not use FTPs.<sup>1,2</sup> The tobacco industry has long marketed FTPs to youth and disenfranchised populations.<sup>3,4</sup> As such, rates of FTP use are disproportionately higher among youth/young adults, racial/ethnic minorities and lower-income populations.<sup>1,5</sup> Menthol-flavoured cigarettes, in particular, are disproportionately used by African American smokers (84.6%) compared with white smokers (28.9%)<sup>6</sup>; reflecting the historic predatory marketing of these products to African American communities.<sup>4,7</sup>



Menthol-flavoured cigarettes are also used at higher rates among Hispanic (46.9%), non-Hispanic (NH) 'Other' (46.7%) smokers, low-income smokers and smokers in metropolitan areas.<sup>6 8</sup>

Until recently, efforts to restrict FTP sales were limited. In 2009, the Tobacco Control Act banned the sale of cigarettes with characterising flavours (eg, cherry and chocolate).<sup>9</sup> However, menthol-flavoured cigarettes and other non-cigarette and non-combustible FTPs were excluded from the ban.<sup>9</sup> Since 2009, menthol-flavoured cigarette, flavoured little cigar/cigarillo and flavoured smokeless tobacco sales have increased.<sup>10–12</sup> Flavoured e-liquids used with electronic cigarettes (e-cigarettes) are also legally available and e-cigarette sales have risen dramatically during 2012–2016,<sup>13</sup> further expanding the availability of FTPs in the USA.

In September 2019, the Food and Drug Administration (FDA) indicated that it would prioritise and enhance enforcement of all flavoured e-cigarette products, except tobacco flavours, from the market while manufacturers submit applications showing that the product meets the statutory standards set by the Tobacco Control Act.<sup>14–16</sup> In January 2020, the FDA issued guidance limiting flavoured e-cigarettes prior to premarket review; however, this exempted menthol and tobacco flavours, flavoured non-cartridge e-cigarette liquids, and disposable e-cigarettes.<sup>17 18</sup> In light of limited federal action, several states and localities have taken action and restricted the sale of flavoured e-cigarettes, mostly based on youth use. In November 2019, Massachusetts became the first state to permanently limit the sale of all FTPs to certain business establishments.<sup>19</sup>

These state and local policies can greatly restrict retail access to and sale of FTPs, however, they also vary widely in their comprehensiveness. Some localities, like San Francisco, California and Mendota Heights, Minnesota, USA prohibit the sale of FTPs in all retail stores citywide,<sup>20 21</sup> whereas others include retailer-based exemptions. Among FTP sale policies that include an exemption, many restrict FTP sales to tobacco specialty stores. Additionally, two policies in the country restrict FTP sales to tobacco specialty stores and menthol-flavoured tobacco sales to tobacco specialty stores and alcohol outlets.<sup>22</sup> These policies often define 'tobacco specialty stores' as stores with a significant percentage of sales from tobacco products and/or e-cigarette products, not merely stores that sell tobacco. As of 31 December 2019, approximately 274 jurisdictions nationwide have FTP sales restrictions (179 of which exempt menthol-flavoured cigarettes and other mint/menthol FTPs). Of these, 29 have either a tobacco specialty store (n=27) or an alcohol outlet exemption (n=2) for menthol-flavoured product sales. Evaluation studies have shown FTP policies can reduce FTP sales and the number of FTP retailers, even with retailer exemptions for tobacco specialty stores or adult-only liquor stores.<sup>23 24</sup> For example, a study of FTP sales restrictions in localities across Massachusetts with ordinances prior to the state-level policy shows a 27.2%–50.9% reduction

following implementation.<sup>24</sup> Additionally, researchers found that Minneapolis' policy, which restricted FTP sales (excluding menthol) to tobacco retailers at the time, resulted in a 92.9% reduction in the number of retailers selling FTPs (350–25 retailers).<sup>25</sup> However, such retailer exemptions may affect some groups more than others; raising concerns if exempted outlets are disproportionately located around low-income populations or communities of colour.<sup>26</sup>

Research suggests the populations covered by current FTP sales restrictions include those most vulnerable to FTP use and those targeted by tobacco industry FTP marketing. Studies found that FTP policies equitably reach most racial/ethnic minority populations and individuals with lower socioeconomic status.<sup>27 28</sup> As recent federal policy and continued action at the state and local-level unfolds, there is a need to estimate the magnitude of effect that comprehensive bans could have on reducing access to FTPs nationwide. In addition, it is important to understand the extent to which the impact may be lessened by including retailer exemptions and the extent to which such exemptions may disproportionately impact vulnerable populations.

This research calculated the proportion and density of FTP retailers that would remain across every US Census tract if FTP sales (including mint-flavoured and menthol-flavoured products) were prohibited in all retailers except: (1) tobacco specialty stores or (2) tobacco specialty stores and alcohol outlets. We provide density estimates overall and by age, race/ethnicity, education and socioeconomic status. Additionally, we calculated how estimates differ by metropolitan status to examine FTP availability based on the intersection of sociodemographic characteristics and urbanicity. Results from modelling these two hypothetical scenarios can inform national and local policy-makers as they consider restricting FTP sales.

## METHODS

### Tobacco retail outlet data

We used a geocoded national business directory (Dun & Bradstreet) to identify tobacco retail outlets.<sup>29</sup> We identified all businesses in 2018 that likely sold tobacco products using North American Industry Classification System codes: beer, wine and liquor stores (445310); supermarkets and other grocery stores (445110); convenience stores (445120); pharmacies and drug stores (446110); gasoline stations with convenience stores (447110); other gasoline stations (447190); department stores (452210); tobacco specialty stores (453991) and warehouse clubs and supercentres (452311). National chain retailers that do not sell tobacco products (eg, Whole Foods, Target) were excluded. Duplicate records, defined as records with the same D-U-N-S number (unique nine digit classifier by Dun & Bradstreet), address or geographical coordinates, were reviewed and excluded. The final geocoded business directory list included n=296 716 retail outlets.

The final business directory list was supplemented with vape stores web scraped from a national online directory of vape stores in 2019 (VapeTrotter)<sup>30</sup> using the Rvest package in R statistical software V.3.6. Supplemental data from VapeTrotter were necessary to include because local and national comprehensive directories do not adequately capture non-traditional stores, like vape stores, that sell tobacco products. With its national coverage of the USA, VapeTrotter data served as a proxy for stores we were unable to estimate otherwise. Vape store data were cross-referenced with the final business directory list and duplicate vape stores were manually reviewed and excluded. The final list of deduplicated vape stores was  $n=13\,374$ . The final national retail outlet dataset included  $n=31\,090$  unique retail outlets and vape stores. We created two retailer-based exemption datasets by subsetting (1) tobacco specialty stores only ( $n=25\,277$ ) and (2) tobacco specialty stores and alcohol outlets ( $n=54\,092$ ). The tobacco specialty stores only group included tobacco stores and vape stores. The tobacco specialty store and alcohol outlet group included all stores listed under the tobacco specialty store only group plus beer, wine and liquor stores.

### Modelling FTP availability

FTP availability was modelled continuously across the USA using static-bandwidth and adaptive-bandwidth kernel density estimation (KDE).<sup>31–33</sup> In both KDE approaches, a Gaussian kernel with a specified bandwidth (ie, a circle of a given radius centred at the focal location) was moved across the USA and the density of FTP retailers within the kernel was computed. At the point where density was being estimated (ie, focal location), FTP retailers within the kernel were weighted according to their distance from the kernel centre, resulting in a continuous density surface where every location (ie,  $1\text{ km}^2$  grid cell) in the USA had an assigned density value.

Static-bandwidth KDE was used to model the overall FTP availability across the USA and is considered the preferred spatial-based approach for modelling overall availability in the retail environment.<sup>32</sup> This uses a fixed distance-based bandwidth for each kernel based on national mobility data (ie, national average shopping trip length by one person in any mode of transportation),<sup>34</sup> resulting in a 6.5 mile search radius to account for the underlying heterogeneity within the FTP retail environment across the USA. Density values for each of the four resulting FTP density surfaces were expressed in units of FTP retailers per square mile.

Additionally, adaptive-bandwidth KDE was used as the preferred approach for modelling the population-level impacts of each policy scenario on FTP availability.<sup>32–35</sup> The bandwidth for each kernel increased until the underlying population reached a user-defined value (ie, 1000 population), limiting the influence of an individual outlet to a small geographical extent; where population density is high, the kernel's bandwidth will be small. Conversely, the geographical extent and influence of an individual

outlet will be larger where the population density is lower. Thus, this method assists with controlling for underlying population density differences when comparing retail availability between scenarios or areas of the country. To assess the policy impacts on FTP availability across various populations, we first generated demographic-specific population density surfaces.

Each national population density surface was created by calculating population counts for the following socio-demographic groups using the 2013–2017 American Community Survey 5-year estimates data at the Census tract level<sup>36</sup>: (1) total population; (2) NH White population (3) NH Black population; (4) NH Other races population; (5) Hispanic population; (6) population aged <18; (7) population aged 18–24; (8) population aged 25+; (9) individuals living at or below the 2018 federal poverty line; (10) individuals living above the poverty line; (11) families living at or below the poverty line; (12) families living above the poverty line; (13) adult population with less than a high school/GED (General Education Development test) education and (14) adult population with at least a high school/GED education. Each of these 14 national population density surfaces was constructed in ArcMap V.10.6 using Inverse Distance Weighting, which extrapolates count data for each sociodemographic group from population-weighted Census tract centroids to a raster grid with a cell size of  $1\text{ km}^2$ . Using these 14 population count surfaces, each final population-based tobacco retail outlet density surface was created to model the current status quo FTP availability (pre-FDA partial ban) and FTP availability under each policy scenario. Density values were initially calculated in units of FTP retailers per 1000 population of interest and subsequently scaled to units of FTP retailers per 100 000 population for ease of interpretation. All static-bandwidth and adaptive-bandwidth KDE density surfaces were constructed using the Raster package in R statistical software V.3.6.

### Outcome measures

For all 60 modelled FTP density surfaces, we used zonal statistics in ArcMap to calculate mean density values for each US Census tract ( $n=74\,131$ ). For each FTP policy scenario, we compared outcomes to a hypothetical national comprehensive FTP retail ban using: (1) the mean number and per cent of FTP retailers remaining and (2) the mean FTP retailer density for each modelled density surface.

Since the number of FTP retailers are correlated to population size, we examined the equity of these policies on the availability of FTPs by stratifying outcomes by metropolitan status using 2013 Rural–Urban Continuum Codes (RUCCs).<sup>37</sup> RUCCs, a county-based classification scheme, provides the ability to examine outcomes across various levels of urbanicity. For each Census tract, we defined metropolitan status as either large metropolitan (RUCC 1: population >1 million); small metropolitan (RUCC 2–3: population <1 million); suburban (RUCC 4–5: urban populations >20 000 and adjacent/



not adjacent to a metropolitan area) or towns/rural areas (RUCC 6–9: population <20 000 and adjacent/not adjacent to a metropolitan area).

### Patient and public involvement

Patients or the public were not involved in the development of the research question, study design or in conducting the research.

## RESULTS

### Overall FTP availability

Across the USA, a total of  $n=310\,090$  retail outlets likely sold FTPs, which included  $n=25\,277$  tobacco specialty stores and  $n=28\,815$  alcohol outlets. Under a status quo scenario, each Census tract had approximately four retail outlets selling FTPs, on average, including 0.35 tobacco specialty stores and 0.39 alcohol outlets. **Table 1** presents the proportion and density of FTP retailers remaining overall and by metropolitan status. The average overall FTP availability across Census tracts was 3.31 FTP retailers per square mile. Compared with a national comprehensive FTP retailer ban, which would eliminate FTP sales, a tobacco specialty store only exemption, on average, would result in 6.02% of FTP retailers (0.23 FTP retailers per square mile) remaining per Census tract. If both tobacco specialty stores and alcohol outlets were exempt, on average 14.25% of FTP retailers (0.57 FTP retailers per square mile) would remain per Census tract. In large metropolitan Census tracts, approximately 6.5% of tobacco specialty stores (0.37 FTP retailers per square mile) and 15.6% of tobacco specialty stores and alcohol outlets (0.95 FTP retailers per square mile) would remain under each respective policy scenario. As expected, the number of outlets remaining and overall FTP availability under each exemption scenario were substantially lower in small metropolitan, suburban and towns/rural areas versus large metropolitan areas.

### Overall FTP availability by population characteristics and metropolitan status

If no FTP sales restrictions existed nationwide (ie, 'status quo'), the overall FTP availability across Census tracts was 20.88 per 100 000 total population (**figure 1A**). Under a national FTP sales restriction that exempts tobacco specialty stores only, the average FTP availability across Census tracts would reduce to 1.49 FTP retailers per 100 000 population (**figure 1B**). Exempting both tobacco specialty stores and alcohol outlets would result in an average of 3.77 FTP retailers per 100 000 population (**figure 1C**).

### Metropolitan status

Average FTP availability across small metropolitan, suburban, towns/rural Census tracts under each exemption scenario would approach zero. However, for each exemption policy scenario, FTP availability would remain

**Table 1** Census tract-level descriptive statistics of retail availability and density nationwide under each flavoured tobacco product sales condition overall and by metropolitan status

By census tract	Flavoured tobacco product sales restriction condition		
	Status quo, no sales restriction*	Tobacco specialty store exemption	Tobacco specialty store and alcohol outlet exemption
<b>Overall</b>			
Avg, n	4.24	0.35	0.74
% remaining	-	6.02	14.25
FTP retailers per square mile	3.31	0.23	0.57
<b>Large metropolitan areas</b>			
Avg, n	4.20	0.37	0.79
% remaining	-	6.50	15.60
FTP retailers per square mile	5.53	0.37	0.95
<b>Small metropolitan areas</b>			
Avg, n	4.19	0.36	0.73
% remaining	-	6.35	5.29
FTP retailers per square mile	1.17	0.12	0.22
<b>Suburban areas</b>			
Avg, n	4.45	0.35	0.70
% remaining	-	5.29	12.12
FTP retailers per square mile	0.33	0.03	0.06
<b>Towns/rural areas</b>			
Avg, n	4.42	0.21	0.54
% remaining	-	3.12	9.52
FTP retailers per square mile	0.10	0.01	0.02

All values are mean estimates; - indicates no data.

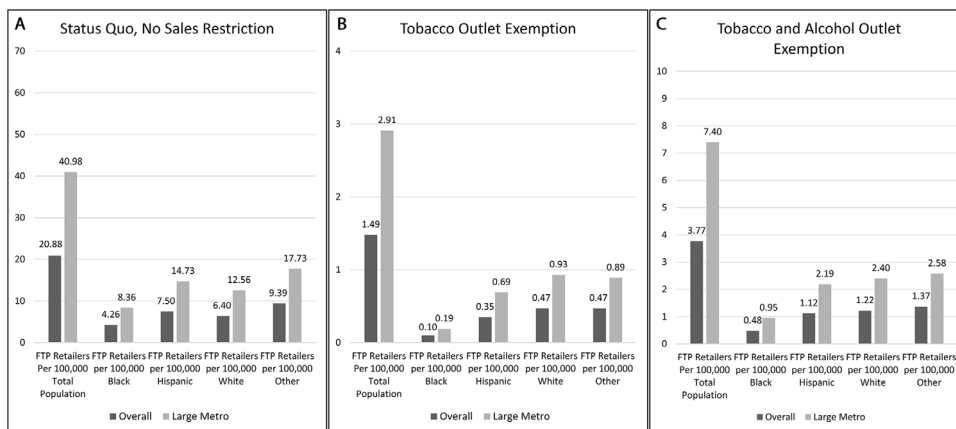
\*The 'Status Quo' estimates do not account for the number of retailers under currently existing FTP restrictions. Retail availability and density are based on the assumption there are no FTP restrictions in the USA.

Avg, average; FTP, flavoured tobacco product.

49% higher among the total population living in large metropolitan areas vs the national average.

### Race/ethnicity

FTP availability was not evenly distributed across different racial/ethnic groups. As displayed in **figure 1A**, the average overall FTP availability per Census tract was 4.26 FTP retailers per 100 000 NH blacks; 7.50 FTP retailers per 100 000 Hispanics; 6.40 FTP retailers per 100 000 NH whites and 9.39 FTP retailers per 100 000 NH other races. Across race ethnicity categories, there would be an



**Figure 1** Average flavoured tobacco product (FTP) retailer density across US Census tracts for the overall population and by race/ethnicity under three policy scenarios: (A) A ‘status quo’ policy, no sales restrictions present anywhere in the USA. (B) A national policy with an exemption for tobacco specialty stores and (C) A national policy with exemptions for tobacco specialty stores and alcohol outlets. Presented as number of retailers per 100 000 individuals for the national population (dark grey), as well as for large metropolitan areas only (light grey).

overall decrease in the average number of FTP retailers available if FTP sales were restricted in all stores except for tobacco specialty stores (figure 1B) or both tobacco specialty stores and alcohol outlets (figure 1C). However, in large metropolitan Census tracts FTP availability for each racial/ethnic group would remain 47%–49% higher under each scenario when compared with the national average (figure 1B,C), while availability would be reduced to nearly zero across small metropolitan, suburban and town/rural Census tracts (results not shown).

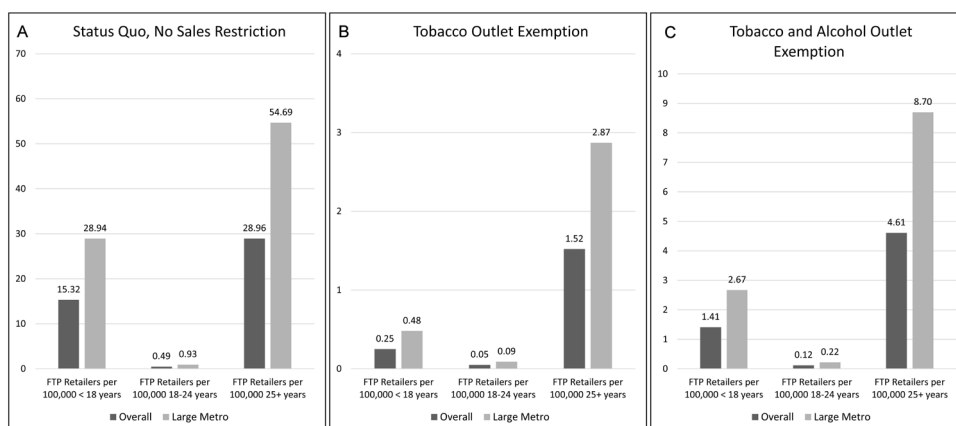
### Age

Figure 2A displays the average overall density of FTP retailers by age. FTP availability was 15.32 FTP retailers per 100 000 youth (<18 years); 0.49 FTP retailers per 100 000 young adults (18–24 years) and 28.96 FTP retailers per 100 000 older adults (25+ years). Figure 2B,C provides estimates of the average remaining FTP availability per 100 000 individuals by age group and metropolitan status

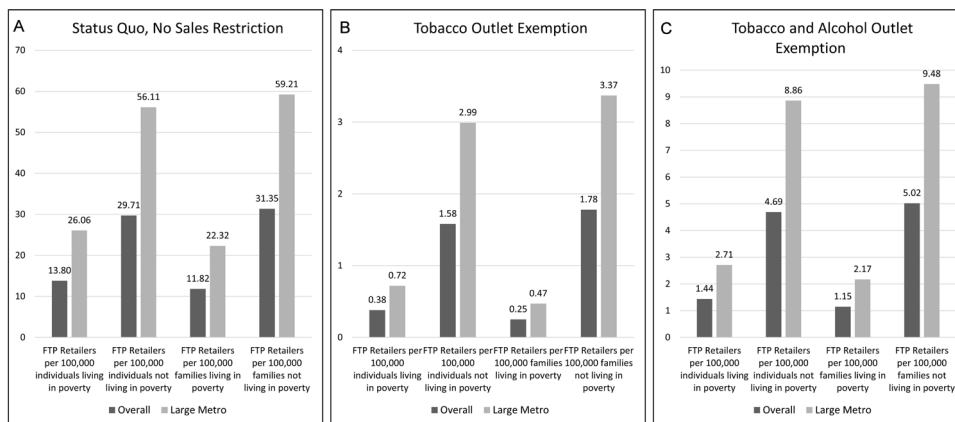
under each policy scenario. On average, the remaining FTP availability across small metropolitan, suburban and towns/rural Census tracts for each age group would effectively reduce to zero (results not shown). However, age-based FTP availability was 44%–48% higher in large metropolitan Census tracts versus the national average if FTP sales were still allowed in tobacco specialty stores (figure 2B) or both tobacco specialty stores and alcohol outlets (figure 2C).

### Poverty status

FTP availability also varied by socioeconomic factors. On average, FTP availability among individuals living in poverty was 13.80 FTP retailers per 100 000 and 29.71 FTP retailers per 100 000 individuals not living in poverty (figure 3A). Similar differences were observed among families living at or below and above the poverty line (11.82 vs 31.35 FTP retailers per 100,000, respectively). Figure 3B,C provides estimates of the average remaining



**Figure 2** Average flavoured tobacco product (FTP) retailer density across US Census tracts by age under three policy scenarios: (A) A ‘status quo’ policy, no sales restrictions present anywhere in the USA. (B) A national policy with an exemption for tobacco specialty stores and (C) A national policy with exemptions for tobacco specialty stores and alcohol outlets. Presented as number of retailers per 100 000 individuals for the national population (dark grey), as well as for large metropolitan areas only (light grey).



**Figure 3** Average flavoured tobacco product (FTP) retailer density across US Census tracts by poverty status under three policy scenarios: (A) A ‘status quo’ policy, no sales restrictions present anywhere in the USA. (B) A national policy with an exemption for tobacco specialty stores and (C) A national policy with exemptions for tobacco specialty stores and alcohol outlets. Presented as number of retailers per 100 000 individuals or families for the national population (dark grey), as well as for large metropolitan areas only (light grey).

FTP availability per 100 000 individuals and families living in poverty and metropolitan status under each policy scenario. FTP availability in small metropolitan, suburban and towns/rural Census tracts approached zero under each policy scenario (results not shown). In large metropolitan Census tracts, remaining FTP availability across socioeconomic categories was 47% higher compared with the national average under each exemption scenario.

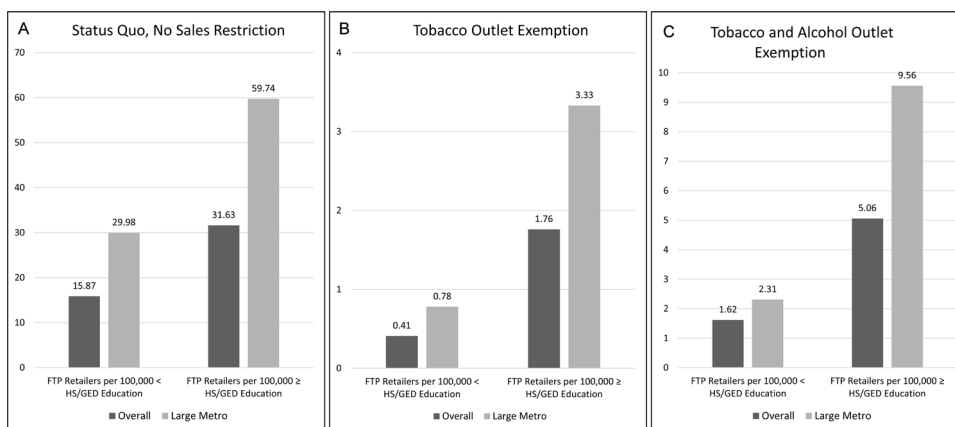
### Education

There were 15.87 FTP retailers per 100 000 adults with less than a high school/GED education and 31.63 FTP retailers per 100 000 adults with at least a high school/GED education (figure 4A). Figure 4B,C provides estimates of the average remaining FTP availability by education group and metropolitan status under the two policy scenarios. Remaining education-based FTP availability was almost zero in small metropolitan, suburban and

towns/rural areas compared with the national average (results not shown). However, among adults with less than a high school/GED education, FTP availability was 30%–47% higher in large metropolitan Census tracts than the national average.

### DISCUSSION

Comprehensive policies that restrict FTP sales in all retail outlets, such as San Francisco’s citywide ban on flavoured tobacco sales, offer the strongest policy option to reduce access to flavoured tobacco in retail stores. In practice, localities facing political challenges to comprehensive policies may offer retailer-based exemptions.<sup>22</sup> This study demonstrated that enacting FTP sales restrictions with retailer-based exemptions would substantially decrease FTP retailers, and in less urban areas of the country accessibility



**Figure 4** Average flavoured tobacco product (FTP) retailer density across US Census tracts by educational attainment under three policy scenarios: (A) a ‘status quo’ policy, no sales restrictions present anywhere in the USA. (B) A national policy with an exemption for tobacco specialty stores and (C) a national policy with exemptions for tobacco specialty stores and alcohol outlets. Presented as number of retailers per 100 000 individuals for the national population (dark grey), as well as for large metropolitan areas only (light grey). HS, High School; GED, General Education Development test (high school diploma equivalent).

may reach near-zero. However, in more urban areas and neighbourhoods, exemptions would still allow limited FTP sales within a neighbourhood, and such exemptions may increase the potential for unintended consequences. For example, there was a substantial reduction in tobacco retailers following Minneapolis' 2015 FTP restriction that exempted tobacco outlets.<sup>25</sup> However, in 2017 after the city added menthol-flavoured cigarettes to the restriction and included an exemption for menthol-FTPs for alcohol outlets, the number of retailers classified as 'tobacco product shops' eligible to sell FTPs more than doubled.<sup>38</sup>

To mitigate potential problems, localities with existing FTP restrictions and retailer exemptions should consider removing retailer-specific, or any product-specific, exemptions and consider adopting other point-of-sale policies. These should be tied to tobacco licensure, if possible, and could include setting a cap on the number of tobacco retailer licenses issued in the jurisdiction, and prohibiting the presence of tobacco retailers within 1000 ft of another tobacco retailer or youth-oriented facility.<sup>39</sup> Building requirements could prevent tobacco retailers from circumventing policies by dividing their establishment into 'two stores' in an attempt to establish a separate FTP-eligible retailer.

This study also considered population-specific FTP retail availability. Creating population-specific density surfaces ensured the unique geographical variability of each demographic group was accurately accounted within the associated density estimate, and thus allowed for further examination of sociodemographic and geographical disparities. While each retailer-based exemption policy scenario provided equitable reach across populations vulnerable to FTP use and marketing, geographical inequities remained. Higher FTP availability was present in large metropolitan areas across all populations under both exemption scenarios compared with national FTP availability or compared with small metropolitan, suburban or towns/rural areas. However, FTP availability remained lower for non-white, younger, less educated and lower socioeconomic status populations. Therefore, our findings highlight the potential equity effect of passing any flavour policy, regardless of retailer-based exemption and informs other studies investigating flavour policies within marginalised communities disproportionately impacted by FTP use.<sup>27 28</sup> Stakeholders and policy-makers should incorporate an equity lens when considering a retailer-based exemption policy to ensure that FTP availability decreases equally in low-income populations and communities of colour.

San Francisco's example also suggests that a comprehensive policy can survive industry interference and enjoys broad public support.<sup>40 41</sup> Legal precedent to date affirms FTP sales regulations as valid exercises of local authority (where not preempted by the state) to regulate the sale and distribution of tobacco products.<sup>42 43</sup> Our study, in combination with others that examine partial bans (eg, menthol-flavoured cigarette exclusion)<sup>10</sup> or restrictions only applicable to outlets near schools,<sup>44</sup> offer

evidence for stakeholders to advocate for comprehensive regulations. Policies that cover all products and all stores can reduce FTP access across all communities, particularly those most vulnerable to predatory FTP marketing and use.

Exempting specific flavours, such as menthol/mint in cigarettes, is problematic as FTPs would remain readily available across neighbourhoods, matching the 'status quo' scenario. Policies that exempt specific products, including recent FDA action, likely reduce the effectiveness of the policy as people initiate with or switch from restricted flavours/devices to those remaining on the market (eg, switching from mint to menthol flavour in restricted products). FTP restrictions also do not prohibit 'non-flavoured' tobacco sales, potentially leaving an inequitable availability of tobacco in communities of colour and low-income neighbourhoods. Potential FTP bans in communities are often circumvented by the tobacco industry using ambiguous concept-flavour descriptors designed to avoid regulatory detection and can result in increased FTP exposure.<sup>45</sup> Implementing comprehensive FTP restrictions, coupled with strong policy enforcement, can reduce overall tobacco use, especially among the populations most vulnerable to FTP use.

Several study limitations warrant discussion. First, the study relied on a commercial business directory to identify potential retailers selling FTPs. Despite an extensive data review and supplementation to account for difficulties in identifying vape outlets, we cannot ensure that the dataset represents the true national FTP retail environment. However, crowdsourcing techniques have been a proven approach to validate these types of commercial and online directories.<sup>46</sup> In absence of a comprehensive and publicly available national database, VapeTrotter provides a critical source of nationwide retailer data that benefits from crowd sourced input and engagement with the vape community. Few studies have attempted to estimate vape retailers nationwide; however, two studies estimating national vape stores using other data report the number of retailers ranging from 7479 to 9943.<sup>47 48</sup> These estimates are of similar magnitude as the estimates in this study, and the variation between data sources for vape stores remains small relative to the total number of retailers. Second, relying on geocoded data from these data sources could have produced bias since location data for tobacco outlets contains some level of positional errors from commercial geocoding services. However, validation studies of commercial business directories have found that between 80% and 90% of retail outlets are within the correct Census tract.<sup>49 50</sup> Third, the national density surfaces did not remove retailers covered by existing FTP restrictions. At the time of our study, many localities with restrictions were passed in relatively small communities; however, several larger cities and Massachusetts also passed restrictions. Given these limitations, the final tobacco retail outlet dataset used is more likely to overestimate than underestimate FTP availability in the USA. Future studies may benefit from accounting for existing FTP restrictions when generating national retailer



estimates. This study also examined only two retailer-based exemption policy scenarios. Other retailer-based exemptions, such as grandfathering in existing retailers; exempting retailers based on age of entry; exempting retailers based on their proportion of tobacco sales to overall revenue; exempting hookah/cigar bars; or any combination could not be examined. Future studies should consider how these other retailer-based exemptions would impact FTP availability and how such policies could be used in coordination to further reduce the FTP availability in large metropolitan areas. Additionally, we did not examine vape shops alone given the prevalence of e-cigarette sales in other tobacco retailers. With more than 13 000 vaping specialty retailers estimated nationwide, further research is warranted. Finally, this analysis only focused on the immediate policy impact of reduced retailer access and it should be acknowledged that unintended consequences of implemented policies (eg, product substitution) may mitigate the impact on actual tobacco product use.

This study demonstrates that, compared with a national comprehensive FTP retail ban, exempting either tobacco specialty stores, or tobacco specialty stores and alcohol outlets would result in greater FTP availability; however, all hypothetical policy scenarios resulted in significant reductions in tobacco retail availability, including a reduction to near-zero access in many less urban portions of the country. Additionally, each exemption-based policy scenario provided equitable reach to vulnerable populations, an essential factor when considering policy solutions. However, the remaining availability in large metropolitan areas highlights the potential for geographical inequities for each exemption-based policy scenario and the need for strong policies. Despite substantial reductions in tobacco retail availability under national policies with tobacco specialty store or alcohol outlet exemptions, comprehensive restrictions without any retailer exemptions provide the greatest potential impact on reducing FTP availability, resulting in more equitable policy reach and reduced FTP access among urban vulnerable populations.

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