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Concept flavor e-cigarette unit sales in the U.S.: 2019–2022

Anuja Majmundar [a], Zheng Xue [a], Samuel Asare [a], Priti Bandi [b], Minal Patel [a], Nigar Nargis [a,*]

[a] Tobacco Control Research, American Cancer Society, Inc., 270 Peachtree StreetAtlanta, GA 30303, USA
[b] Risk Factors and Screening Surveillance Research, American Cancer Society, Inc., 270 Peachtree StreetAtlanta, GA 30303, USA

A B S T R A C T

Introduction: Concept flavor e-cigarettes, defined as products with vague/ambiguous flavor (tobacco flavor and non-tobacco flavor) names, may limit the intended impact and enforcement of flavored tobacco restrictions. This study assessed trends in unit sales of concept flavor e-cigarettes in the U.S. by volume, nicotine concentration levels (NCL), flavor and device type.

Methods: We analyzed NielsenIQ Retail Scanner point-of-sales data collected from 2182 Local Trade Areas in the contiguous 48 U.S. states and the District of Columbia aggregated weekly from August 10, 2019, through April 9, 2022. Concept flavors were categorized by: flavor type (tobacco, fruity, menthol, mint, and other); device type (pods/refillable cartridges, disposables, e-liquids, and other); and NCL (0 %-2.0 %, 2.1 %-4.0 %, > 4.1 %, unknown). Joinpoint regression was used to assess sales trends.

Results: Overall unit sales during the study period increased by 33.63 % from 1040.85 to 1390.88 thousand units per month ($p = 0.006$). Between August 2019 and September 2021, unit sales increased and peaked; between September 2021 and April 2022 sales decreased by 14.46 % (from 1626.02 to 1390.88 thousand units; $p = 0.002$). Sales of fruity, menthol and mint flavors concept flavor e-cigarettes increased by > 1000 %; disposable devices by 302.18 %; pods and refillable cartridges by 33.81 % overall; and products NCL > 4.0 % increased by 110.18 %. Tobacco flavor concept flavors (93.28 %), pods (94.63 %), and products with 2.1 %-4.0 % NCL (88.40 %) dominated unit share.

Conclusion: Sustaining the recent overall decline in the unit sales of concept flavor e-cigarettes and monitoring the sales of products with nicotine concentration greater than 2.0%, non-tobacco flavor, and pod products warrant prioritization in tobacco control efforts.

1. Introduction

The evolution of the e-cigarette marketplace includes a growing range of flavors and devices. Evidence suggests that flavors enhance the appeal of e-cigarettes among youth and young adults, who are also known to typically initiate tobacco use with a flavored e-cigarette product. (Gentzke et al., 2022) Recently, flavored tobacco regulatory policies at the state and local levels, address this trend by restricting the sale of concept flavor e-cigarettes products. (Center, 2022) These policies may generally apply to tobacco products with 'characterizing flavors' (non-tobacco flavors with a distinguishable taste or aroma), but may exclude tobacco flavors and constituents, creating a specific sensory experience (e.g., cooling or icy sensation). (Leventhal et al., 2023) Additionally, young consumers may be misled if they come across concept flavor tobacco products that lack characterizing descriptors. (Kreslake et al., 20232023)

For effective enforcement and precise evaluation of the impact of flavored tobacco sales restriction policies, it is crucial that retailers and enforcement authorities are able to accurately identify all available flavored tobacco products, as defined in policies, in the marketplace. (Health CDoP, 2019) However, concept flavor e-cigarettes and other tobacco products, products with vague or ambiguous flavor (tobacco flavor and non-tobacco flavor) names (e.g., rainbow, fusion), have introduced enforcement challenges and may limit the intended impact of flavored tobacco restrictions. (Ali et al., 2020; Diaz et al., 2021; Rogers et al., 2020; Rogers et al., 2022) These vague or ambiguous flavor names may also raise challenges in retailer education efforts and other enforcement strategies to ensure that sales of concept flavored tobacco products do not increase post-policy implementation. (Gammon et al., 2022)

A majority of state and local flavored tobacco restrictions in the U.S. include broad definitions of flavored tobacco to include concept flavor e-cigarettes. However, enforcement authorities may be able to more easily and accurately identify products with characterizing flavors that are explicitly labelled such as mango, strawberry, and thus may prioritize enforcement efforts on these products compared to products with ambiguous or vague concept flavor names. For example, New York City, local jurisdictions in Providence, Rhode Island, Minnesota and other states prioritized enforcement of flavored tobacco policy restrictions on products clearly labeled as flavored and available for sale even though

* Corresponding author.
E-mail address: nigar.nargis@cancer.org (N. Nargis).

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the definition of products covered in their policies potentially included concept flavor products. (Health CDoP, 2019; Farley et al., 2018) Another study found that remaining flavored products post implementation of flavored tobacco restrictions in Boston were concept flavors. (Kephart et al., 2020) In essence, concept flavor e-cigarettes may continue to be sold even in jurisdictions where flavored tobacco sales restrictions are being implemented.

Research assessing point-of-sales trends of concept flavor tobacco products is limited and specifically e-cigarette products is lacking. Past work has documented a marked increase in concept flavors for cigar products (Gammon et al., 2019; Kurti et al., 2020; Viola et al., 2016) and suggests that sales of concept flavor e-cigarettes in the U.S. are known to be approximately 5.6 % of total e-cigarette sales during 2014–2021. (Ali et al., 2020; Ali et al., 2022) To address gaps in the literature and inform tobacco regulations, we assessed trends in point-of-sale of concept flavor e-cigarette in the U.S. by volume, flavor type, device type, and nicotine concentration levels (NCL) as indicated on the packaging during August 2019 to April 2022. Findings may inform future investigations assessing the unintended impact of state or local tobacco sales restrictions on the sales of concept-flavored e-cigarettes, and help prioritize areas related to retailer compliance monitoring and policy enforcement actions, incorporate information about concept flavors in retailer and consumer education programs aimed at reducing policy violations, and warning consumers against potential health risks of and inadvertent choice of concept flavor e-cigarettes.

2. Methods

2.1. Data source

NielsenIQ Retail Scanner point-of-sales data collected from 2182 Local Trade Areas in the contiguous 48 U.S. states and the District of Columbia were aggregated weekly from August 10, 2019, through April 9, 2022. The retail sales included unit sales, dollar sales, and product characteristics (flavor, NCL) at universal product code (UPC) level from food, drug, mass merchandiser, liquor, and convenience stores. Online and tobacco specialty store sales were not available. Actual sales were aggregated into 4-week ('monthly' from hereon) sales.

2.2. Procedure

Concept flavor e-cigarettes were defined as e-cigarettes with "vague, non-characterizing flavor names". We first created a list of e-cigarette flavors, and identified concept flavors from this list based on the definition. The analytic sample comprised of 35 months of observations on concept flavor e-cigarettes sales. (See Supplement Table 1 for list of concept flavors).

2.3. Measures

Flavor names that did not explicitly indicate a distinct flavor (e.g., strawberry, lemon) were considered to be vague or non-characterizing. We conducted online searches of product information and packaging on manufacturers' websites to determine the flavor type as fruity (e.g., Blue Breeze), mint (e.g., Champion's Juice), menthol (e.g., Riptide), tobacco (e.g., American Blend), and other (e.g., rainbow, energy drink). NCL information was available in the Nielsen dataset. E-cigarette devices were categorized into: pods and refillable cartridges (referred to as pods), disposable devices, e-liquid bottles, other devices (tanks, vape pens, mods), and unknown devices (i.e., additional information about device type was unavailable during analysis). Per prior work based on Nielsen sales data, one standardized unit was equal to five pods or refillable cartridges; one disposable device; one e-liquid bottle, and one other or unknown device. (Ali et al., 2022; Marynak et al., 2017) NCL were categorized in terms of 0 %-2.0 %, 2.1 %-4.0 %, greater than 4.1 % and unknown (i.e., information about NCL unavailable at the time of data analysis). These categories were arrived at after considering two factors: findings from prior research suggests that sales of e-cigarettes with NCL above 4 % led market share followed by products with 2 %-4% NCL while those with less than 2 % NCL accounted for less than 1 % market share during 2013 to 2018; (Romberg et al., 2019) our data distribution conformed with past findings. Based on prior work, 1 percent NCL was considered to be 10 mg/ml. (Hajek et al., 2017) Products with NCL (1.01 % of total unit sales) reported in mg in the data were divided by 10 to arrive at percentage concentration levels For example, a 50 mg NCL product was considered to have 5 % NCL. Unknown devices comprised 0.003 % of total sales and were excluded from the analysis assessing trends related to device type. The study used aggregate point of sales data and did not require institutional review board review or informed consent.

2.4. Statistical analysis

Overall unit sales and share of unit sales of concept flavor e-cigarettes by nicotine concentration level (NCL) as indicated on the packaging, flavor type, and device type were calculated as a proportion of total concept flavor e-cigarette unit sales. Average monthly percentage change (AMPC) in unit sales and 95 % CIs were calculated using Joinpoint version 4.9.1.0 (National Cancer Institute), a segmented regression analysis application. Based on the approach adopted in prior research, (Ali et al., 2022) time points detected during the analysis of concept flavor e-cigarette sales overall (i.e., across all years) were used to assess whether trends by flavor type, device type and NCL varied significantly during these time periods. Supplemental Fig. 1 demonstrates trends in concept flavor e-cigarette sales as a proportion of overall e-cigarette unit sales in the US during 2019–2020. Supplemental Fig. 2 demonstrates proportion of concept flavor e-cigarette vs. non-concept flavor e-cigarette unit sales during 2019–2022. Figs. 1-3 depict trends in unit sales overall, by nicotine concentration levels, and flavor type; and Fig. 3 Supplemental section by device type respectively. Table 1 includes data related to AMPC or MPC and corresponding 95 % Confidence Intervals, and monthly percentage unit shares. Unit sales for each time period are reported in Supplemental Table 2. Statistical significance was defined as $p < 0.05$.

3. Results

Overall, concept flavor e-cigarette unit sales as a proportion of overall e-cigarette sales was about 2.34 % during August 2019, rose to 3.70 % during October 2021 and was on a declining trend (3.13 % during March 2022 (Supplemental Figs. 1 and 2).

3.1. Trends in concept flavor e-cigarette overall unit sales

During the study period from August 2019 to April 2022, unit sales increased by 33.63 % from 1040.85 to 1390.88 thousand units per month overall. The Joinpoint model identified 2 joinpoints or 3 different trend periods during the study period: August 2019 to April 2021 when sales increased by 20.38 % from 1040.85 to 1252.93 thousand units per period, April 2021 to September 2021 when sales increased by 29.78 % from 1252.93 to1626.02 thousand units per period, and September 2021 to April 2022 when sales decreased by 14.46 % from 1626.02 to 1390.885 thousand units per period (Fig. 1).

3.2. Trends in concept flavor e-cigarette unit sales by flavor type

During the overall study period of August 2019 to April 2022, overall unit share of tobacco concept flavor e-cigarettes was 93.28 %, fruity flavored was 4.38 %, mint flavored was 0.23 %, menthol flavored was 1.48 %, and other flavors was 0.63 % (Fig. 3). Sales of fruity (by 269.48 %), and mint (by > 1000 %) increased whereas share of other flavored e-cigarette products decreased overall (tobacco flavor by 98.05 %; other

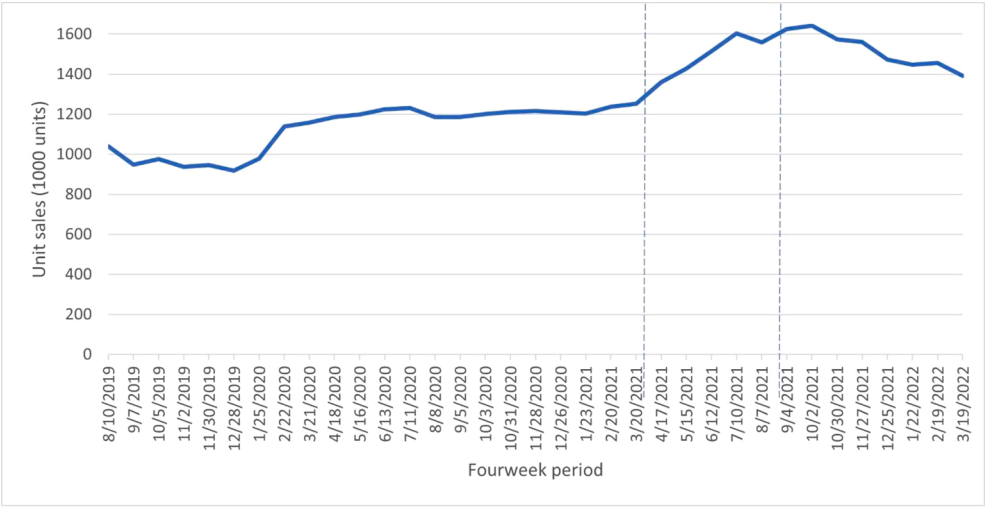

Fig. 1. Overall sales of concept flavor e-cigarettes in the US: August 2019-April 2022.

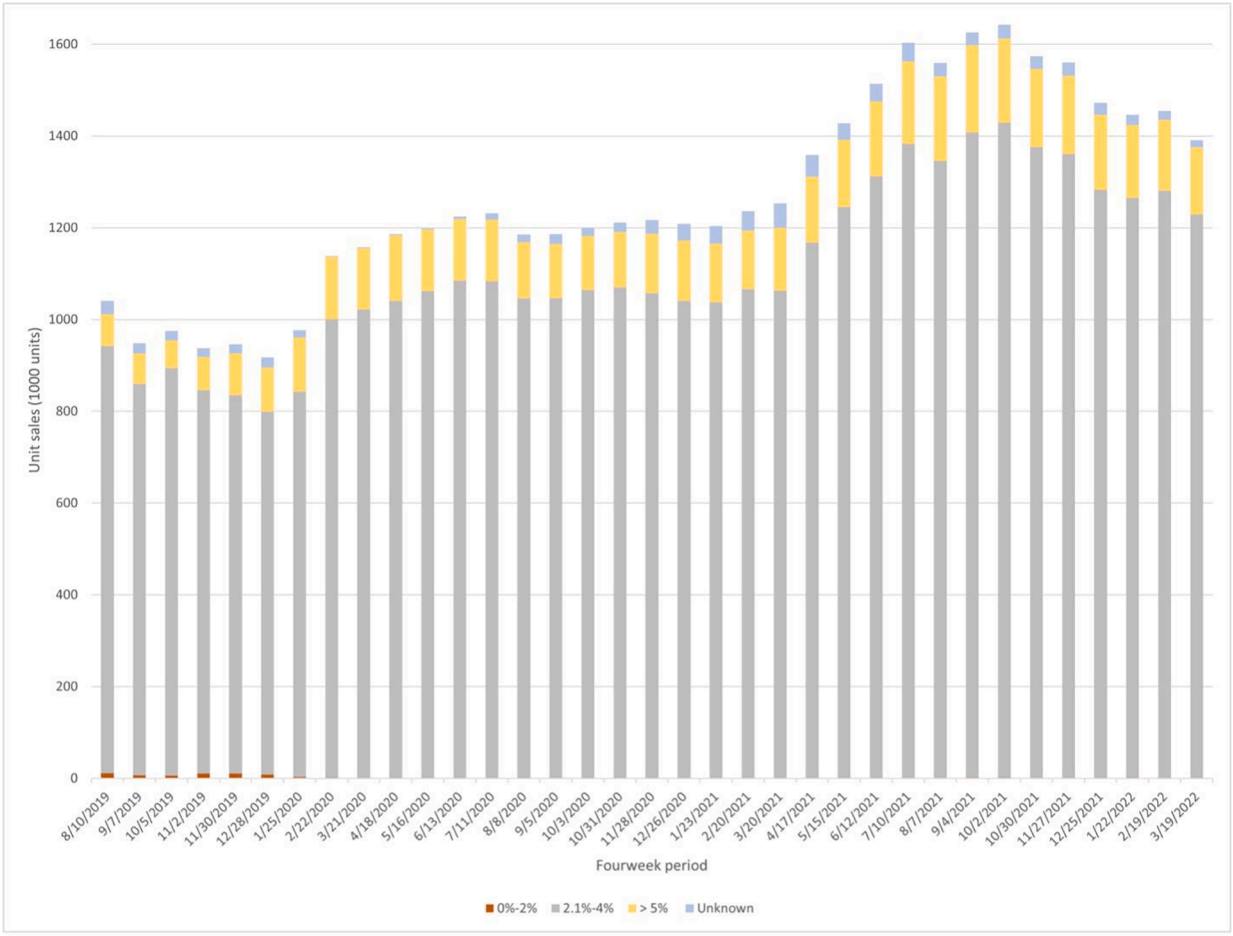

Fig. 2. Trends in unit sales of concept flavor e-cigarettes by nicotine concentration in the US: August 2019-April 2022. Notes: Concept flavor e-cigarette products were categorized in terms of 0%-2.0%, 2.1%-4.0%, greater than 4.1% and Unknown nicotine concentration levels. Each bar in the figure represents aggregate sales in a 4-week interval.

flavors by 88.81 %). Menthol products sales were recorded only starting April 2021 (Fig. 3).

During August 2019 to April 2021, there was an increase in sales across all categories: mint from 3 units to 5.60 thousand units (1,86,600 %); fruity from 11.27 to 104.33 thousand units (826.10 %). An increase of 14.36 % sales for tobacco flavored products was statistically non-significant. In contrast, other flavored products sales decreased by 98.03 %.

During April 2021 to September 2021, sales increased for tobacco, menthol and other flavors whereas fruity and mint flavors sales

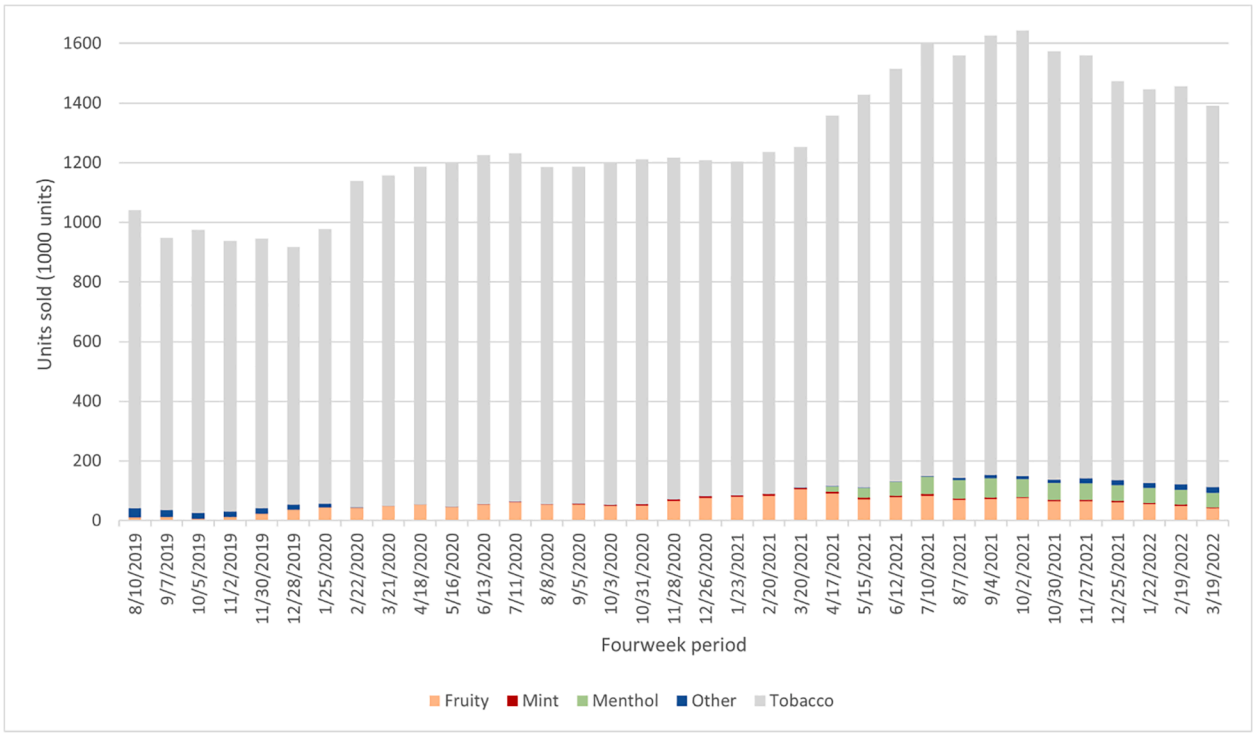

Fig. 3. Trends in unit sales of concept flavor e-cigarettes by flavor type in the US: August 2019-April 2022. Notes: Concept flavor e-cigarette product flavors were categorized in terms of tobacco, fruity, mint, menthol, and other flavors. Each bar in the figure represents aggregate sales in a 4-week interval.

Table 1
Concept flavor e-cigarettes unit sales average monthly percent change and unit share for each time period: August 2019-April 2022.

	August 2019-April 2021		April 2021-September 2021		September 2021-April 2022		August 2019-April 2022	
	MPC (95 %CI)	Unit share (%)	MPC (95 %CI)	Unit share (%)	MPC (95 %CI)	Unit share (%)	AMPC (95 %CI)	Unit share (%)
Overall sales	1.1(0.3–2.0)*	–	3.9(1.8–6.0)*	–	−2.1(−3.1- −1.1)*	–	1.0(0.2–1.7)*	–
	AMPC (95 %CI)	**Unit share (%)**	**AMPC (95 %CI)**	**Unit share (%)**	**AMPC (95 %CI)**	**Unit share (%)**	**AMPC (95 %CI)**	**Unit share (%)**
Nicotine concentration levels								
>4.0 %	3.2(1.9–4.6)*	6.69–10.96	5.2 (2.0–8.5)*	10.96–11.68	−3.1(−4.1–2.0)*	11.68–10.52	2.2(1.2–3.3)*	6.69–10.52
2.1 %-4.0 %	0.7 (0.2–1.6)	89.36–84.83	4.6 (1.4–8.0) *	84.83–86.47	−1.8(−2.7 - −0.9)*	86.47–88.27	0.9(0.0–1.7)*	89.36–88.27
0 %-2.0 %	16.7(26.6- −5.4)*	1.14–0.01	24.1(−5.6–63.3)	0.01–0.12	6.8 (9.7–26.2)	0.12–0.10	−5.9 (−15.7–5.0)	1.14–0.10
Unknown	3.5(−4.1–11.7)	2.80–4.20	7.3(9.5- −5.1) *	4.20–1.73	−7.3(−9.5 - −5.1)*	1.73–1.10	−0.8(−5.4–4.1)	2.80–1.10
Flavor type								
Tobacco	0.7(−0.1–1.6)	95.96–91.16	4.2(1.1–7.4)*	90.58–91.16	1.9(−2.8 - −1.1)*	91.16–91.92	0.8(0.0–1.6)	95.96–91.92
Fruity	10.2(4.8–15.8)*	1.08–8.33	−5.1 (−6.5- −3.7)	8.33–4.47	−5.1(−6.5–3.7)*	4.47–2.99	4.1(0.8–7.4)	1.08–2.99
Mint	41.9(27.6–57.6)*	0.00001–0.45	−4.7(−7.5- −1.9)*	0.45–0.28	−4.7(−7.5 - −1.9)*	0.28–0.25	21.8(14.0–30.2)*	0.00001–0.25
Menthol	N/A	N/A	126.4 (105.4–149.5)*	0.20–3.96	1.4(−3.6–0.8)	3.96–3.44	44.7(38.0–51.7)	N/A-3.44
Other	−16.4(19.5–3.1)*	2.96–0.05	66.4(48.9–86.9)*	0.05–0.71	6.5(3.2–9.9)*	0.71–1.40	−0.8(−3.8–2.4)	2.96–1.40
Product type								
Pods and refillable cartridges	0.0(−0.1–1.6)	95.21–91.17	4.9(1.8–8.0)*	91.17–94.54	−2.0(−2.8 - −1.1)*	91.17–95.34	0.9(0.1–1.7)*	95.21–95.34
Disposables	8.8(4.2–13.6)*	1.54–8.49	−2.3(3.5 - −1.1)*	8.49–5.44	−2.3(−3.5 - −1.1)*	5.44–4.64	4.4(1.7–7.3)*	1.54–4.64
E-liquids	1.5(−8.3–12.5)	0.30–0.34	−31.6 (−35.0–28.1)*	0.34–0.02	−31.6(−35.0- −28.1)*	0.02–0.002	−12.7(−18.3- −6.7)*	0.30–0.003
Other	−28.3(−9.6- −14.8)*	2.93–0.003	−9.6(−14.8–4.1)*	0.003–0.003	61.5(25.3–10.8.2)*	0.003–0.0004	−11.7 (−22.7–0.8)	2.93–0.01

*Indicates that AMPC is significantly different from zero at alpha = 0.05.

declined. Menthol product sales, recorded for the first time in April 2021, increased by 27917.40 %, other flavors by 1806.93 % from 606 units to 11,556 units, followed by tobacco flavored products which increased by 28.95 %. In contrast, sales declined for fruity and mint flavors decreased by 30.39 % and 18.67 % respectively.

During September 2021 to April 2022, there was a decrease in sales across all flavor types: fruity flavors by 42.69 %, menthol flavors by 25.74 %; mint flavors by 24.38 %; tobacco flavors by 13.20 %; and other flavors by 68.55 %.

3.3. Trends in concept flavor e-cigarette unit sales by device type

During the overall study period of August 2019 to April 2022, overall unit share of pods was 94.63 %, disposables was 4.94 %, e-liquids was 0.11 %, and other devices was 0.32 % (Table 1). Sales of disposables increased steeply by 302.18 % and pods by 33.81 % respectively whereas share of other devices decreased overall (e-liquids by 98.79 %; other devices by 99.50 %); unit share of disposable products increased by 3.1 % and pods by only 0.13 % while shares of other products decreased (e-liquids by 0.3 % and other products by 2.92 %) (Supplemental Fig. 1).

During August 2019 to April 2021, sales of disposable device increased by 562.19 %. Sales of other devices were either not statistically significant (pods - unit share: 95.21 % to 91.17 %; $p = 0.07$)) or remained a small proportion of overall sales during this period (e-liquids - unit share: 0.30 % to 0.34 %; other devices: 2.93 % to 0.003 % of unit share). During April 2021 to September 2021 sales of pods increased by 34.56 % whereas disposable device sales decreased by 16.85 %. E-liquids unit share decreased from 0.34 % to 0.02 % and other devices share remained unchanged. During September 2021 to April 2022, pod sales decreased by 13.73 % to return approximately to previous levels. Disposable product sales also decreased by 26.95 % with an increased unit share of 4.64 % while e-liquid unit share decreased further to 0.002 % and other devices to 0.0004 %.

3.4. Trends in concept flavor e-cigarette unit sales by nicotine concentration levels

During the study period of August 2019 to April 2022, overall unit share of concept flavor e-cigarettes with greater than 4.1 % NCL was 10.53 %; with 2.1 %-4.0 % NCL was 88.40 %; 0 %-2% NCL was 0.17 %; and with unknown concentration levels was 1.89 %. Sales increases during this time was steepest for products with > 4.1 % NCL (110.18 %) followed by those with 2.1 %-4.0 % (32.00 %); sales of other products decreased overall (0 %-2% levels by 88.51 %; unknown levels by 47.30 %) (Fig. 2).

During August 2019 to April 2021, sales increases were restricted to products with > 4.1 % NCL (by 97.19 %). In contrast, sales of products with 0 %-2.0 % concentration level decreased by 98.81 %. During April 2021 to September 2021, sales of products with > 4.1 % NCL increased most steeply followed by products with 2.1 %-4.0 % and unknown NCL. Products sales of > 4.1 % e-cigarettes increased by 38.27 % and those with 2.1 %-4.0 % increased by 32.39 % whereas sales of products with unknown NCL decreased by 46.55 %. During September 2021 to April 2022, there was a decrease in sales of all categories of NCL with the steepest decline recorded for products with > 4.1 % NCL (22.91 %) followed by those with 2.1 %-4.0 % NCL (12.68 %).

4. Discussion

Monitoring concept-flavor e-cigarettes sales trends is critical for tracking the implementation and enforcement of flavored tobacco sales restrictions in the U.S., sustaining the recent decline in concept-flavor e-cigarettes, and assessing the implications for e-cigarette use prevention and e-cigarette cessation. Unit sales of concept flavor e-cigarettes increased by 33.63 % from August 2019 to April 2022 but declined more recently during September 2021 until April 2022. Tobacco flavors led market share during the study period; more recently sales of tobacco flavored products declined, and menthol flavors increased during September 2021 and April 2022. Pods and refillable cartridges led market share; e-liquids and other devices (e.g., tanks) comprised less than 0.002 % of unit share. Concept flavor e-cigarettes with 2.1 %-4.0 % NCL dominated unit share by over 80 %; sales of products with levels exceeding 4.0 % declined during September 2021 and April 2022 while taking up the second largest proportion of sales during the study period. Findings may inform ongoing surveillance efforts monitoring sales of flavored e-cigarette products and health interventions addressing nicotine addiction among youth and those interested in cessation.

Sustaining the recent decline in overall sales of concept flavor e-cigarettes may be an important priority for tobacco control efforts. Continuous monitoring of the trends in point-of-sales of concept flavor e-cigarettes can offer useful data to track policy implementation and retailer compliance. Rapid surveillance of concept flavor e-cigarette point-of-sales may be especially beneficial for jurisdictions where retailers have the initial responsibility for classifying flavored vs. non-flavored tobacco products (e.g., Oakland) (News, 2020) or where multiple retail exemptions exist. (Center, 2022) Incorporating adequate budget for rapid surveillance of concept flavor e-cigarettes in upcoming flavored tobacco restrictions may also help improve their effectiveness and address the overall increase in concept flavor e-cigarette sales.

This paper makes a methodological contribution by conducting online searches to determine the flavor type of a large volume of e-cigarette products. Tobacco concept flavor e-cigarettes led unit share. While there is no prior work investigating sales trends of concept flavor e-cigarette products, flavored cigarillos sales are the highest among sweet, jazz and green sweets concept flavors during 2012–2016. (Gammon et al., 2019) Previous research also suggests that state-wide restrictions on the sale of flavored e-cigarettes were linked to a significant reduction in total e-cigarette sales; but an increase in tobacco-flavored e-cigarette sales. (Ali et al., 2022) We found that the sales of tobacco flavored e-cigarette products was on a declining trend during September 2021-April 2022. Rapid surveillance of such products in light of state-level policies timelines may offer insight into tobacco use patterns arising as a consequence of population-level policies. Additionally; decreasing sales of tobacco and fruity concept flavor e-cigarettes may be associated with the implementation of local tobacco restrictions and federal enforcement policies. Future work may examine differences in trends among jurisdictions with flavored restrictions that do and do not prohibit the sales of concept flavor products.

Sales of concept flavor e-cigarettes with NCL greater than 2.1 % warrant close monitoring as increasing sales of higher levels of nicotine in e-cigarettes may widen tobacco-related health disparities. Preliminary evidence suggests that use of e-cigarettes with higher nicotine concentrations among youth may increase subsequent frequency and intensity of smoking and vaping, (Goldenson et al., 2017) raising concerns about increased nicotine dependency among individuals susceptible to cigarette use. Adolescents, to whom tobacco products cannot be sold legally under the Tobacco 21 law in the U.S., may also incorrectly interpret concentration levels in terms of whether the strength is low, medium or high and metrics in terms of mg and percentage and misperceive the relative health harms and benefits of e-cigarettes (versus cigarettes). Misleading marketing practices have also downplayed the presence of nicotine in e-cigarettes. (Morean et al., 2019; Morean et al., 2021; Tan and Bigman, 2020) These factors, in addition to potentially misleading concept flavor names, may contribute to inadvertent exposure to high NCL and flavored e-cigarettes among youth, persons with co-morbidities, and racial-ethnic minority groups and other populations susceptible to and addicted to nicotine.

Concept flavor e-cigarette sales with lower levels of NCL (0 %-2%) contributed to less than 2 % of unit share and declined more recently (September 2021-April 2022), while those with 2.1 %-4.0 % NCL led market share. The FDA intends to establish a maximum nicotine level to

reduce the addictiveness of cigarettes and certain other combusted tobacco products. (FDA, 2022) Future research may continue tracking sales of e-cigarettes and cigarettes with higher levels of NCL, to capture intended and unintended population-level impact of the potential product standard.

Pods and refillable cartridges dominated point-of-sales market share. These findings match existing literature indicating that pods and refillable cartridges are the most common type of e-cigarettes used in the U.S. E-liquid products were a small percentage of unit sales reported in point-of-sales covered in the dataset, which conforms with past findings related to overall sales of e-cigarette products in the U.S. (Ali et al., 2020) Future research may monitor audience visits to online e-liquid retail platforms to capture emerging trends.

5. Limitations

As indicated in prior work, actual NCL present in the e-liquids often vary from the levels indicated on the packaging for the same product and brand. (Prochaska et al., 2022) As a result, it is possible that sales of products with 2.1 % - 4.0 % concentration levels may include products with higher levels of nicotine or products with higher levels of concentration levels mentioned on the packaging may, in fact, have lower levels of nicotine. Products with NCL (<10 %) reported in mg were divided by 10 to arrive at percentage concentration levels, which may not reflect the actual nicotine content in those products. Findings reported in this study may not reflect the trends in e-commerce sales of concept flavor e-cigarettes. Point-of-sale trends may not reflect actual use trends in the U.S. as data is limited to participating retail stores and does not capture sales from vape stores, e-commerce sites or illicit sales, therefore indicating lack of coverage and underassessment of overall retail sales. Standardization of unit sales did not take into account e-liquid volume, which may vary across and within product types. This study presented the overall trends in concept flavor e-cigarettes unit sales; therefore, the impact of population-level tobacco control programs, the 2019 EVALI outbreak and the COVID-19 pandemic and other factors including e-cigarette taxes and seasonality were not assessed. Future research may explore seasonality patterns and overlay those patterns with external factors such as state-level tobacco policies. Although the time trends did not take into consideration the implementation of tobacco regulatory policies, the findings of this study are to inform future policies. Findings for categories with unit sales in the hundreds or a few thousands should be interpreted with caution.

6. Conclusion

Concept flavor e-cigarettes sales trends are critical for tracking the implementation of flavored tobacco prohibitions in the U.S. and assessing the implications for e-cigarette use prevention and tobacco cessation. As such, sustaining the recent decline in concept flavor e-cigarette sales is crucial. Raising awareness about concept flavor e-cigarettes among retailers may facilitate improved compliance of flavored tobacco prohibitions, and among e-cigarette use susceptible groups may prevent inadvertent use of these products.

CRediT authorship contribution statement

Anuja Majmundar: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Zheng Xue:** Writing – review & editing. **Samuel Asare:** Writing – review & editing. **Priti Bandi:** Writing – review & editing. **Minal Patel:** Writing – review & editing. **Nigar Nargis:** 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

American Cancer Society, Inc. researchers own analyses and calculations based in part on data reported by NielsenIQ for the e-cigarette category for the 139-week period ending April 2022, for the U.S. market. Copyright © 2022, Nielsen Consumer LLC (NielsenIQ). The conclusions drawn from the Nielsen data are those of American Cancer Society's researchers and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for and had no role in, was not involved in analyzing and preparing the results reported herein.

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Appendix A. Supplementary data

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