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Bigger, stronger and cheaper: growth in e-cigarette market driven by disposable devices with more e-liquid, higher nicotine concentration and declining prices

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ABSTRACT

Objective Given the evolving changes in the disposable e-cigarette market, we explore patterns of sales in the USA by e-liquid volume capacity, nicotine strength and real sales-weighted average prices by both e-cigarette unit and volume of e-liquid.

Methodology We used NielsenIQ retail scanner data from January 2017 to September 2022 to examine changes over time for average product volume capacity in millilitres, nicotine strength (%) and both sales-weighted average price per disposable unit and per millilitre of e-liquid for each 4-week period.

Results Among disposable e-cigarettes sold between January 2017 and September 2022, average volume capacity increased 518% from 1.1 mL to 5.7 mL and average nicotine strength increased 294% from 1.7% to 5%. Sales-weighted average price per disposable unit and millilitres of e-liquid both remained relatively constant until January 2020. From January 2020 through September 2022, average unit prices increased 165.7% from US\$8.49 to US\$14.07, while the average price of 1 mL of e-liquid decreased 69.2% from US\$7.96 to US\$2.45.

Conclusions The current regulatory regime around e-cigarettes has resulted in disposable e-cigarette manufacturers providing consumers with bigger, cheaper disposable e-cigarettes that come in increasingly higher nicotine strengths. Tobacco policy recommendations such as restricting e-liquid capacity and minimum price laws as well as regulations on product characteristics that affect nicotine emissions and delivery such as nicotine strength, nicotine output, device power, and puff duration should be considered in regulating the e-cigarette market.

INTRODUCTION

The e-cigarette market has grown exponentially since e-cigarettes were introduced in 2007.¹ Currently, the US e-cigarette market is valued at over eight billion dollars,² with more than 50% of unit sales coming from disposable single/one-time-use products.³ To date, the Food and Drug Administration (FDA) has only issued a marketing order on one disposable e-cigarette product, tobacco-flavoured NJOY Daily.⁴ Meanwhile, all other disposable e-cigarette brands are being sold without marketing authorisation.⁵

The lack of comprehensive policies regulating e-cigarettes drive market conditions that enable rapid evolution of new products. Examining

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ As of fall 2022, disposable e-cigarettes account for nearly 50% of the US e-cigarette market.
- ⇒ Fruit and flavours that produce a cooling sensation have proliferated in the disposable e-cigarette market.

WHAT THIS STUDY ADDS

- ⇒ From January 2017 through September 2022, disposable e-cigarettes quintupled in e-liquid capacity and nearly tripled in average nicotine strength, while decreasing threefold in price per millilitre of e-liquid.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Tobacco policy recommendations, such as restricting e-liquid capacity and minimum pricing laws, as well as regulation of product features that affect nicotine emissions and delivery such as nicotine strength, nicotine output, device power and puff duration should be used to better regulate the e-cigarette market.

product trends can provide insight to inform regulatory priorities. While previous studies have analysed changes in product type (eg, prefilled cartridges and disposable products) and flavour offerings,^{6,7} this study analyses changes in product characteristics for disposable e-cigarettes from January 2017 to September 2022, specifically focusing on product size (e-liquid volume capacity), nicotine strength and price.

METHODS AND DATA SOURCE

We analysed US-level retail scanner data estimates from the 4-week period ending 28 January 2017 to the 4-week period ending 3 September 2022 provided by NielsenIQ. NielsenIQ provides universal product code (UPC)-level sales dollars and units aggregated to 4-week periods from independent, chain and gas station convenience stores; food, drug and mass merchandisers; discount and dollar stores; and military commissaries. The US-level data provided by NielsenIQ is a UPC-level aggregated estimate of e-cigarette sales with a proprietary vendor calculation applied to account for non-participating retailers from the 48 contiguous states. Our analysis focused exclusively on



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disposable products. For each 4-week period, we excluded all products with zero sales dollars and calculated the average volume capacity measured in millilitres (henceforth referred to as capacity), average nicotine strength and sales-weighted average price per 1 disposable unit and per 1 mL of e-liquid. All prices are inflation-adjusted to September 2022 dollars using Consumer Price Index figures from the US Bureau of Labor Statistics.⁸ For these analyses, we further excluded products with missing nicotine strength information (1.8%) and missing e-liquid capacity information (1.4%).

RESULTS

From January 2017 (4-week period ending 28 January 2017) through December 2019 (4-week period ending 28 December 2019), average capacity remained stable at 1.1 mL. Through the summer of 2021, average capacity increased from 1.1 to 1.6 mL (4-week periods 25 January 2020 through 12 June 2021). Starting in July 2021 (4-week period ending 10 July 2021), average capacity more than doubled to 3.6 mL, further increasing to 5.7 mL in September 2022 (4-week period ending 3 September 2022). During the study period, capacity increased by 518% (figure 1, panel A). For the period between April and September 2022 (4-week period ending 16 April 2022 to 3 September 2022), there were 18 products with a capacity of 20 mL (results not shown).

Average nicotine strength also increased over time. Prior to 2019 (4-week period ending December 29, 2018), average nicotine strength remained below 2%. By the fourth quarter of 2020 (4-week periods ending 3 October 2020 to 26 December 2020), average nicotine strength doubled to 4% and continued to steadily increase reaching an average 5% through September 2022 (4-week period ending 3 September 2022). During the study period, nicotine strength increased 294% (figure 1, panel B). For the period between March and September 2022 (4-week period ending 19 March 2022 to 3 September 2022), 48 new products were introduced with 6% nicotine strength (results not shown).

As disposable devices increased in capacity and nicotine strength, their prices decreased. The average real price per unit and the average real price per millilitre of e-liquid both remained relatively stable from January 2017 (4-week period ending 28 January 2017) through December 2019 (4-week period ending 28 December 2019), averaging US\$8.68 per unit and US\$8.56 per millilitre of e-liquid. Starting in January 2020 (4-week period ending 25 January 2020), unit prices and millilitre prices started to diverge. From January 2020 (4-week period ending 25 January 2020) through September 2022 (4-week period ending 3 September 2022), average unit price increased from US\$8.49 to US\$14.07—a 65.7% increase. However, as devices increased in capacity, the average price per 1 mL of e-liquid fell from US\$7.96 to US\$2.45—a 69.2% decrease (figure 1, panel C).

To contextualise our findings, we aggregated nicotine strength and device capacity data to compare trends over time. We used JUUL's previously industry-leading 5% nicotine strength as a benchmark,⁹ visualising aggregate real sales dollars (online supplemental figure 1) and the number of unique bar codes (online supplemental figure 2) for each 4-week period. At the beginning of 2017 (4-week period ending 28 January 2017), nearly all products sold (99.9%) had less than 5% nicotine strength. By the 4-week period ending 3 September 2022, nearly all products sold (95.5%) had 5% or higher nicotine strength. For device capacity, we used median capacity (2 mL) and the IQR (1–6 mL) as our benchmarks. We thus visualise aggregate

real sales dollars (online supplemental figure 3) and unique bar codes (online supplemental figure 4) as low (≤ 1 mL), moderate (>1 mL but ≤ 6 mL) and high capacity (>6 mL). From the 4-week period ending 28 January 2017, through the 4-week period ending 5 October 2019, the majority of sales (95.8%) were for low-capacity devices. Beginning of the 4-week period ending 18 April 2020, moderate-capacity devices comprised 80.0% of sales before July 2021 when large capacity devices first outnumbered low-capacity devices. By September 2022 (4-week period ending 3 September 2022), the market share of moderate-capacity devices accounted for 57.5%. During the same period, the market share of high-capacity devices increased to 35.7% of aggregated sales. Unique barcodes followed the same trajectory with moderate-capacity devices overtaking low-capacity devices in the 4-week period ending 11 July 2020 and high-capacity devices overtaking low-capacity devices in the 4-week period ending 10 July 2021.

DISCUSSION

Disposable e-cigarettes have changed dramatically between 2017 and 2022, quintupling in volume capacity, nearly tripling in average nicotine strength and falling in average per millilitre price of e-liquid by nearly 70%. The shift in the e-cigarette marketplace towards disposables was partially brought about by FDA's policy prioritising enforcement against most flavoured closed cartridge-based e-cigarettes that exempted disposable e-cigarettes. This regulatory action provided consumers with a plethora of product choices and the market with competition, and the findings of this paper exemplify how e-cigarette manufacturers responded in an underregulated market. The rise we document in millilitre capacity that started in early 2019 coincides with the rise in market popularity of Puff Bar.^{10 11} In the same manner, the major increases in millilitre capacity and nicotine strength growth, combined with decreasing prices more closely coincide with the July 2020 FDA warning letters to Puff Bar and the introductions of numerous new Puff Bar—look-alikes and counterfeit disposable products. Without proper regulation, manufacturers will likely continue to introduce products with even larger capacity and higher nicotine strength. As our results show, 48 products with 6% nicotine strength were introduced between March and September 2022, a 20% increase in nicotine strength from the now more common 5%. Eighteen products have 20 mL of capacity, 29 times the size of one JUUL refill.

Stronger policies that address all e-cigarettes, including disposable e-cigarettes, should be implemented to minimise youth vaping and nicotine addiction. Several proven policy recommendations merit attention, the first of which is packaging standards. Research shows that cigarette minimum pack standards included in the 2009 Family Smoking Prevention and Tobacco Control Act effectively raised prices, discouraged experimentation and brand switching, and reduced youth access and light use.¹² Similarly, local minimum packaging standards for cigars and cigarillos implemented in several states¹³ effectively increased price and decreased youth access.¹⁴ It follows that cheap, high-capacity disposable e-cigarettes may be an appealing entry point for non-tobacco users, experimenters and light users, just as small packs of combustible products are appealing to price-sensitive consumers and light users.^{15 16} While additional research is needed on the effects that e-cigarette volume capacity may have on access, initiation, sustained use or progression to other tobacco products, it is clear that e-cigarettes require their own packaging standards based on volume capacity. Many of

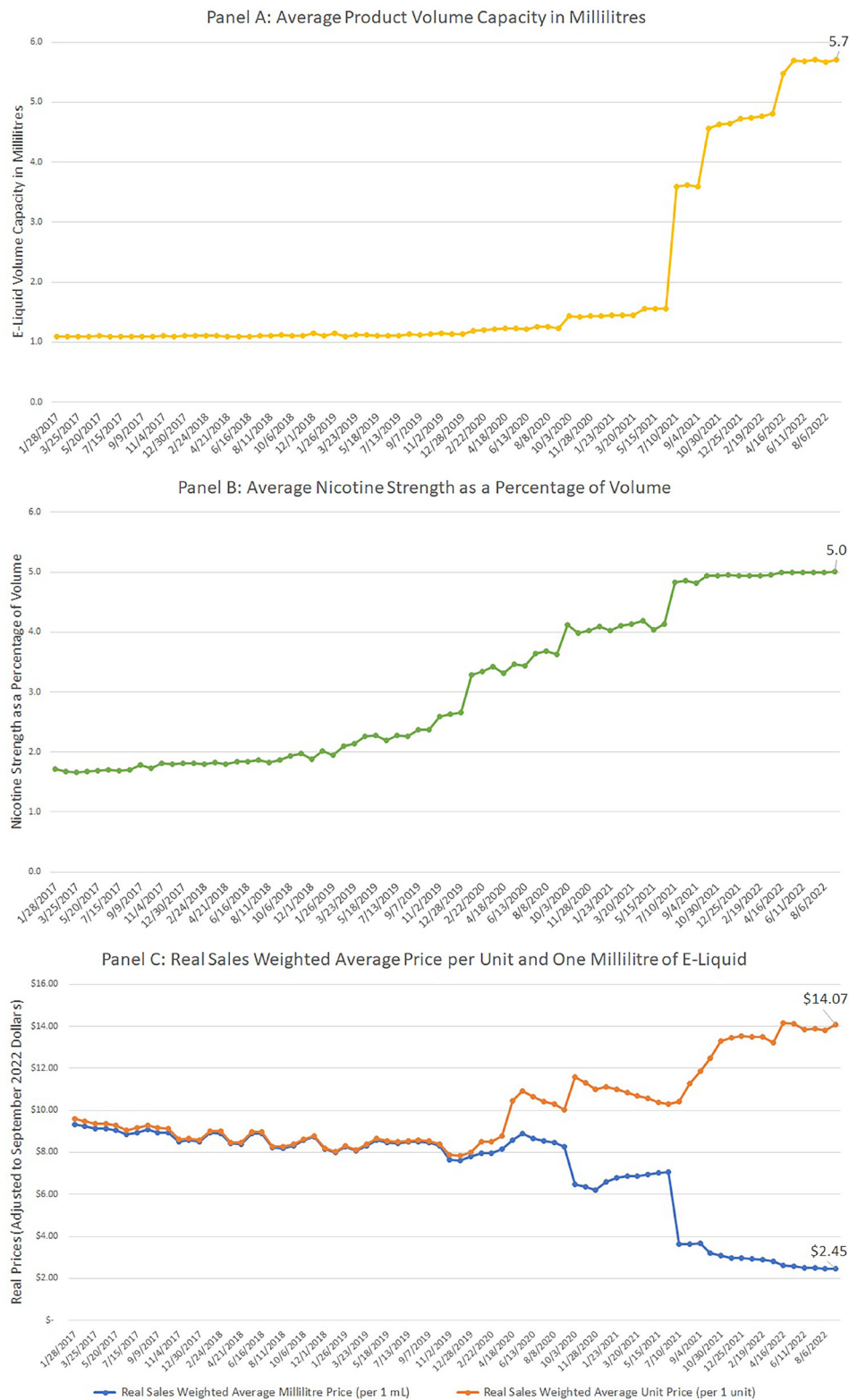


Figure 1 Panel A: average millilitre volume capacity; panel B: average nicotine strength as a percentage of volume; panel C: real sales-weighted average price of 1 mL of e-liquid and one disposable unit, disposables e-cigarettes, NielsenIQ United States, January 2017–September 2022*. *Each time period represents a 4-week interval.

these disposable e-cigarette devices contain nicotine quantities comparable to multiple cartons of cigarettes suggesting that volume capacity should be limited. To our knowledge, the Tobacco Products Directive (TPD) 2014/40/EU implemented in the European Union,¹⁷ along with Albania, Jordan, Moldova

and New Zealand are the only countries to date establishing a maximum tank and pod size (2 mL),¹⁸ though research has not explored the effects of this volume-based package standard.

Volume-based packaging standards are most effective when implemented with minimum price laws.¹⁹ While excise tax

increases are considered the gold standard for increasing product price, minimum price laws can also be effective, especially when taxes are not politically feasible.²⁰ All US non-preempted states and local governments may implement a minimum price law given their mandates to protect the health, safety and welfare of their communities.²¹ Like excise taxes, minimum price laws make it harder for price-sensitive youth to purchase products^{22–25} or initiate use.^{15 16 26 27} This is an important consideration given that based on our price analysis, young people who consume disposable e-cigarettes saw their purchasing power nearly tripled in only 3 years. Minimum price laws also prevent tobacco companies from manipulating prices later on if a tax increase is implemented.²⁰

Our study builds on previous research findings that nicotine strength has increased over time^{28 29} and points to the regulation of nicotine as a significant public health priority. Nicotine is a highly addictive substance,³⁰ linked to initiation and further use of combustible tobacco products,³¹ making it difficult to reduce or quit using these products.³⁰ Furthermore, nicotine use poses serious health risks, particularly among youth users as it can harm brain development,³² damage blood vessels³³ and its use has been linked to increased feelings of depression and anxiety.³⁴ Legislation introduced in past years in Congress would cap nicotine strength in e-cigarettes at 2% or direct FDA to set nicotine strength limits, though these bills have been unsuccessful.^{35–38} To date, the 27 European Union member states under the TPD 2014/40/EU, together with Albania, Armenia, Canada, China, Israel, Jordan, Kazakhstan, Moldova, the UK, Russia, Saudi Arabia and the UAE have implemented nicotine strength standards. Except for Jordan (capped at 2.5% for nicotine salt), Kazakhstan (capped at 1%) and New Zealand (capped at 5% for nicotine salt) all strength standards cap nicotine strength to 2%.^{39 40} According to the TPD, the rationale for a 2% nicotine cap is because this dose ‘is comparable to the permitted dose of nicotine derived from a standard cigarette during the time needed to smoke such a cigarette’.¹⁷ To our knowledge, only one study from the UK finds preliminary evidence on the effectiveness of nicotine standards, suggesting a decline in interest in e-cigarette use among youth.⁴¹

Regulating nicotine strength by implementing a nicotine strength cap has also been a policy option that some localities have pursued. However, for e-cigarette products, nicotine emissions and delivery are a function of many moving parts, including nicotine strength, nicotine output, device power and puff duration.^{42–44} To skirt a nicotine strength cap, a manufacturer wishing to maintain a high nicotine emission rate could simply modify device power or other product features that increase how much e-liquid is aerosolised into a puff. For example, JUUL’s release of a new device in the European Union used a new wick design to facilitate the heating of e-liquid, leading to 50% greater nicotine and particulate matter emissions for the same nicotine strength.⁴⁵ Moreover, users may use low nicotine products differently. For example, a study of Dutch and Belgian e-cigarette users showed that users of lower nicotine concentration products compensated by using more e-liquid, leading to the same levels of nicotine consumption as those using higher concentration e-liquids.⁴⁶ As a policy strategy on its own, a cap on nicotine strength does not prohibit high nicotine emissions or intake and could incentivise manufacturers to increase sales by altering the device to heat more e-liquid and users to consume more. In turn, burning e-liquid hotter and faster would expose users to more toxicant emissions, increasing the danger to users without decreasing the addictive potential.⁴⁷ In regulating nicotine strength, policies should consider also addressing

the regulation of product performance specifications,⁴⁵ such as nicotine flux/output,⁴⁸ which would account simultaneously for all factors that influence e-cigarette nicotine emissions (ie, resistance, voltage, coil diameter, number of coils) and puff duration.⁴⁹ These policy recommendations are especially important, given that disposable e-cigarettes tend to be constructed of lower quality and lack proper temperature control.⁵⁰

Another policy option is for state and local jurisdictions to prohibit the sale of single-use or disposable e-cigarettes, as some localities in California have done.^{51–54} Disposable products are marketed as ‘beginner friendly’, have been shown to encourage youth initiation⁵⁵ and discourage quitting attempts.⁵⁶ Aside from these public health considerations, disposable e-cigarettes pose a substantial threat to the environment.^{57–59} Citing environmental concerns, countries such as Scotland and Ireland are considering removing disposable e-cigarettes from the market.^{57 58}

In addition to these implications for policy, these findings also suggest a need to re-examine how e-cigarettes are standardised for unit of analysis. Widely used standardisation practices,^{7 60} where five pre-filled cartridges are standardised to equal one disposable device, may be outdated. Researchers should consider using millilitres of e-liquid, akin to cigarette sticks or standardised packs, as a unifying measure to make accurate comparisons between products. For further precision, researchers should consider using millilitres of e-liquid by nicotine strength, though future research is warranted.

The main limitation in our study is that while retail sales data are a direct measure of aggregate consumption, they do not capture the entire e-cigarette market. We estimate that our data captures approximately 61% of the market in 2021, according to an industry document.⁶¹ Our data do not capture sales of online or independently owned vape shops, which are estimated to account for 20–30% of sales.^{61 62}

The current federal regulatory regime around e-cigarettes has created conditions allowing disposable e-cigarette manufacturers to provide consumers with products that are bigger, stronger and cheaper than ever. Actions from the FDA such as issuing warning letters, civil money penalties and complaints for permanent injunctions to retailers and distributors selling unauthorised tobacco products should curtail some market growth.⁶³ However, as the e-cigarette market continues to evolve in ways that remain highly appealing to young people, policy makers must act to regulate these products to reduce youth vaping and nicotine addiction.

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