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Google Shopping Queries for Vaping Products, JUUL and IQOS during the E-cigarette, or Vaping, product use Associated Lung Injury (EVALI) Outbreak

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Abstract (Word Count: 254)

Objectives. To assess whether the late 2019 US outbreak of pulmonary disease linked to vaping ["E-cigarette, or Vaping, product use Associated Lung Injury" (EVALI)] impacted online shopping queries for vaping products and IQOS heated tobacco.

Methods. We tracked online shopping queries for vape(s), JUUL and IQOS by analyzing rates of Google queries indicative of shopping (e.g., buy IQOS) after news of the outbreak was first reported (the week of July 29, 2019) until hospitalizations ceased (the week of February 16, 2020). We compared observed rates of shopping during the outbreak to counterfactual expected rates that were predicted using an autoregressive iterative moving average model fit to queries from January 1, 2014 to the week of July 21, 2019.

Results. During the outbreak, vape shopping queries were 34% (95%CI: 30-38) lower than expected and JUUL shopping queries were 39% (95%CI: 34-45) lower than expected, translating into about 7.2 million and 1.0 million fewer searches. IQOS shopping queries were 58% (95%PI: 34-87) higher than expected, translating into 35 thousand more searches. Moreover, IQOS shopping queries reached a historic high the week they were discussed as a potentially safe alternative to vaping (the week of September 29, 2019), when they were 382% (95%PI: 219-881) above expected rates for the week.

Conclusions. These results suggest that unplanned events, such as the EVALI outbreak, can provoke changes in the epidemiology of product usage. Tobacco companies should be prohibited from using events such as disease outbreaks to position their products as less harmful without prior approval.

What this study adds

- In late 2019, an outbreak of pulmonary disease linked to vaping products occurred in the United States resulting in 2807 hospitalizations and 68 deaths, as of February 18, 2020.
- Past studies have identified that during the outbreak vaping news stories shifted to more frequently warn about the dangers of vaping and news coverage spoke of Philip Morris' heated tobacco product IQOS as a potentially safe alternative to vaping and traditional tobacco.
- We identify an unprecedented contraction in Google searches indicative of shopping for JUUL and other vaping products corresponding with initial coverage of EVALI. At the same time, queries indicative of shopping for IQOS rose, with a record setting week in shopping searches corresponding with a spike in news coverage discussing IQOS as a potentially safe alternative to vaping and traditional cigarettes.

Introduction

A substantial increase in youth vaping in 2017-2018–concurrent with JUUL becoming the most popular vaping product–led the US Food and Drug Administration (FDA) Commissioner and the US Surgeon General to declare youth vaping an "epidemic".[1,2] However, in late 2019, an outbreak of pulmonary disease linked to vaping products occurred in the United States resulted in 2,807 hospitalizations and 68 deaths and may have disrupted the marketplace for e-cigarette products.[3]

In recent analyses, we have shown that during the outbreak, which the US Centers for Disease Control and Prevention (CDC) named "E-cigarette, or Vaping, product use Associated Lung Injury (EVALI)," vaping news articles shifted to more frequently warn about the dangers of vaping products and internet searches for resources to quit vaping increased, especially during the first two months of the outbreak when the primary source was uncertain.[4] We have also shown that news articles began to discuss Philip Morris' novel "heated tobacco" product IQOS as a potentially less harmful alternative to both vaping and traditional cigarettes following press releases from the manufacturer, even though at the time they did not have authorization from the FDA to market IQOS in such a manner.[5] How the outbreak impacted demand for vaping products or IQOS has not been evaluated. Herein, we sought to fill these knowledge gaps.

First, we hypothesized that the outbreak would decrease interest in shopping for vaping products (including the most popular product at the time, JUUL). Specifically, we expected that interest in shopping would begin to decline following the initial press coverage of the outbreak that was published on July 25, 2019. Additionally,

we hypothesized that the outbreak would increase interest in shopping for IQOS, particularly when news reports discussed IQOS as an alternative to vaping and traditional cigarettes during the outbreak around the week of September 29, 2019. To test these hypotheses, we used an approach developed in past assessments of product shopping,[6,7] utilizing Google Trends to track internet searches indicative of shopping for vaping products, JUUL and IQOS.

Methods

We retrieved weekly Google search rates (www.google.com/trends) originating from the United States that mentioned "buy," "order," "shop(s)," "retailer(s)," or "sale(s)" in combination with **a)** "vape(s)," as indicators of vape shopping queries (e.g. "online vape shops"); **b)** "JUUL" as indicators of JUUL shopping queries; and **c)** "IQOS" as indicators of IQOS shopping queries. Search rates on Google were obtained from January 1, 2014, to allow for historical searches to inform our forecasts for expected rates during the outbreak, through February 18, 2020, when the last hospitalization resulting from the outbreak was reported. The search rates provided by Google were defined as the number of searches occurring in the US that matched the criteria above on a given week divided by the total number of searches during the same week (expressed as per 10 million).

To test our hypotheses, we compared search rates after news of the outbreak was first reported on July 25, 2019 with expected search rates had the outbreak not occurred, thereby taking into account any historical seasonality, periodicity, or upward-or-downward trend in the data. Expected search rates and corresponding prediction intervals (PIs) were computed using an autoregressive integrated moving

average model selected by Hyndman and Khandakar's model selection algorithm,[8] using historical trends from January 1, 2014 to the week of July 21, 2019 (the week with the first news report of the outbreak) to predict counterfactual trends for the 31 weeks following the initial report to February 18, 2020, when the last hospitalization resulting from the outbreak was reported. Given the apparent spikes in queries on the weeks of Black Friday, and the holidays in late December, we also imposed a fixed effect for the weeks of these holidays in our forecasts for vaping and JUUL. We calculated the ratio of observed and expected rates and PIs for individual weeks, as well as the cumulative excess or dearth in search volume for the period with bootstrap 95% Confidence Intervals (CIs). Finally, we also estimated the excess and dearth in Google searches in absolute numbers by multiplying the search rates provided by Google Trends with the estimates of total search volume derived from ComScore.com. All analyses were performed using R version 3.6.1 (R Foundation).

Results

Vape shopping queries saw steady growth from 2014 to the partial 2019 year, increasing by an average of 36% (95% CI: 35-37) annually, with queries typically higher during summer and spiking around Black Friday in November and the holidays in late December (**Figure 1A**). JUUL shopping queries saw similar seasonal and holiday patterning, and substantial growth in this trend occurred after 2016 (**Figure 1B**). For instance, from 2016 to 2017 alone, JUUL shopping queries grew by 212% (95% CI: 187-236). IQOS shopping queries did not have identifiable seasonal or holiday patterning and had much lower search rates compared to the trends for vaping products and JUUL (**Figure 1C**). However, the shopping queries for IQOS

grew over the interval, particularly in 2019 when queries grew an average of 27% (95% CI: –5-64) per week in the 30 week period prior to the outbreak.

For both JUUL and vaping in general, search volumes were expected to increase but instead the observed search trends declined. During the outbreak, vape shopping queries were cumulatively 34% (95% CI: 30-38) lower than expected **(Figure 1A)** for the 31 weeks following the initial report of the vaping outbreak on July 25, 2019. Shopping queries for JUUL were also 39% (95% CI: 34-45) lower than expected, with all weeks in the interval also below expected rates (**Figure 1B**). By contrast, IQOS shopping queries were cumulatively 58% (95% PI: 34-87) higher than expected during the outbreak, with the observed search trend eclipsing the already projected increase in searches (**Figure 1C**). IQOS shopping queries reached record rates on the week beginning on September 29, 2019, when they were 382% (95% PI: 219-881) higher than expected for the week, corresponding with a major press week where several news articles discussed IQOS as an alternative to vaping and traditional cigarettes. In absolute terms these rates translate into about 7.3 million fewer vape shopping searches, 1.1 million fewer JUUL shopping searches, and 35 thousand more IQOS shopping searches than expected for the time period.

Discussion

The induction and growth of the EVALI outbreak coincided with an unprecedented contraction in shopping queries for vaping products, including the most notable brand at the time JUUL, following nearly a half-decade of continual growth. Shopping queries for IQOS increased well beyond what increases were expected

during the outbreak, including a record-setting single-week spike during the outbreak.

Although most recent case investigations have suggested that the EVALI outbreak was primarily caused by additives used in marijuana vapes, our results reveal a decline for all vaping products including the most popular product, JUUL. These declines coincide with growth in news coverage that warned about the dangers of vaping and mirrors a growth in queries indicative of seeking information on vaping cessation as well as news coverage warning about the dangers of vaping.[4] These corroborating trends combined with evidence that product harm perceptions are strong drivers of tobacco use[9] may suggest that the health concerns surrounding EVALI could be a reason for this notable decline. However, an alternative explanation is that the decline could have resulted from changes in product availability. For instance, JUUL voluntarily removed flavored products offerings other than menthol and tobacco from retail stores in 2018 requiring purchasing of these flavors on an age-verified website.[10] JUUL then later also removed these flavors from their website on October, 17 2019.[11] Other alternative explanations are that some jurisdictions announced restrictions on flavored tobacco and e-cigarettes, including the federal restriction on the sale of flavor-cartridges other than menthol and tobacco, which took effect on February 6, 2020 after a 30-day sell-off period,[12] and the legal purchasing age for tobacco being raised to 21 on December 20, 2019.[13] Although each of these factors could be contributing synergistically to the observed decline in late 2019, the initial decrease in vaping queries first fell outside the forecasted levels on the week of July 28, 2019, 11 weeks prior to JUULs ceasing the sale of flavors other than tobacco and menthol on their website, 20 weeks prior to

the federal minimum purchasing age increase, and 27 weeks prior to the effective date of federal restriction on the sale of flavor-cartridges.

The results also suggest that the EVALI outbreak may have been a boon for Philip Morris' new heated tobacco product IQOS. The observed increase in shopping queries for IQOS coincides with a Philip Morris' press release and subsequent news coverage positioning IQOS as a safe alternative to vaping and traditional tobacco.[5] However, the timing of this advertising push also coincided with the launch of Philip Morris' new Atlanta store on October 4th making it difficult to disentangle whether the increase in queries was an effect of any health concerns surrounding EVALI or just a response to increased exposure to advertising and product availability. Yet, these events too are not isolated incidents as indeed some press articles discussed the launch of the Atlanta store as "perfect timing" for Philip Morris given the health concerns for EVALI.[14] Regardless, earned-media and especially news media spawned by a company press release should be considered as a form of advertising and be regulated as such. All tobacco brands that wish to market using claims of reduced risk are required by the Family Smoking Prevention and Tobacco Control Act (FSPTCA) to complete the Modified Risk Tobacco Product application process with the FDA prior to their use.[15] Philip Morris was aware of this law as its application for IQOS was submitted to the FDA but had not yet received approval at the time it issued its press release.

Our analysis of shopping queries was limited in that we cannot determine the demographics of Google searchers, how often queries resulted in purchases, and the quantity and type of products purchased, but there are several indications that the searches may measure shopping for tobacco products. As with past studies that

have suggested a strong correlation between search trends and product purchasing behavior,[16,17] the growth in shopping searches mirror the timing and trajectory of growth in vaping unit sales in brick-and-mortar tobacco retailers.[18,19] The seasonal patterning for the vape queries also correspond with trends in purchasing behavior of many other consumer products, such as prepackaged software, video games,[20] and U.S. motion picture sales.[21] Another limitation is that vaping products can also be purchased in retail locations in addition to online, which we do not capture; however, no data source captures both retail and online purchasing.

While considering the limitations, the results provide a first look into the collateral impact EVALI may have had on the epidemiology of vaping products in the United States. The data suggest there could be both public health benefits if the outbreak discouraged youth vaping but also risks if the outbreak simultaneously increased initiation of other tobacco products. Continued monitoring with other forms of surveillance, such as retail scanner data and surveys, are needed to further corroborate these findings. As the tobacco product landscape grows more diverse and the marketplace expands via a new media 2.0 landscape, with changes in the use of search engines and consumption of news and social media, marketplace shocks like EVALI will potentially grow more common. As such, EVALI is an important case study to understand collateral impacts of events such as disease outbreaks and how to respond to these collateral impacts in addition to responding to the outbreak itself.[22,23] For example, herein our results suggest a need for active monitoring and enforcement of tobacco companies' unauthorized use of events such as disease outbreaks to position their products as less harmful in line with the laws established in the FSPTCA. Fortunately, novel forms of data such as queries are

available in near real time, implying that our methods can be replicated on-demand to study the collateral impacts of other events in the future.

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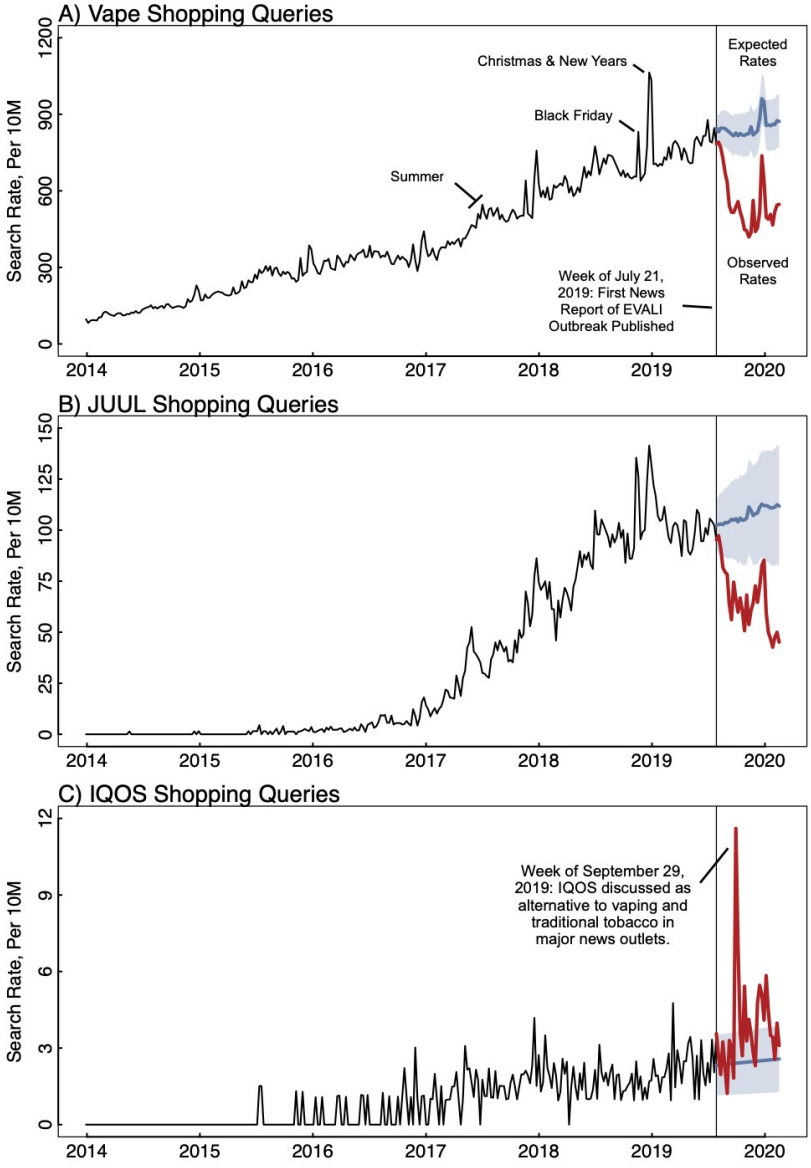
Figure 1. Changes in shopping searches following the outbreak of vaping-induced pulmonary disease.



Note: The figures are the observed weekly shopping search rates for vape (A), JUUL (B), and IQOS (C) from January 1, 2014 to February 18, 2020 and expected weekly search rate from the first week after news of the outbreak was reported on July 25, 2019 (i.e., the week beginning on July 29, 2019) to February 18, 2020; Search rates from January 1, 2014 to the week of July 22, 2019 (black lines) were used to develop forecasts of expected search rates (blue lines) and prediction intervals (blue bands) for the outbreak-era that were then compared against observed search rates (red lines) for the same time period. The observed search rates were generated from criteria described in the methods (i.e., Google search queries that contain unique combinations of the following terms: vape(s), JUUL, or IQOS with buy, order, shop, store or sale, such as order JUUL or order vapes).