E-cigarette brands and social media influencers on Instagram: a social network analysis

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/tobaccocontrol-2021-057053).

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Received 12 September 2021
Accepted 22 December 2021
Published Online First 7 February 2022

To cite: Vassey J, Valente T, Barker J, *et al*. *Tob Control* 2023;**32**:e184–e191.

ABSTRACT

Background Exposure to visual posts featuring e-cigarette products on social media is associated with increased e-cigarette use among US adolescents. Instagram is the largest source of e-cigarette social media marketing, where influencers—for example, bloggers, brand ambassadors—post promotional materials. This study analysed the network of e-cigarette brands and influencers on Instagram, characterising the most central players in e-cigarette social media marketing.

Methods We tracked influencers with public profiles on Instagram who posted promotional e-cigarette content in 2020, had over 1000 followers and high user engagement rate (ratio of likes and comments to followers) of 1%–25% per post. By conducting a social network analysis, we identified the most central (highly involved in promotional activities) influencers and e-cigarette brands. The number of the influencers' followers aged 13–17 years old and the age verification practices restricting youth access were also assessed.

Results There is a highly interconnected network of engaging e-cigarette influencers (n=55) worldwide who collaborated with over 600 e-cigarette brands in 2020. The Asian and US influencers had five to six times more teenage followers compared with the European influencers. 75% of the influencers did not restrict youth access to their promotional content on Instagram. The brands Voopotech, Innokin, Geekvape, Lost Vape, Smok and Vaporesso collaborated with the largest number of influencers (mean n=20).

Conclusions It is important to understand associations among influencers and e-cigarette use behaviours, especially youth, to inform effective public health communication and potential policies that could regulate social media marketing sponsored by e-cigarette companies.

INTRODUCTION

E-cigarette consumption among youth around the world is a public health concern.[1–3] In 2020, more than 3.5 million teenagers in the USA used e-cigarettes. During 2019–2020, the use of low-priced disposable e-cigarette devices increased approximately 1000% (from 2.4% to 26.5%) among US high school current e-cigarette users.[1] In addition, more than 8 in 10 teenage e-cigarette users in the USA reported consuming flavoured e-cigarettes. E-cigarettes can harm the adolescent brain, may be associated with respiratory symptoms and may contribute to increased susceptibility to tobacco addiction.[1 4–7] Exposure to visual posts featuring e-cigarette products on social media, including promotional content, has been associated with increased e-cigarette use among US adolescents,[1 5 8–11] more positive e-cigarette attitudes and lower perceived danger of e-cigarette use.[12]

Instagram, one of the most popular social media platforms among adolescents with approximately 1 billion users worldwide in 2021,[13] is considered the second largest source of social media marketing,[14] including e-cigarettes. The platform is home to content from e-cigarette stores, brands, distributors and social media influencers[15 16]—for example, models, bloggers, brand ambassadors with 1000 to over 1 million followers who post e-cigarette and e-liquid content on behalf of brands for monetary compensation or other non-monetary rewards (eg, free e-cigarette supply in exchange for promotion). In response to the US Food and Drug Administration (FDA) warnings about unauthorised marketing of e-cigarettes as modified risk tobacco products at schools,[17] several major e-cigarette brands, including JUUL, voluntarily suspended their social media youth-oriented marketing.[17] In 2019, Instagram banned all worldwide branded[18 19] e-cigarette content (that features or is influenced by a business partner) from its platform. Despite FDA's actions,[20] youth-appealing content is still present on this platform. The featured products include flavoured e-liquids, flavoured disposable (eg, Puff Bars) and cartridge-based e-cigarettes, the most commonly used devices in 2020,[1] as well as product packaging featuring cartoon characters and youth-appealing food. E-cigarette influencers continue to serve as a marketing tool that may be particularly effective for engaging youth. In March 2021, the FDA sent letters to e-cigarette brands (Aspire, Joyetech, Vaporesso and Voopoo) requesting information about their youth-oriented e-cigarette influencer marketing on social media[21] and their actions on tracking and managing the ages of followers and viewers as well as restricting youth access to this marketing.

A growing body of literature analyses the role of social media influencers in tobacco product marketing,[22 23] finding that they are regarded as more trusted and authentic sources of content than traditional advertising.[24] Focus group research among young adults suggests that tobacco-related posts made by sponsored users may be seen as more trustworthy than posts made by the brands themselves.[25] Yet, influencer marketing on social media has not been studied extensively. We located no previous studies that used social network analysis[26 27] to investigate brand–influencer promotion of tobacco products on social media. The social

network framework shifts the focus from studying individual traits to analysing interactions, relationships and communications.[28] Social network analysis captures distribution of a specific content (eg, promotional posts on social media) and identifies users who are responsible for distribution of this content. For example, Himelboim and Golan[28] analysed the role of social media influencers in diffusion of social media beer advertising on Twitter. The study identified primary influencers (highly retweeted users), bridges (connector hubs who spread information from followers of one influencer to another) and isolates (low-influence users with limited individual contributions to content distribution, but with substantial cumulative influence).

A social network is formed when connections ('ties') are created among social actors ('nodes'), such as individuals (eg, social media influencers) and organisations (eg, e-cigarette brands). Therefore, one way to capture brand–influencer relationships is to examine the number of ties or connections between brands and influencers. These connections are measured by degree centrality,[29 30] a commonly used measure in social network analysis, which is the number of ties a node has to other nodes. Nodes that have more ties are considered more *central*, that is, important and influential since they can play a key role in content distribution. For example, if an e-cigarette brand collaborates with multiple influencers, the content they promote on social media may potentially reach a larger network of the influencers' followers. Similarly, influencers who collaborate with multiple e-cigarette brands might expose their social media followers, including youth, to a wider variety of tobacco-related content. Considering potential exposure to harmful content, social network analysis merits consideration in tobacco control regulation of industry marketing tactics.

This study is the first to analyse the network of e-cigarette brand–influencers on Instagram, providing a global view of potential collaboration among US and international influencers. The study aimed to: (1) identify the most engaging e-cigarette influencers on Instagram in 2020; and (2) conduct a social network analysis to characterise connections between the most central influencers and e-cigarette brands these influencers promoted on Instagram.

MATERIALS AND METHODS

Data collection

In October-–December 2020, we used a commercial social media listening platform Meltwater[31] to track Instagram influencers with public profiles and over 1000 followers who posted promotional content that included the most frequently used e-cigarette hashtag and keyword 'vape'. Using this search term, we identified 260 influencers who posted about e-cigarettes in English in 2020 (posts were collected over the whole year both prospectively and retrospectively).

Identifying the most engaging e-cigarette influencers

Of the 260 influencers' profiles, we selected 55 influencers who met all of the following criteria considered metrics of good performance and high engagement: (1) having more than 1000 followers[32]; (2) having at least 2:1 ratio[33] of the number of *followers* to the number of users who an influencer *follows;* (3) having high engagement rate (1%–25% per post) based on the engagement rate benchmarks on Instagram frequently cited by social media analysts[34] (ie, 6-month average engagement rate per post, which is a sum of 'likes' and comments divided by the number of followers); (4) posting e-cigarette promotional content at least once a month over 12 months in 2020.

Characterising e-cigarette influencers and their promotional content

We collected the following influencer profile metrics (table 1):

The influencers' Instagram profile descriptions and captions to their e-cigarette 2020 promotional posts (N=9280) were then examined by four independent coders (one of the coauthors of this study and three undergraduate student assistants). The assistants were trained to identify any indication of the influencers' association with an e-cigarette brand (eg, a mention of an e-cigarette brand in a post's caption, figure 1A and C). Brand names were documented.

The coders also evaluated the posts for the presence ('yes'/'no') of the fully compliant Federal Trade Commission (FTC)-required sponsorship disclosure,[35 36] that is, (a) a description

Table 1 Metrics collected about social media influencers (n=55) who posted promotional e-cigarette content on Instagram in 2020

Variable (metric)	Description/operationalization
Provided by Meltwater	
Username	Instagram username of an influencer who posted e-cigarette-related contact in 2020 and used hashtags and keywords described in Section 2.1
Gender	Male/female (based on Instagram images featuring an influencer in the collected dataset)
Geolocation	A location (country) (a) directly identified in an influencer's Instagram profile or captions to posts; or (b) inferred from a phone number or a flag emblem provided in the profile or a language used in captions/comments
Number of followers	Number of users who follow an influencer on Instagram
Number of followed users	Number of users followed by an influencer on Instagram
Number of followers aged 13–17 years old	Information about followers' age range is a standard Instagram feature made visible by those influencers who provided access to their demographic data to Meltwater
Engagement rate	Six-month average engagement rate per post is a sum of the number of 'likes' and the number of comments divided by the number of followers (range: 1–25)
Collected by the authors and coders	
Profile self-identification	Example: blogger, artist, public figure
Frequency of posting of e-cigarette content	Example: once a month, weekly, daily posting of e-cigarette-related content in 2020
Total number of posts	Total number of posts an influencer had on any topic in 2020
Number of e-cigarette-related posts	Number of e-cigarette-related posts an influencer had in 2020
E-cigarette brand name	E-cigarette brand names disclosed in captions to an influencer's posts on Instagram

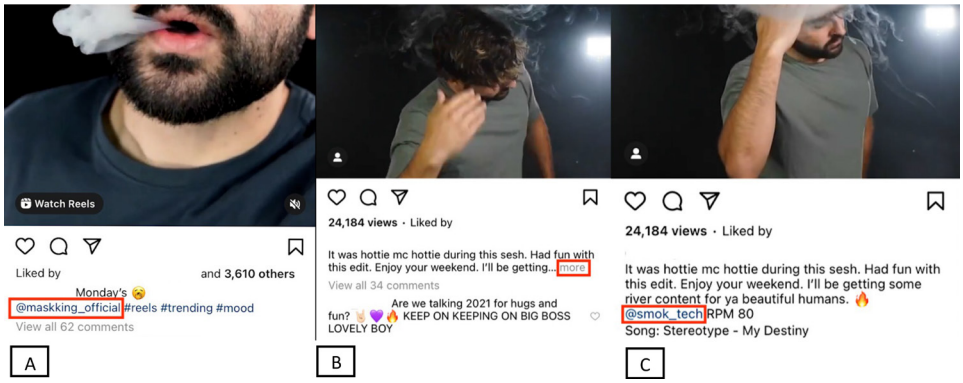

Figure 1 Evidence of collaboration between influencers and e-cigarette brands. (A,B) E-cigarette brands mentioned in captions to the influencers' Instagram posts; (B,C) example of a violation* of the Federal Trade Commission (FTC) guideline for sponsorship disclosures. *When a post is viewed on a mobile device, the brand name gets truncated requiring a user to click 'more' (B) to see a brand name (C). Publicly available photographs and captions were sourced from the public Instagram account of an influencer Drewdirps on December 2020 (https://www.instagram.com/drewdirps/).

of collaboration with an e-cigarette brand that discloses either monetary compensation or non-monetary rewards (eg, 'a product provided by X brand in exchange for Y service'); and (b) the placement of this disclosure at the top of the Instagram caption (which is relevant for mobile devices when longer descriptions get truncated and users need to click 'more' to view the complete caption text,[35] figure 1B,C). The coders also reviewed non-e-cigarette promotional posts (N=1992) to document other topics featured in the influencers' 2020 Instagram posts.

Social network analysis method

We conducted a social network analysis[26 27] to describe connections between e-cigarette brands and the most engaging e-cigarette influencers (n=55) by identifying the most central brands and influencers in the network. The primary metric we use is degree centrality,[37] which represents the number of e-cigarette brands an influencer partners with and the number of influencers an e-cigarette brand partners with. We used a *two-mode* network,[38 39] which characterises ties existing between two distinct types of *nodes* (eg, e-cigarette brands and e-cigarette influencers), but not ties within brands or within influencers. We treated e-cigarette brands as a primary (tie-creating) mode of nodes and e-cigarette influencers as a secondary mode of nodes. We justified this classification based on the assumption that e-cigarette brands could be considered more responsible for creating ties with influencers by inviting them to collaborate on product promotion. We also classified e-cigarette brands as a primary mode since we identified them in this manuscript: this information may be valuable for the FDA that periodically issues warning letters to specific tobacco brands in an attempt to regulate their promotional activity. We de-identified influencers (the secondary mode) by masking their Instagram usernames, in compliance with the Institutional Review Board protocol.

We colour-coded geographical region *USA* as red, *Asia* as green, *Europe* as blue and *'Other'* as pink represented by one influencer from South Africa and one from Brazil. We defined the North America region as the USA, because only one influencer from Canada met the inclusion criteria; the rest were from the USA.

Descriptive statistics

For descriptive analysis, we divided e-cigarette brands into three categories based on their degree centrality, that is, the number of influencers with whom they collaborated. The categories included e-cigarette brands that were connected to: (1) more than 10 influencers (the maximum was one brand that worked with 27 influencers); (2) 5–10 influencers; and (3) 1–4 influencers. For each of these three categories, we provided the average number of the US, Asian and European influencers' followers, including the number of teenage (13–17 years old) followers, and the average engagement rate (table 1) to assess popularity of the influencers' e-cigarette content in their network.

Similarly, we divided the influencers into three categories based on their degree centrality (high, mid-range and low degree centrality). Among these three categories, we compared self-identification of the influencers in their profile descriptions (eg, 'influencer', 'blogger', 'public figure'), compliance of their posts with the FTC requirements for sponsorship disclosures,[35 36] and the diversity of their promotional content (if they posted exclusively about e-cigarettes or about other topics as well). Coders also documented the number of brands' followers, including teenage followers (13–17 years old), and whether the brands and influencers had age-gating notifications (eg, this content is for 18+ or 21+ audience) on their Instagram profiles. In addition, our 20-year-old and 17-year-old coders attempted to follow these e-cigarette brands and influencers on Instagram for the purpose of this study.

Cohen's kappa for the initial inter-rater reliability (IRR) ranged from 0.87 to 0.95. Differences in coding were discussed and reconciled by the coders until the final IRR for all categories reached >0.95.

Inferential statistics

The one-way analysis of variance test followed by the Tukey Honest Significant Differences test for pairwise comparison were conducted to estimate mean differences in the number of followers and engagement rates among the three groups based on the influencers' geolocation (USA vs Asia vs Europe). The social network and statistical analysis were conducted in R.

RESULTS

Social network of e-cigarette brands and influencers

The 55 most engaging e-cigarette influencers collaborated with 640 e-cigarette brands that the influencers disclosed in their Instagram captions. In the full network of 640 brands, 5 (9%) of the influencers had the highest degree centrality, collaborating with 60–90 e-cigarette brands, 34 (61%) had mid-range degree

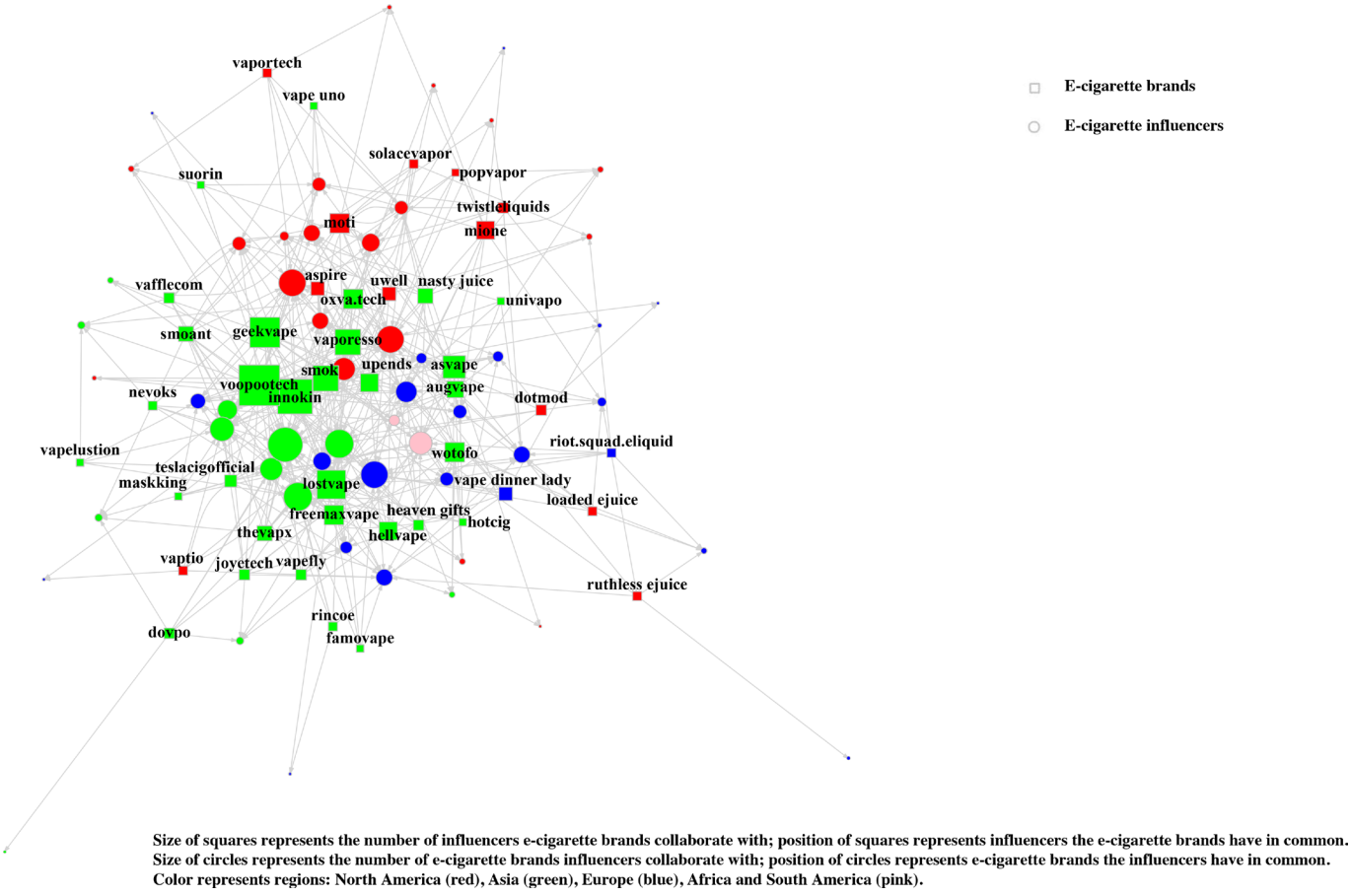

Figure 2 A two-mode network of the most central e-cigarette brands (primary mode, n=45) that from January to December 2020 collaborated with five or more Instagram influencers (secondary mode, n=52).

centrality, collaborating with 11–50 brands, and 16 (30%) had low degree centrality, collaborating with 10 or fewer brands.

To simplify the social network visualisation, we restricted the social network analysis to the e-cigarette brands that collaborated with five or more influencers (n=45 brands, n=52 influencers; figure 2).

Figure 2 shows a highly interconnected network comprised of e-cigarette brands that promoted their e-cigarette products in 2020 on Instagram via influencers from all over the world, primarily from the USA, Indonesia, Germany, France, Malaysia and Italy. We identified 18 influencers from the USA (red), 12 from Asia (green), 20 from Europe (blue) and 2 influencers from South Africa and Brazil (pink). The full distribution of the influencers' country-wide geolocation in our dataset is presented in online supplemental figure 1.

The influencers with the highest degree centrality (larger circles located near the centre, figure 2) were primarily from Asia followed by the USA. The influencers with lower degree centrality (smaller circles located further away from the centre) represented all three regions, but the majority were from Europe and the USA.

E-cigarette brands with the highest degree centrality collaborated with predominantly the same influencers

Twelve e-cigarette brands (table 2)—big China-based manufacturers and worldwide distributors of e-cigarette products—had the highest degree centrality, collaborating with the largest number of influencers (17–27). Proximity of the squares representing these e-cigarette brands (figure 2) indicates that they mostly collaborated with the same influencers (sharing more than 70% of them). These e-cigarette manufacturers also collaborated with Asian influencers who had the highest degree centrality (ie, they collaborated with 10–18 brands in the restricted network of 45 brands), and with European and US influencers who had lower degree centrality (they collaborated with 5–10 brands in the restricted network of 45 brands).

E-cigarette brands with mid-range degree centrality collaborated with the European influencers who were distinct from those working with the most central brands

Thirty-three e-cigarette brands (table 2)—manufacturers, distributors and retailers from China, the USA, and the UK—had mid-range degree centrality (collaborating with 6–10 influencers) or low degree centrality (collaborating with five influencers). Brands with mid-range degree centrality hired predominantly the same US and Asian influencers as did the most central e-cigarette brands but had distinct European influencers who did not collaborate with the most central brands

E-cigarette brands and influencers with the low degree centrality appeared to be relatively disconnected

Peripheral brands with low degree centrality, located away from the centre (figure 2), were more 'contained' in their niche market rarely sharing influencers. These e-cigarette brands partnered with US and European influencers with relatively small degree centrality (collaborating with 1–5 e-cigarette brands in the restricted network of 45 brands). These brands also collaborated

Table 2 Characteristics of e-cigarette brands (N=640) by the number of influencers they collaborated with, the influencers' user engagement and the number of the influencers' followers on Instagram in 2020

Geolocation of influencers	Average number of influencers per brand	Average number of influencers' followers/SD/range			Average number of influencers' followers <18 years old (% of total average followers)/SD/range			Average influencers' engagement rate*
		Followers	SD	Range	Followers	SD	Range	
12 most central e-cigarette brands that collaborated with more than 10 (up to 27) influencers: Voopotech, Innokin, Geekvape, Lostvape, Smok, Vaporesso, Asvape, Oxva.tech, Freemax, Wotofo, Augvape, Upends								
USA	6	100 793	67 651	32 833–153 325	3930 (4%)	3033	1274–6881	3.18
Asia	5	91 160	56 892	4421–146 721	4778 (5%)	3290	1645–7076	10
Europe	5	23 241	13 911	8708–43 387	267 (1%)/	253	106–601	3.60
33 mid-tier and peripheral e-cigarette brands that collaborated with 5–10 influencers: Hellvape, Nasty Juice, Smoant, Aspire, Dotmod, Uwell, Mione, Thevapx, Heaven Gifts, Dovpo, Vapefly, Rincoe, Ruthless Ejuice, Moti, Famovape, Hotcig, Joytech, Maskking, Popvapor, Suorin, Twisteliquids, Univapo, Vafflecom, Vape Dinner Lady, Vape Uno, Vapelustion, Loaded Juice, Nevoks, Riot Squad Eliquids, Solacevapor, Teslacig, Vaportech, Vaptio								
USA	2	88 021	67 751	6187–221 400	3238 (4%)	3107	0–6714	2.79
Asia	3.5	102 546	40 418	40 650–140 868	5074 (5%)	3271	1494–8280	7.41
Europe	3	27 297	14 991	9899–50 161	360 (1%)	266	0–1003	3.38
595 e-cigarette brands† that collaborated with 1–4 influencers:								
USA	0.4	73 738	62 607	6187–221 400	2697 (4%)	3107	0–8856	3.85
Asia	1.2	75 466	68 166	3140–173 000	2973 (4%)	3943	0–10 380	9.33
Europe	0.8	18 446	16 805	2553–58 900	194 (1%)	269	0–1003	4

Brazil and South Africa were excluded from the table, because only two influencers were from these countries.
*The engagement rate represents a 6-month average engagement rate per post, which is calculated as a sum of the number of likes and the number of comments divided by the number of followers.
†The list of the 595 brand names that were not included in the social network analysis (figure 2) and that collaborated with one to four influencers is available in the online supplemental appendix.

slightly less frequently with Asian influencers compared with the more central brands.

Descriptive and inferential statistics

Influencers' followers and engagement

The number of influencers with whom the brands collaborated appeared to be very right skewed. Twelve brands collaborated with more than 10 and up to 27 influencers, 33 brands collaborated with 5–10 influencers, and most of the brands (n=595 brands) collaborated with 1–4 (table 2).

Across all categories (table 2), on average, Asian and US influencers had about five times more followers overall and about six times more under 18-year-old followers compared with European influencers ($p<0.05$). The e-cigarette content posted by Asian influencers was about three times more engaging than e-cigarette content posted by US and European influencers ($p<0.05$).

Influencers' profiles

All the influencers included in our analysis typically described themselves in their Instagram profiles as 'public figure', 'brand ambassador', 'promoter', 'video creator', 'artist', 'photographer', 'blogger', 'model' or 'fitness lover'. The word 'influencer' was rarely used (only by two influencers). Gender representation was almost equally split between male and female: 50% of them (27) were female. Sixty per cent of the influencers mentioned e-cigarette brands they collaborated with on their Instagram profiles, included descriptions such as 'promotion', 'sponsored', 'endorsements', 'collaboration', or provided their contact phone or email for business inquiries. Influencers with the highest degree centrality had on average 103 000 followers (SD=74 100, range=2100–221 400). This was three times the number of followers of the influencers with mid-range and lower degree centrality ($p<0.05$). On average, 4% of the most central influencers' followers were 13–17 years old, which was three times the number of teenage followers (1%) of the less central influencers.

Sponsorship disclosures

Only 5% of the influencers' posts had sponsorship disclosures[19] fully compliant with the FTC requirements, that is, positioned at the very top of a caption or had a description of the type of collaboration, for example, 'a product provided by X brand in exchange for Y service'.

Variety of content posted by e-cigarette influencers

Twenty percent of the influencers (11 out of 55) posted exclusively e-cigarette-related promotional content, while the majority—80% (44)—had other promotional topics featured in their posts besides e-cigarettes, including cannabis (CBD) products, fashion, nicotine chewing gums or pouches, and beauty products (figure 3). Still, most of the posts (N=9280) of almost all the influencers were-e-cigarette related (online supplemental figure 2).

We found that more than 60% of the e-cigarette brands (n=45) had no age-gating restrictions for followers, although about 40% stated that their posts were only for age-appropriate (18+ or 21+) users. Similarly, 41 out of 55 (75%) of the influencers had no age-restricting notifications. Our 20-year-old and 17-year-old coders were able to follow over 60% of the brands and all the influencers.

DISCUSSION

Despite FDA's actions against any e-cigarette ads targeting youth[6 20 21 40] and the Instagram ban on sponsored e-cigarette content,[18 19] in 2020 influencers were still collaborating with e-cigarette companies and promoting specific brand-related content on the youth-popular social media site, Instagram. This cross-sectional study analysed Instagram user profiles of 55

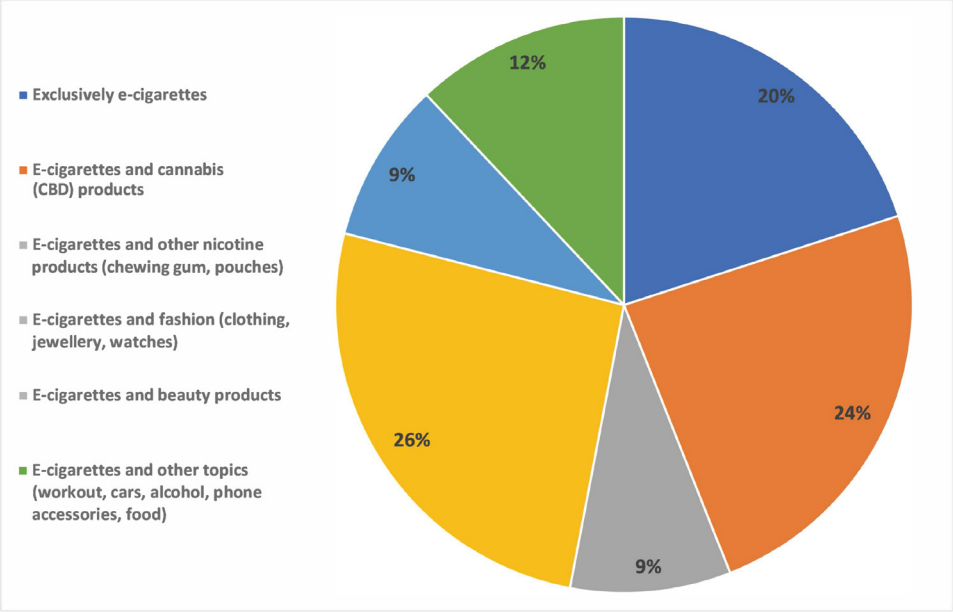

Figure 3 Proportion of the influencers (n=55) who posted exclusively about e-cigarettes (n=11 or 20%) compared with the influencers (n=44 or 80%) who posted about e-cigarettes and other topics on Instagram in 2020.

engaging influencers with at least 1000 followers and characterised their connections with over 600 e-cigarette brands to promote e-cigarette-related content.

The social network analysis in this study provided a methodology that may be relevant for tobacco control policy regulators such as the FDA to identify the connections among e-cigarette companies that use brand ambassadors and influencers to post youth-appealing content. By applying the social network method, we discovered a highly dense and intertwined brand–influencer network. E-cigarette brands often hire the same influencers from all over the world, primarily from the USA, Indonesia, Germany, France and Malaysia. International borders on social media are absent. E-cigarette international content could reach US audiences, since influencers from different countries comment on and 'like' each other's Instagram posts, potentially exposing their followers to broader e-cigarette promotional materials.

The social network analysis also allowed us to distinguish the network of influencers used by the most central versus less central e-cigarette brands. The most central brands are large China-based manufacturers and worldwide distributors of a variety of e-cigarette products, including flavoured disposable devices. In 2020, they collaborated with up to 27 US and international influencers (especially Indonesian and Malaysian) with a large number of followers. Less central brands appeared to be smaller manufacturers, distributors and retailers that concentrated more on their respective local markets (US, Asian or European).

The study described the potential reach of the influencers based on their engagement, followers and geolocation. Asian influencers had the highest engagement rate compared with US and European influencers. Both US and Asian influencers had a follower base averaging 90 000, with about 5% of those under 18 years. European influencers had smaller number of followers and smaller under 18-year-old audiences of about 1%. It is an empirical question for further study to explain the association between the e-cigarette influencers' geolocation, their engagement rate and the number of their followers. It is possible that the absence of policy restrictions on e-cigarette use in Indonesia and Malaysia allows social media e-cigarette influencers in these countries to actively engage with their audiences and have higher reach among youth. In contrast, the smaller number of teenage followers of European influencers could be attributed to more frequent use of Instagram's 18+ age restriction tool, compared with US and Asian influencers, or European Union (EU) policies (eg, EU Tobacco Products Directive and the Tobacco and Related Products Regulations).[41 42]

Our study also showed that regardless of the region (USA, Asia or Europe), the influencers' e-cigarette promotional posts were rarely fully compliant with the FTC-required sponsorship disclosures.[35 36] Also, very few e-cigarette brands and influencers used the age-gating feature on Instagram (restricting youth access), despite stating on their Instagram profiles that their content is for the 18+ or 21+ audience. Moreover, Instagram seems not to diligently adhere to its own age-gating policy, since teenage users can easily provide a fake age over 21 years. Prior research suggests that youth regularly enter fake ages to obtain access to platforms and content.[43 44] Because of this loophole, the number of under 18-year-old followers reported in this study may be underestimated.

Finally, influencers often collaborate with multiple industries (eg, fashion, beauty products, healthy lifestyle) in addition to e-cigarette brands. These influencers could potentially expose their non-e-cigarette-focused audience (including non-users of e-cigarettes) to e-cigarette content. Thus, these influencers could be considered an even higher risk for youth compared with those who post exclusively about e-cigarettes. That is especially problematic because most e-cigarette brands claim that their advertising and promotional content is meant to target current cigarette smokers to help them switch to e-cigarettes,[45 46] rather than people who do not use nicotine at all.

The results from this study should provide guidance for future research. A social network analysis of influencers' interactions and users' reactions to their promotional e-cigarette posts on social media would be an important future direction to expand this work and understand diffusion of information about e-cigarette marketing. Another important direction is to characterise variations in influencer marketing strategies and types

of promoted e-cigarette and other tobacco products among different racial/ethnic groups to address disparities in tobacco product exposure on social media.

Limitations

Since accessing the Instagram Application Programming Interface directly became impossible for non-commercial parties after 2016, we used a commercial social media listening platform Meltwater for data collection. Although Meltwater, based on their agreement with Instagram, provides access to a rich dataset of over 10 million influencers with public profiles who post on a variety of topics, the sample from which we selected e-cigarette influencers might have been not truly random.

It is not possible to say with absolute certainty that all posts made by influencers were truly sponsored, since some influencers may also upload content that they were not incentivised to post about. This may overstate the number of sponsored posts, as well as complicate enforcement efforts.[47]

We only conducted a descriptive analysis and looked at the most frequently used measure in social network analysis, degree centrality. We did not assess the effect of exposure to promotional content on followers or product users.

Finally, we only reviewed the posts' accounts and captions written in English. Translating and analysing captions to e-cigarette promotional posts in other languages could be a direction for future research.

CONCLUSIONS

Instagram is home to many social influencers with widespread audiences, including youth, high levels of engagement and a highly interconnected, dense social network. The influencers often post promotional images and videos of e-cigarette products without disclosing their incentive arrangements with e-cigarette brands. This type of marketing deserves closer research and policy attention to reduce tobacco product influence, especially among youth. Even if policies were to enforce disclosure requirements more strongly, youth and non-users of e-cigarettes could still be exposed to non-compliant content posted by influencers from other countries. Similarly, when e-cigarette influencers from different countries react to (comment on or 'like') each other's posts, they potentially expose their respective audiences to each other's promotional content. Social media influencer marketing is no longer dominated by mega-influencers with millions of followers, but is powered by an interconnected global network of micro-influencers[48 49] (with 1000–100 000 followers) who collaborate with multiple industries and multiple brands, including tobacco. Large e-cigarette brands also have a global network of smaller distributors and retailers whose products are promoted by influencers. While it may be difficult for public health officials to regulate this interconnected global network, improved monitoring of how social media sites implement and enforce their own restrictions on tobacco-related content may help overcome this hurdle.

What this paper adds

- ⇒ Exposure to influencer marketing and other promotional strategies related to e-cigarette content on social media has been associated with increased risk of e-cigarette use among adolescents and young adults.
- ⇒ Despite the US Federal Food and Drug Administration (FDA) actions against any e-cigarette ads targeting teenagers and the Instagram ban on e-cigarette-branded content, youth-appealing promotional posts are still present on this platform.
- ⇒ Influencer marketing on social media has not been studied extensively. This study is the first to analyse the network of e-cigarette brand–influencers on Instagram, providing a global view of potential collaboration among US and international influencers.
- ⇒ We discovered a highly interconnected network of engaging e-cigarette influencers (n=55) worldwide who collaborated with over 600 e-cigarette brands in 2020. Most of the influencers we reviewed did not restrict youth access to their promotional content on Instagram.
- ⇒ The US and Asian influencers had a follower base averaging 90 000, with about 5% of those under 18 years, which is sizeable considering the large number of followers.

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Acknowledgements The authors acknowledge the contribution of the undergraduate students Sofia Santoro, Jacqueline Usibelli, Ashley Smith, Ali Zafar-Khan and Ana Alexandra Natividad, Department of Population and Public Health Sciences, University of Southern California (USC), for their assistance with coding of the influencers' posts and documenting e-cigarette brand names mentioned in the posts. The authors acknowledge that figure 1 contains a publicly available Instagram image of an influencer with a public Instagram account.

Contributors JV conceived the paper and wrote the first draft of the manuscript. All coauthors provided feedback on the first draft and substantial writing to the final version of the paper. All coauthors approved the final version. JV acts as a guarantor.

Funding Research reported in this publication was supported by the National Cancer Institute and the Food and Drug Administration Centre for Tobacco Products (CTP) (grant # U54 CA180905, U54CA228110), the National Institute of Health (grant # 1R01CA260459-01), the National Centre for Advancing Translational Sciences (grant # UL1TR002001), and the Centre for Coordination of Analytics, Science, Enhancement and Logistics (CASEL) in Tobacco Regulatory Science (grant # U54DA046060-01).

Disclaimer The funders had no role in study design; collection, analysis, and interpretation of data; writing the report; and the decision to submit the report for publication. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funders.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This research was approved by the Institutional Review Board (IRB) of the University of Southern California (USC): UP-21-00352.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation and in compliance with the IRB protocol, to any qualified researcher.

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REFERENCES

1 Wang TW, Neff LJ, Park-Lee E, *et al*. E-cigarette Use Among Middle and High School Students - United States, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1310–2.
2 Fauzi R, Areesantichai C. Factors associated with electronic cigarettes use among adolescents in Jakarta, Indonesia. *Journal of Health Research* 2020.

3 Kapan A, Stefanac S, Sandner I, *et al*. Use of electronic cigarettes in European populations: a narrative review. *Int J Environ Res Public Health* 2020;17:1971.
4 Fraga JA. The dangers of Juuling, 2018. National center for health research. Available: http://www.center4research.org/the-dangers-of-juuling/ [Accessed 12 Jan 2020].
5 Gentzke AS, Creamer M, Cullen KA, *et al*. Vital Signs: Tobacco Product Use Among Middle and High School Students - United States, 2011-2018. *MMWR Morb Mortal Wkly Rep* 2019;68:157–64.
6 FDA. Fda finalizes enforcement policy on unauthorized flavored cartridge-based e-cigarettes that appeal to children, including fruit and mint, 2020. Available: https://www.fda.gov/news-events/press-announcements/fda-finalizes-enforcement-policy-unauthorized-flavored-cartridge-based-e-cigarettes-appeal-children [Accessed 03 Jan 2021].
7 Statement from FDA Commissioner Scott Gottlieb, FDA. MD., on proposed new steps to protect youth by preventing access to flavored tobacco products and banning menthol in cigarettes, 2019. Available: http://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-proposed-new-steps-protect-youth-preventing-access [Accessed 14 Jan 2020].
8 King AC, Smith LJ, Fridberg DJ, *et al*. Exposure to electronic nicotine delivery systems (ends) visual imagery increases smoking urge and desire. *Psychol Addict Behav* 2016;30:106–12.
9 Maloney EK, Cappella JN. Does Vaping in e-cigarette advertisements affect tobacco smoking urge, intentions, and perceptions in daily, intermittent, and former smokers? *Health Commun* 2016;31:129–38.
10 Pokhrel P, Fagan P, Herzog TA, *et al*. Social media e-cigarette exposure and e-cigarette expectancies and use among young adults. *Addict Behav* 2018;78:51–8.
11 Kim M, Popova L, Halpern-Felsher B, *et al*. Effects of e-cigarette advertisements on adolescents' perceptions of cigarettes. *Health Commun* 2019;34:290–7.
12 Vogel EA, Ramo DE, Rubinstein ML, *et al*. Effects of social media on adolescents' willingness and intention to use e-cigarettes: an experimental investigation. *Nicotine Tob Res* 2021;23:694–701.
13 Most used social media, 2021. Statista. Available: https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/ [Accessed 15 Nov 2021].
14 Social media platforms used by marketers, 2021. Statista. Available: https://www.statista.com/statistics/259379/social-media-platforms-used-by-marketers-worldwide/ [Accessed 14 Nov 2021].
15 Definition: what is an Instagram Influencer? Pixlee. Available: https://www.pixlee.com/definitions/definition-instagram-influencer [Accessed 13 Jan 2020].
16 Vassey J, Metayer C, Kennedy C. #Vape: Measuring E-cigarette Influence on Instagram with Deep Learning and Text Analysis. *Front Commun* 2019;4.
17 Why Juul shut down social media accounts on Facebook and Instagram - Business Insider, 2018. Available: https://www.businessinsider.com/why-juul-shut-down-social-media-facebook-instagram-vaping-2018-11 [Accessed 12 Jan 2020].
18 Frier S. Instagram Won't Let Influencers Promote Vaping Products, 2019. Available: https://finance.yahoo.com/news/instagram-won-t-let-influencers-173038853.html?guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAC4v8_j0cSPlXfc6nEVfFEJrq2nZRXKaSvPk0HRBty8_pp5Fs5yHcW3n68I2a0XuSeYSaIbcpfGM4pUh8muysmZPf6HHxhTTXap-CeBK2aMUaQCbqTGnyfsva_p2-rn-mKNzwpoKnXNgO-s2R2UjSv6UFILUXDE0OrHVWtkhFNAu&guccounter=2 [Accessed 12 Jan 2020].
19 Facebook business help center. Branded content policies. Available: https://www.facebook.com/business/help/221149188908254 [Accessed 20 May 2020].
20 FDA. launches new FDA comprehensive campaign to warn kids about the dangers of e-cigarette use as part of agency's Youth Tobacco Prevention Plan, amid evidence of sharply rising use among kids, 2019. Available: http://www.fda.gov/news-events/press-announcements/fda-launches-new-comprehensive-campaign-warn-kids-about-dangers-e-cigarette-use-part-agencys-youth [Accessed 12 Jan 2020].
21 FDA. Fda in brief: FDA requires four e-cigarette brands to provide critical information on social media practices, 2021. Available: https://www.fda.gov/news-events/fda-brief/fda-brief-fda-requires-four-e-cigarette-brands-provide-critical-information-social-media-practices [Accessed 04 Apr 2021].
22 Navarro MA, O'Brien EK, Ganz O, *et al*. Influencer prevalence and role on cigar brand Instagram Pages. *Tob Control* 2021;30:e33–6.
23 Vogel EA, Guillory J, Ling PM. Sponsorship disclosures and perceptions of e-cigarette Instagram posts. *Tob Regul Sci* 2020;6:355–68.
24 Childers CC, Lemon LL, Hoy MG. #Sponsored #Ad: Agency Perspective on Influencer Marketing Campaigns. *Journal of Current Issues & Research in Advertising* 2019;40:258–74.
25 Laestadius LI, Penndorf KE, Seidl M, *et al*. Assessing the appeal of Instagram electronic cigarette refill liquid promotions and warnings among young adults: mixed methods focus group study. *J Med Internet Res* 2019;21:e15441.
26 Valente TW. Social networks and health: models, methods, and applications. Oxford university press. Available: https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780195301014.001.0001/acprof-9780195301014 [Accessed 17 May 2021].
27 Valente TW, Pitts SR. An appraisal of social network theory and analysis as applied to public health: challenges and opportunities. *Annu Rev Public Health* 2017;38:103–18.
28 Himelboim I, Golan GJ. A social networks approach to viral advertising: the role of primary, contextual, and low Influencers. *Soc Media Soc* 2019;5:205630511984751.
29 Disney A. Social network analysis: understanding centrality measures Cambridge intelligence, 2020. Available: https://cambridge-intelligence.com/keylines-faqs-social-network-analysis/ [Accessed 01 Nov 2021].
30 Landherr A, Friedl B, Heidemann J. A critical review of centrality measures in social networks. *Bus Inf Syst Eng* 2010;2:371–85.
31 Social Influencers. meltwater. Available: https://www.meltwater.com/social-influencers/ [Accessed 26 Jun 2020].
32 Maheshwari S. Are you ready for the Nanoinfluencers? 2018. The new York times. Available: https://www.nytimes.com/2018/11/11/business/media/nanoinfluencers-instagram-influencers.html [Accessed 09 Feb 2021].
33 Cotter K. Playing the visibility game: how digital influencers and algorithms negotiate influence on Instagram. *New Media Soc* 2019;21:895–913.
34 Geyser W. The state of Influencer marketing 2020: benchmark report, 2020. Influencer marketing hub. Available: https://influencermarketinghub.com/influencer-marketing-benchmark-report-2020/ [Accessed 08 Aug 2021].
35 The FTC Releases New Guidelines (And Its First Creator-Friendly Brochure) for Influencers Who Post Sponsored Content - Tubefilter, 2019. Available: https://www.tubefilter.com/2019/11/06/the-ftc-releases-new-guidelines-and-its-first-creator-friendly-brochure-for-influencers-who-post-sponsored-content/ [Accessed 20 May 2020].
36 Federal Trade Commission. Ftc releases advertising disclosures guidance for online Infl, 2019. Available: https://www.ftc.gov/news-events/press-releases/2019/11/ftc-releases-advertising-disclosures-guidance-online-influencers [Accessed 12 Jan 2020].
37 Freeman LC. Centrality in social networks conceptual clarification. *Soc Networks* 1978;1:215–39.
38 Borgatti SP, Chair C. 2-Mode concepts in social network analysis, 2007. Available: http://www.analytictech.com/borgatti/papers/2modeconcepts.pdf
39 Latapy M, Magnien C, Vecchio ND. Basic notions for the analysis of large two-mode networks. *Soc Networks* 2008;30:31–48.
40 FDA. Fda Notifies companies, including puff bar, to remove flavored disposable e-cigarettes and Youth-Appealing E-Liquids from market for not having required authorization, 2020. Available: https://www.fda.gov/news-events/press-announcements/fda-notifies-companies-including-puff-bar-remove-flavored-disposable-e-cigarettes-and-youth [Accessed 03 Jan 2021].
41 Asa ruling on British American tobacco UK LTD. Available: https://www.asa.org.uk/rulings/british-american-tobacco-uk-ltd-G19-1018310.html [Accessed 08 Aug 2021].
42 Article 20(5), tobacco products directive: restrictions on advertising electronic cigarettes. GOV.UK, 2020. Available: https://www.gov.uk/government/publications/proposals-for-uk-law-on-the-advertising-of-e-cigarettes/publishing-20-may-not-yet-complete [Accessed 14 Nov 2021].
43 O'Neill B. Who cares? practical ethics and the problem of underage users on social networking sites. *Ethics Inf Technol* 2013;15:253–62.
44 Boyd D, Hargittai E, Schultz J. Why parents help their children lie to Facebook about age: Unintended consequences of the 'Children's Online Privacy Protection Act&rsquo. *First Monday* 2011;16.
45 Prakash S, Xu Y, Goldenson NI, *et al*. Transitions in smoking among adults newly purchasing the JUUL system. *Am J Health Behav* 2021;45:546–62.
46 Dewhirst T. Co-optation of harm reduction by big tobacco. *Tob Control* 2021;30:e1–3.
47 Laestadius LI, Wahl MM, Vassey J, *et al*. Compliance with FDA nicotine warning statement provisions in E-liquid promotion posts on Instagram. *Nicotine Tob Res* 2020;22:1823–30.
48 Guo M, Ganz O, Cruse B, *et al*. Keeping it fresh with Hip-Hop teens: promising targeting strategies for delivering public health messages to hard-to-reach Audiences. *Health Promot Pract* 2020;21:61S–71.
49 Appel G, Grewal L, Hadi R, *et al*. The future of social media in marketing. *J Acad Mark Sci* 2020;48:79–95.