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JUUL: Spreading Online and Offline

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A B S T R A C T

Purpose: The increasing popularity of the JUUL electronic nicotine delivery system among youth poses several potential public health concerns. Social media can be used to better understand the spread of information related to JUUL. This study examined whether adolescents (age < 18) are following JUUL's official Twitter account and subsequently sharing (retweeting) JUUL's posts to their followers. We also assessed various patterns in which adolescents share information on JUUL with each other.
Methods: We collected 3,239 tweets from JUUL's official Twitter account (@JUULVapor) for one full year from February 2017 to January 2018. These tweets were shared by Twitter users to their followers 1,124 times by 721 unique users. Users were determined to be either adolescent (age <18) or adult (≥18) based on a systematic procedure involving double coding. We used social network analysis to explore the relationships between users retweeting JUUL.
Results: One-quarter (25%) of users were determined to be adolescents. Social network analysis revealed a maximum path length of 4 and a positive assortativity ($r = .29$). There were 25 (9%) instances of an adolescent retweeting content from another adolescent, 35 (12%) of an adolescent retweeting from an adult, and 30 (11%) of an adult retweeting from an adolescent.
Conclusions: JUUL's official Twitter account is being followed—and its messages are being shared—by adolescents. Rigorous policies and prevention programs are needed to curb adolescent exposure to JUUL content and discussions online.

IMPLICATIONS AND CONTRIBUTION

Electronic cigarette use by adolescents is a public health concern. This study provides evidence that adolescents follow market leader JUUL on Twitter and that those followers spread JUUL's messages to broader social networks that also contain adolescents. Policies and prevention messages are needed to reduce youth exposure to promotional messaging around electronic cigarettes.

Electronic cigarette (e-cig) use is growing rapidly among American youth, posing several public health concerns [1]. The Surgeon General has identified risks from harmful ingredients, the negation of gains made against conventional cigarette smoking, the need to protect America's youth as reasons to prevent youth from using e-cigs [2]. Recent studies have found significant levels of chemical toxicants in the urine of adolescent e-cig users [3] and demonstrated that acute exposure to nicotine impacts brain development during adolescence [4]. This is particularly concerning, as many e-cigs—particularly JUUL—can produce more nicotine than conventional cigarettes [5,6]. There is also strong and consistent evidence of an association between initial e-cig use and subsequent initiation of cigarette smoking [7–9] and marijuana use [10].

JUUL is currently the fastest growing e-cig company in the United States; its rapid spread has allowed the company to capture 32% of the e-cig market and become the brand leader [11,12]. Use of the device is often referred to as "juuling" and its flavor cartridges are called "pods" [13]. The prevalence of JUUL use among youth might have been under-reported in recent years because

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national surveys were not using the term "JUUL" in their questions, and youth might not realize that JUUL is included in the broader category of e-cigs [6]. JUUL has a design that resembles a USB flash drive—including the ability to be charged when plugged into a laptop. Researchers have identified social media forums that provide underage users with advice on how to obtain JUUL products and offer strategies for concealing them [14]. Many news stories and social media posts report JUUL's frequent use in elementary, middle, and high schools [15,16]. Analysis of JUUL posts on Twitter has found that messages demonstrate use by adolescents, including mentions of school sites and concealment strategies as well as flavors appealing to youth such as mint, cucumber, and mango [14,16].

Exposure to e-cig marketing, including traditional and online channels, has been shown to increase the risk of ever use of e-cigs among adolescents [17,18], possibly due to content that is attractive to youth [19]. Given the near ubiquitous use of social media by adolescents [20], platforms such as Twitter have been leveraged to study e-cig use and marketing [21,22]. Researchers in adolescent and young adult health have advocated for more studies harnessing social media, which can provide a rich and diverse source of data [23]. Large numbers of adolescents are exposed to e-cig marketing on social media [24,25], increasing the risk of subsequent tobacco use [26]. Moreover, sharing e-cig messages with friends on Twitter can lead to an exponentially higher number of recipients [22]. Previous research has found that Twitter posts (tweets) rapidly diffuse, and that users do not have to follow e-cig companies' official Twitter accounts to be exposed to their content [22]. This is particularly alarming if e-cig content reaches adolescents as they tend to frequently share and trust information from others close in age [27]. However, little is known about characteristics of adolescents' online communication networks around the topic of e-cigs. For example, do these messages tend to circulate within homogenous adolescent groups or do messages permeate among heterogeneous groups (e.g., transmission from older adults)?

To our knowledge, prior work has not systematically characterized communication related to JUUL among adolescents. Therefore, the purpose of this study was to use social network analysis (SNA) and qualitative analysis to assess (1) whether adolescents (age $<$ 18) are following JUUL's official Twitter account; (2) to what extent adolescents subsequently share JUUL's posts to their followers; and (3) in what patterns adolescents and adults share information on JUUL with each other.

Methods

Data

We collected all tweets from JUUL's official Twitter account (@JUULVapor) from February 2017 to January 2018 using Twitter's free Search Application Programming Interface (n = 3,239). These tweets were retweeted 1,124 times by 721 unique users.

Coding Procedures

Trained human coders examined each of the 721 users' Twitter profiles and coded them on our primary variable, which was whether the profile was maintained by someone who was an adolescent versus an adult. While tobacco use in some states is legal at age 21, we selected 18 to be more conservative. Age-defining criteria for adolescents included any mention of a specific age (e.g., "I'm excited about my upcoming sweet 16") [28], images of age-specific events (e.g., pictures of high school sporting event), username that includes a possible birth year (e.g., JohnSmith2005), "liking" friends' tweets that reference specific ages [28], and personal descriptions that mentions age-related event (e.g., "Currently a Smith High School student.") [29]. It is important to note that coders considered each profile holistically rather than depend on a single criterion. To be consistent with our conservative approach, any ambiguous profile was coded as an adult.

Coders assessed whether the profile was maintained by an actual individual human being or whether it was from a commercial source (e.g., company account, spam account, institutional account, or automated Twitter account). Commercial accounts were not coded for age.

Each category was double-coded by two trained coders working independently. Coders examined each of the following characteristics of the profile in order to make determinations: (1) profile picture; (2) Twitter handle; (3) personal biography/description; (4) posted media (e.g., pictures or videos), (5) posted messages; and (6) likes/favorites, which are tweets posted by other users that were marked as personal favorites. Interrater reliability (assessed using Cohen's κ) [30] was high for human/commercial status (κ = .85) and moderate (κ = .53, 75% agreement) for age. Because of the subjective nature in assessing age, all 721 profiles were double coded. All disagreements were adjudicated between the coders, with final decisions made by the lead author. This study was approved by the Institutional Review Board at the lead author's university.

Analyses

We first computed the proportion of adolescents and adults that retweeted JUUL. We further broke down those groups by whether or not the users followed the JUUL account. We then constructed a network to explore the interconnections between users retweeting JUUL's tweets. Path lengths between nodes were calculated to describe the potential reach of information [31]. To help understand the nature of JUUL's retweets, we calculated the level of homophily in the JUUL retweet network. Homophily theory suggests that there is the tendency for a person to form relationships with similar others, often described as "birds of a feather flock together" [32]. Measuring homophily in a Twitter network can help us determine if adolescents are frequently retweeting other adolescents. The measure of assortativity r describes the level of homophily in a network [33], where -1 is where people only make connections with others that have opposite traits, 0 describes random connections, and 1 is where everyone only makes connections with others like themselves. The R package iGraph [34] was used to perform network calculations. The Gephi software package was used to generate a network graph to help visualize the JUUL social network and explore the relationships between JUUL and its followers.

Because our kappa value for age was only moderate after the first set of assessments, we conducted a sensitivity analysis to address the potential bias of age classification. Our primary analyses included all data, both with user agreement as well as adjudication. However, sensitivity analyses included only data for which coders agreed on their initial assessments. This analysis, therefore, did not include data for which there was any disagreement regarding age. While primary and secondary

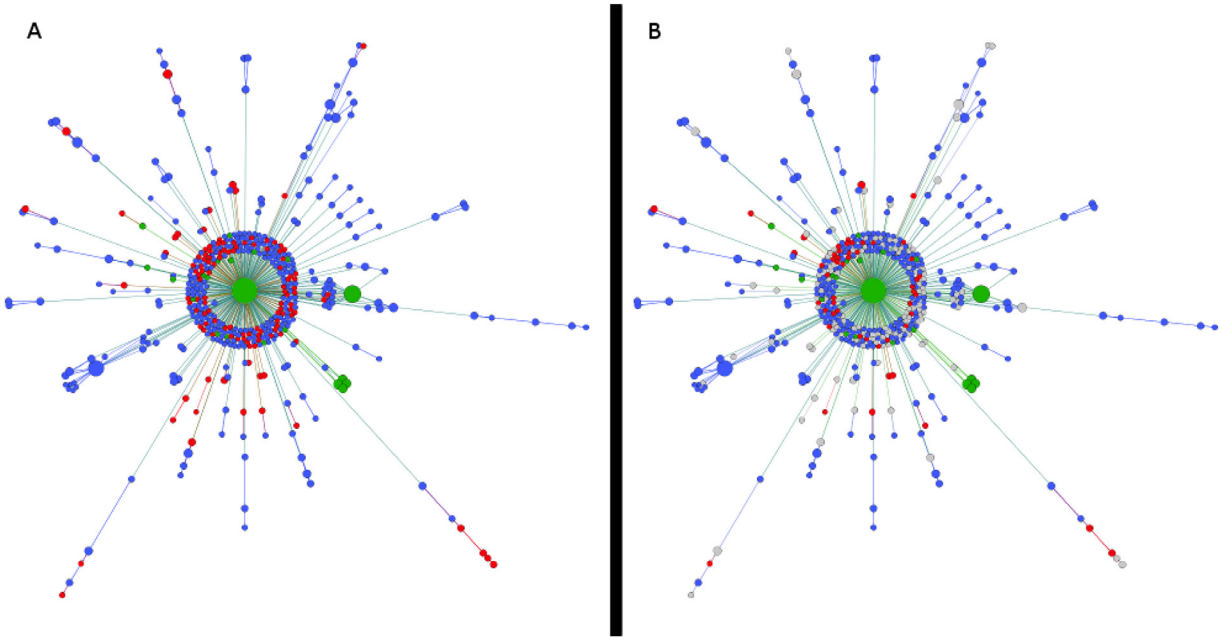

Fig. 1. JUUL retweet network. Each node (circle) represents someone who retweeted JUUL and each edge (line) represents a follow-and-retweet relationship between two people. The two images are differentiated based on the sensitivity analysis. Red are <18, blue are ≥18, and green are commercial. The left image (A) is color coded to show the final age value for both 100% agreement and adjudication. The right image (B) shows profiles with disagreements as grey. Node sizes represent the number of connections a given node has (e.g., large nodes have many followers that retweet them). The center node is the JUUL Twitter account, notably large (having many followers that retweet their messages).

analyses were consistent, we present the results of both analyses for comparison.

Results

Figure 1 shows visual representations of the JUUL retweet network. Each node represents a Twitter user, with red nodes indicating underage individuals and blue nodes indicating individuals 18 or over. In Panel A, all individuals are represented as either red or blue, while Panel B shows individuals of initially unclear age as grey nodes. The thick perimeter of nodes directly around JUUL represent individuals who follow JUUL and directly retweeted content posted by JUUL. As nodes appear further from the center, their relationship with JUUL becomes less direct (i.e., followers of followers). JUUL has a maximum reach of 4 degrees.

Table 1 describes JUUL retweeters by age and whether or not the user follows JUUL's official account. Although the majority of human retweeters in each follower category were coded as adults, 25% were coded as adolescents.

The homophily analysis found that there were 25 (9%) instances of an adolescent retweeting content from another adolescent, 35 (12%) of an adolescent retweeting an adult, 30 (11%) of an adult retweeting an adolescent, and 193 (68%) of an adult retweeting an adult. Only human relationships with other humans are included. Based on these dyadic relationships, assortativity *r* was .29.

When we varied the age classification parameter in the sensitivity analysis, the percentage of adolescent accounts ranged from 14% (100% agreement, not including data with disagreement on age) to 25% (combined 100% agreement and adjudication). Complete data from the sensitivity analysis are presented in Table 1.

Discussion

This study suggests that JUUL's official Twitter account is being followed—and its messages are being retweeted—by adolescents. This presents a major public health concern because e-cig marketing exposure increases the adolescent risk of ever use of e-cigs [17,18]. In particular, adolescents exposed to e-cig messages online are more likely to initiate tobacco use later in life [35,36]. Retweet networks are often studied for properties of diffusion [22] or online content going viral [37]. JUUL's retweets extend beyond its immediate followers, reaching Twitter users that are separated from JUUL by up to 4 degrees.

Table 1
Number of adolescent and adult profiles varied by classification parameters

Classification parameter	All profiles, including adjudicated age agreements (n = 681)		100% age agreement (n = 508)	
	<18	≥18	<18	≥18
All coded profiles	171 (25%)	510 (75%)	73 (14%)	435 (86%)
Follower status				
Users that follow JUUL	107 (16%)	267 (39%)	45 (9%)	223 (44%)
Users that do not follow JUUL	64 (9%)	243 (36%)	28 (5%)	212 (42%)

Our research supports previous analyses documenting tobacco marketing on the Internet. It complements other research suggesting that underage use of JUUL is being discussed on social media platforms [14,16]. Such research indicates the need for stronger policies restricting underage access to tobacco brand social media sites, and prevention programs to help curb adolescent exposure to JUUL content and discussions online. For example, Twitter has a gateway feature that can perform age screening, although this is not utilized by JUUL [38]. Twitter's policies also ban the promotion of tobacco brands—including e-cigs—globally [39]. Developing policies for online age screening as well as enforcing existing policies can help to curb adolescent exposure to JUUL content and discussions online.

The homophily analysis found a positive assortativity ($r = .29$), suggesting that adolescents are often following other adolescents and retweeting shared content. For interpretation, .29 is comparable to the "closeness" between directors in business organizations [40]. Though the majority of retweets were adults retweeting other adults, a number of retweets involved youth, either as the source, i.e., they retweeted a JUUL post that was retweeted again (19%), the retweeter (21%), or both (9%). These results demonstrate that when an e-cig message from JUUL reaches adolescents, it will be shared with their networks consisting of many additional adolescents. Further research is needed to understand these communication dynamics and to identify potential opportunities for interventions or education. For example, public health practitioners can leverage the homophilous nature of JUUL's social network to target clusters of adolescents when responding to potentially misleading tweets. Other SNA-focused methods can be applied to understand the unique characteristics between different clusters of pro-e-cig adolescents.

The primary limitation of this study was that assessment of the age of a Twitter user can be challenging. We did use two techniques to minimize this concern. First, we developed a systematic protocol to assess age. Second, we present results of a sensitivity analysis greying out all accounts for which there was any initial disagreement. Results from this analysis were similar to primary results suggesting biases were constrained. Additionally, it is important to acknowledge that data collection was restricted to publicly accessible Twitter accounts limiting generalizability to those Twitter users with private accounts.

Despite these limitations, this study highlights a need to address the rapid diffusion of JUUL and other e-cig–related messages to adolescents on social media. Public health practitioners could begin to address this issue from multiple directions, including developing policies that apply Twitter's age-gateway features. Innovative strategies such as leveraging SNA can help to inform the development of prevention programs that are able to quickly and accurately reach the adolescent population.

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