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## Impact of social networks and norms on e-cigarette use among adolescents in Southern California: a prospective cohort study

Sarah Elizabeth Piombo,

Jessica Barrington-Trimis,

Thomas W Valente

Department of Population and Public Health Sciences, University of Southern California Keck School of Medicine, Los Angeles, California, USA

### Abstract

**Objective**—Using social network analysis, we assessed the mechanisms of social influence that promote e-cigarette use in adolescent networks.

**Methods**—Data on health behaviours and friendship networks from a cohort of 10 high schools in Southern California (N=1599) were collected in grade 9 Spring 2021 (W1), grade 10 Fall 2021 (W2) and Spring 2022 (W3). Two mixed effects logistic regression models were estimated (full sample and subsample of non-vapers only) to evaluate the associations of W1 and W2 pro-vaping norms, peer e-cigarette use exposure and prior e-cigarette use (full sample) on past 6-month vaping at W3, adjusting for demographic covariates and school clustering.

**Results**—Previous vaping was the strongest predictor of past 6-month vaping at W3 among the full sample. Greater exposure to friend e-cigarette use at W2 (adjusted OR (AOR)=12.2, 95% CI 4.04 to 36.5) and greater pro-vaping norms at W2 (AOR=2.63, 95% CI 1.24 to 5.55) were significantly and positively associated with increased odds of initiating e-cigarette use at W3 among students with no lifetime e-cigarette use.

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**Correspondence to:** Sarah Elizabeth Piombo; [piombo@usc.edu](mailto:piombo@usc.edu), **Twitter** Sarah Elizabeth Piombo @sarah\_piombo.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Ethics approval** This study was approved by the University of Southern California Institutional Review Board (#HS-19-00682-CR002). Participants gave informed consent to participate in the study before taking part.

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**Conclusion**—Peer network exposure and pro-vaping norms are significant predictors of vaping initiation even when network vaping prevalence is low.

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## INTRODUCTION

### E-cigarette use

E-cigarette use (eg, vaping) has rapidly increased and gained popularity among youth and is now the most commonly used nicotine product among adolescents.<sup>1</sup> In the USA, 14.1% of high school students and 3.3% of middle school students reported using e-cigarettes in the past 30 days in 2022.<sup>2</sup> Mounting evidence that e-cigarette use is associated with combustible cigarette use and other negative health outcomes have led to increased concern about the popularity of e-cigarette use among youth.<sup>3 4</sup> Trends suggest that youths have more positive norms regarding e-cigarettes compared with combustible cigarettes and report greater peer approval of e-cigarettes.<sup>5</sup> However, reducing adolescent vaping through behaviour change interventions can be challenging due to the complex influences of inter-personal and intra-personal factors.

### Social networks

Social networks are the relationships or connections between people, organisations or other entities.<sup>6</sup> Social influence occurs through social network interactions, which shape normative behavioural perceptions. For tobacco use, prior social network research has demonstrated a positive association of having friends who smoke with individual combustible cigarette use.<sup>7–22</sup> Adolescence is a developmental period often characterised by experimentation and the desire to fit in, making adolescents susceptible to social influence from friends and peers. If an individual perceives vaping as normative in their network, then the desire to conform with friends creates a unique social pressure, potentially driving e-cigarette initiation and use.

### Social norms

Social norms have been extensively explored across the social sciences from a range of theoretical perspectives. Descriptive norms are the perceptions about the behaviours of individuals in one's network (what people do), whereas injunctive norms are perceptions of approval from one's social network or opinions on what one should or should not do (what people think).<sup>23</sup> Norms are generally disseminated across networks through communication and interaction with others and are implicit to group membership.<sup>24</sup> Therefore, understanding social network dynamics is essential to understanding the influence of social norms on behaviour.

Past studies have demonstrated that perceptions of friends' behaviour compared with friends' self-reported behaviour are often not in alignment.<sup>12 25 26</sup> In a nationwide survey of 6th to 12th grade students in the USA, 85% of students perceived that most students in their grade typically use tobacco, while only 21% of students reported having ever used tobacco.<sup>27</sup> These misperceptions surrounding peer norms can lead to the belief that certain behaviours, such as tobacco or e-cigarette use, are more common than they actually are, which leads to artificially high perceptions about network prevalence. Compared with

friends' self-reported behaviour, perceived friend norms have significantly greater influence on individual behaviour.<sup>12 25 28</sup> This can be problematic because adolescents may base decisions about e-cigarette use on inaccurate perceptions about their peers in an effort to fit in.

Prior studies have laid the groundwork for the strength of association between perceived norms and individual behaviour,<sup>12 25 26 29</sup> but few studies have examined tobacco use in the context of norms and social networks. Valente *et al*<sup>28</sup> explored the effects of peer influence and peer norms by examining multiple measures of peer influence on combustible tobacco use in a predominantly Hispanic adolescent cohort. Perceptions of friend smoking were significantly and consistently associated with individual smoking. Research has demonstrated that injunctive norms are associated with adult smoking<sup>30</sup> and a recent systematic review and meta-analysis on the longitudinal effects of social norms and smoking found that descriptive norms were significant predictors of smoking initiation among youth.<sup>23</sup> Overall descriptive norms (perceived smoking behaviour) of close friends, parents, siblings and adults were all significantly associated with smoking initiation, with descriptive norms for close friend smoking and sibling smoking having the strongest positive associations with smoking initiation.<sup>23</sup> However, agreement between perceived friend smoking and self-reported friend smoking was low among confirmed smokers, further demonstrating the importance of using peer self-reported data to accurately measure exposure and to quantify the discrepancy between perceived and actual smoking prevalence.

A breadth of studies have explored social networks and combustible tobacco use through a variety of analytic approaches.<sup>7-11 13-16</sup> However, many studies were limited either by sample size because they focused on a single network<sup>31</sup> or duration, often limited to one or two waves of data,<sup>28 32 33</sup> and none of these studies has specifically examined e-cigarette use in this context. Given the rise in popularity of e-cigarettes, perceptions about prevalence and peer use may be stronger, but exposure to friends' vaping behaviour may also be higher. Alternatively, pro-vaping norms and social acceptability of vaping may persist even when exposure to vaping among peers is low. Therefore, it is difficult to discern what social dynamics are more strongly associated with individual use and what factors predict e-cigarette use initiation.

Another limitation in this area of research is that studies frequently operationalise peer behaviour through measures that only capture the participant's perception of their friends' behaviour (ie, asking people to estimate the number of friends that use a substance instead of surveying those friends), which fails to capture the actual behaviour of friends and tends to result in an overestimation of peer use. Using network analysis allows us to compare perceived peer norms to friends' self-reported e-cigarette use, providing a better understanding of network-dependent factors that drive e-cigarette use.

This study uses social network analysis to assess the mechanisms of social influence that drive e-cigarette use by evaluating the differential effects of perceived norms and friend use on individual e-cigarette use. We will explore whether individuals who perceive greater e-cigarette use, and pro-vaping norms are more likely to use e-cigarettes. Furthermore, we

will examine whether pro-vaping norms or peer exposure to vaping has a stronger effect on individual vaping behaviour.

## METHODS

### Participant recruitment

Assessing Developmental Patterns of Vaping, Alcohol, Nicotine, and Cannabis Use and Emotional Well-being is a prospective cohort study on the health behaviours of high school students in the Southern California area.<sup>34</sup> Among the 10 high schools, three are in low income, low resource settings, two are in middle to high-income settings, and the remaining five schools are in middle-income urban settings. The schools all comprise racially and ethnically diverse student populations with school size ranging from 1700 to 2700 students. Two schools participate in the California Tobacco Use Prevention Education (TUPE) programme, one school which has the highest e-cigarette use prevalence in our sample. The TUPE programme is a state-funded programme aimed at reducing youth tobacco use through tobacco-specific, research-validated, education and reinforcement activities, including intervention and cessation programmes for students. Schools must undergo a competitive application process to participate. Data collection began in Fall 2020 with a pilot subset, and then began in Spring 2021 with the full sample. This analysis uses the first three full waves of data from Spring 2021 to Spring 2022 across 10 high schools, each high school is considered one social network. Participants (analytic sample N=1599) were recruited in ninth grade (ages 13–15) at baseline. Written parental consent and student assent were obtained before data collection. Strengthening the Reporting of Observational Studies in Epidemiology study cohort reporting guidelines were used.<sup>35</sup> This study was approved by the University of Southern California Institutional Review Board (#HS-19–00682-CR002).

**Patient and public involvement**—The public was not involved in developing, conducting or reporting the results of this study due to the sensitive nature of the data collected from minors.

### Measures

**Demographic covariates**—Demographic covariates include sex assigned at birth (male, female), Hispanic ethnicity (non-Hispanic, Hispanic), age at baseline and sexual identity (heterosexual, sexual minority (gay, lesbian, bisexual, asexual, queer), questioning or prefer not to disclose). Due to unequal counts in each category, respondents who identified as non-heterosexual were collapsed into one category for analyses with heterosexual as the reference category.

**Estimated e-cigarette use among friends**—Participants were asked to estimate how many of their friends use e-cigarettes: *How many of your five closest friends use electronic cigarettes for vaping nicotine (E-cigs, vaporizer, JUUL, Puff Bar)? (0–5; not sure).*

**Friendship networks**—Friendship networks were assessed by asking participants: *name up to seven<sup>1</sup> of your closest friends in your grade at school in the spaces below. Enter your friends first and last real name, not their nickname.* School rosters were preloaded,

so that names would populate as students began typing. This nomination method has been successfully deployed in several studies, including school-based adolescent studies, and provides valid and reliable network data.<sup>6 28 36 37</sup> Friendship nominations were used to construct social networks for each school, at each study wave. Social networks are represented as directed adjacency matrices, where each cell in the matrix represents a friendship between a given pair of students in the cohort ( $x_{ij}$ ) at that wave (a friendship nomination from student  $i$  to student  $j=1$ , and no friendship/tie= $0$ ).

**Network exposure**—Friends' e-cigarette use was operationalised as network exposure. Personal network exposure is the proportion of people in one's personal network who have adopted a behaviour.<sup>6</sup> Network exposure is a measure of influence in one's social network defined as:

$$E_i = \frac{\sum W_{ij}y_j}{W_{i+}} \quad (1)$$

Where  $W$  is the social network weight matrix and  $y_j$  is a vector of adoption behaviour. To calculate network exposure,  $W_{ij}$  is multiplied by  $y_j$  to get a count of the number of friends who have adopted the behaviour. This value is then divided by the total number friends named to get a proportion or percentage. Network exposure was calculated for each individual based on their outgoing ties and the alter self-report data.

**Perceived pro-vaping norms**—Perceived pro-vaping norms measure an individual's perception of pro-vaping/e-cigarette attitudes and beliefs. The following questions were asked to measure perceptions about network e-cigarette use and attitudes or approval of e-cigarette use: people who are important to me use e-cigarettes; my friends do not mind when other people use e-cigarettes around them; e-cigarettes are more socially acceptable than smoking cigarettes; a lot of people vape e-cigarettes (*do not agree=0, don't know=1, agree=2*). A composite perceived pro-vaping norm score variable was calculated as an average of the four items (see the Confirmatory factor analysis section).

**E-cigarette use**—The outcome of this study was individual past 6-month vaping/e-cigarette use defined as: *any electronic cigarette for vaping nicotine (E-cigs, vaporizer, JUUL, Puff Bar)*, dichotomised as (*use in the past 6 months, no use in the past 6 months*).

## Statistical analysis

**Confirmatory factor analysis (perceived pro-vaping norms)**—Confirmatory factor analysis for the four perceived pro-vaping norm indicators was conducted using the lavaan package for latent variable modelling in R.<sup>38</sup> The four ordinal indicator items were loaded onto a single factor and measurement models were estimated separately for each respective wave. As such, the four items were averaged to create a composite measure of perceived pro-vaping norms for each wave (range 0–2), with higher scores indicating stronger perceived pro-vaping norms. Cronbach's alpha for the pro-vaping norm factor at each wave was lower than desired (wave 1  $\alpha=0.58$ ; wave 2  $\alpha=0.64$ ).

**Logistic regression**—Mixed effect logistic regression using complete cases was used to evaluate the association of wave 1 and 2 perceived pro-vaping norms, peer e-cigarette use exposure, prior wave e-cigarette past 6-month use and demographic covariates with wave 3 past 6-month e-cigarette use (in one model), including random effects for school clustering. An initiation model was run on a subsample of individuals with no lifetime vaping behaviour as of wave 2 to test the association of these factors with vaping initiation during the past 6 months at wave 3. An additional model was also run separately using pooled data from the 10 imputed data sets (online supplemental appendix A; see details below). The model specification is as follows:

$$\log\left(\frac{\Pr(y_{ij} = 1)}{1 - \Pr(y_{ij} = 1)}\right) = \alpha \sum_{k=1}^k \beta_k X_{kij} + y_{t-1ij} + \rho(\text{peer } y_{t-1ij}) + \rho(\text{peer } y_{t-2ij}) + U_j + \varepsilon \quad (2)$$

where  $i$  individuals are nested in  $j$  schools over  $t$  time periods, and  $t=3$ . Where  $y_j$  is the dichotomous individual past 6-month e-cigarette use outcome,  $\alpha$  the intercept,  $\beta_k$  parameter estimates for vectors of  $k$  covariates, which includes demographics and pro-vaping norms ( $X_{ki}$ ),  $y_{t-1ij}$  (prior e-cigarette use behaviour) and  $\rho$  the parameter estimates for the network exposure to peer e-cigarette use at waves 1 and 2. Additionally,  $U_j$  is the random intercept for each school and  $\varepsilon$  is the residual error term.

**Multiple imputation**—In addition to the observed model, an imputed model was run for comparison. Since many individuals had data that was close to complete (ie, missing a single covariate or outcome at one wave), an imputed model was run to maximise use of the collected data and serve as a robustness check. Out of the full sample (N=2912), 1599 had complete data for all three waves and were included in the full model, 1431 individuals had no lifetime e-cigarette use and were included in the initiation model. After independent variable imputation, a sample of 2154 individuals were retained in the imputed model. Missing data were imputed using multiple imputation by chained equations with the MICE package in R.<sup>39</sup> Multilevel imputation, controlling for school clustering, was used to impute data for all independent variables for 10 imputed data sets (ie, vaping behaviour outcomes were not imputed for any wave) (online supplemental appendix A). For pro-vaping norms, an average score was imputed instead of imputing individual items. Network exposure to vaping was imputed as a continuous variable instead of imputing the vaping behaviour of friends. Imputed variable distributions were assessed against observed distributions to evaluate the integrity of the imputations. All analyses were performed using R (V.4.2.3).<sup>40</sup>

## RESULTS

Analytic sample demographics are displayed in table 1. The majority of the study sample was female (58.3%), identified as heterosexual (73.7%) with a large proportion of Hispanic students (44.9%). The average age at baseline was 14.4 years old (SD=0.5). Past 6-month vaping prevalence was 2.4% at baseline and increased to 6.1% at wave 2, and 7.9% at wave 3. Among the full sample, the estimated number of friends that currently use e-cigarettes at wave 3 was 0.53 friends on average, while the actual number of friends who used

e-cigarettes based on their self-reports was 0.36 friends on average (results not shown;  $t=-6.39$ ,  $p<0.001$ ). Among e-cigarette users at wave 3 ( $n=126$ ), the estimated number of friends who use e-cigarettes was 2.4 friends on average, while the actual average based on their self-reports was 0.83 friends using e-cigarettes at wave 3 ( $t=-9.06$ ,  $p<0.001$ ).

The factor loadings and measurement model fit for the confirmatory factor analysis are shown in table 2. Overall, factor loadings were moderate. The comparative fit indices for both waves were  $> 0.95$  and the Tucker Lewis Indices for both waves were  $> 0.90$ . For both waves, a perceived pro-vaping norm score was calculated as an average of the four items (composite score range 0–2), with higher scores, indicating greater agreement with the statements and perceived approval of vaping (wave 1 mean=0.95; wave 2 mean=0.97).

The results for the mixed effects logistic regression for both the full sample and the initiation models are displayed in table 3. In the full sample model, previous 6-month vaping at waves 1 and 2 was both the strongest predictors of past 6-month vaping at wave 3. On average, students who were older at baseline were more likely to report past 6-month vaping. Greater network exposure to friends who vape at the prior wave was significantly associated with past 6-month e-cigarette use in adjusted models (adjusted OR; AOR=2.65; 95% CI 1.02 to 6.89). Perceived pro-vaping norms at wave 2 were also significantly and positively associated with increased odds of past 6-month vaping in adjusted models (AOR=1.81; 95% CI 1.08 to 2.83). An indicator for participation in the TUPE programme was tested, but its inclusion did not change the model results, so it was omitted.

To further test the strength of these relationships, we ran an initiation model, constrained to individuals who had no lifetime use of e-cigarettes at both waves 1 and 2 (table 3). We found that greater network exposure to friend vaping at wave 2 was the strongest predictor of reported past 6-month vaping initiation at wave 3 (AOR=12.2; 95% CI 4.04 to 36.5). Positive perceived pro-vaping norms from the previous wave were also significantly associated with vaping initiation at wave 3 (AOR=2.63; 95% CI 1.24 to 5.55). The imputed model results were consistent with the observed model results, but the strength of the association was greater for perceived pro-vaping norms and weaker for network exposure (see online supplemental appendix table A1).

A network plot of one school is shown in figure 1 to illustrate differences in network structure and vaping prevalence across the three time periods. In this study, trends show increased vaping prevalence throughout the networks over time.

## DISCUSSION

Network exposure to peer e-cigarette use and perceived pro-vaping norms among friends were the strongest factors associated with e-cigarette initiation (among those who had no lifetime use of e-cigarettes by wave 2); these factors were also associated with any past 6-month e-cigarette use in the overall sample, though prior vaping was the strongest factor associated with past 6-month vaping at wave 3. While students who were older at baseline were significantly more likely to report past 6-month e-cigarette use, this finding was not observed in the initiation model. This may indicate that students who

are older than their peers are more likely to have already initiated use before wave 3, which is why they were not eligible to be included in the initiation model. Social networks not only influence individual behaviour through direct contact with network members but also through attitudes, norms and ideas that reinforce behaviours. This study also demonstrates that adolescents tend to significantly overestimate the number of friends who use e-cigarettes and that this difference is especially pronounced among vapers.

Past research provides evidence that people have difficulty accurately assessing the behaviour of others, even if those individuals are close ties in their network. Discrepancies in perceived peer norms and actual peer behaviour could be attributed to several cognitive biases. One phenomenon known as the majority illusion has been demonstrated in past social network research.<sup>41</sup> People often do not have enough information to accurately estimate the prevalence of a behaviour and instead tend to estimate the behaviour of an entire network based on observations in their personal network.<sup>41</sup> When this occurs, people tend to overestimate behaviours in the network based on the behaviour of high degree or 'popular' network members. Since these popular members are more connected and more visible, this can lead to the belief that certain behaviours, such as substance use, are more common, which results in an artificially high perception about the network prevalence.

Another contributor to inaccurately estimating peer behaviour is the false consensus effect, otherwise known as normative fallacy, in which people believe that others behave the same way they do. This results in people projecting their own behaviour onto others, leading substance users to overestimate use among their friends. Work by Henry *et al* has demonstrated this effect in substance use estimates among adolescents' cohorts.<sup>33</sup> Our finding, that on average vapers estimate more friends use e-cigarettes, is consistent with this viewpoint.

Perceptions of peer behaviour is a significant, influential, predictor of individual behaviour. Evidence suggests that peer norm perceptions are often not aligned with reality and that actual e-cigarette use among friends may be much lower than people believe. This discrepancy can be problematic because compared with friends' self-reported behaviour, perceived norms have a stronger association with individual behaviour.<sup>12 25 28</sup> Thus, one's perception of friends' behaviour can be more powerful and influential than the actual behaviour of one's friends. Adolescents may be at further increased risk of vaping due to the high visibility and social acceptability of vaping compared with smoking combustible cigarettes. A recent study by Valente *et al*<sup>37</sup> is one of the first to show peer network exposure effects on e-cigarette use among youth.<sup>37</sup> The findings of the present study are consistent with the effects of network exposure, but our study also includes the effects of peer norms on behaviour, both of which are associated with e-cigarette use initiation.

Both network exposure and perceptions of peer pro-vaping norms increase the odds of recent e-cigarette use among adolescents. This study demonstrates two important findings: even when prevalence of a behaviour in a network is low, exposure effects can have a significant impact on behaviour, and second, inaccurate perceptions of other people's behaviour can also have influential effects. In this study, even though network exposure to peer vaping



was low, many adolescents believe e-cigarette use is common. This illustrates that these perceptions may continue to persist, even in the absence of peer network exposure.

This study included a sample of adolescents from diverse cultural and socioeconomic backgrounds in Southern California. Emerging themes surrounding social network exposure to peer vaping, norms and individual use that could be applicable to adolescents in different settings but may vary depending on laws surrounding e-cigarette sales and use. California prohibits the sale of tobacco products to individuals under the age of 21 and recently enacted a law prohibiting the sale of flavoured tobacco products, including e-cigarettes or flavour enhancers.<sup>42</sup> States or countries with less stringent regulations may observe even greater rates of use and peer exposure among adolescents.

Future research could focus on developing or using validated measures of perceived norms on e-cigarette use. Interventions should focus on changing norms and perceptions about e-cigarette use among adolescents and dispelling the notion that many of their peers use e-cigarettes. Using norms messaging in combination with network intervention strategies could be another approach to curtailing use. Early interventions using peer leaders have shown promising results.<sup>43</sup> The efficacy of a norm-based social network intervention should be evaluated in future studies.

### Strengths and limitations

This study has several strengths and some limitations. Inherent to all longitudinal studies, there may be some bias in which participants are lost to follow-up. Hispanic individuals, and those who identify as heterosexual, were more likely to be lost to follow-up between waves 2 and 3 (see online supplemental appendix table A2). Some students nominated individuals who were not students within their school or could not be identified from roster information yielding those nominations unusable. We could not control for sibling or parent vaping because the survey did not contain questions asking about family e-cigarette use. The peer norms factor is not based on a validated scale, but moderate factor loadings indicate construct validity and the Cronbach's alpha indicates acceptable reliability. The relatively low prevalence of vaping in the networks resulted in wide 95% CIs for estimates of network exposure to vaping in all models.

Strengths of this study include the prospective cohort design, which allows causal inferences to be made about factors driving vaping initiation. The use of sociometric data allows us to compare the veracity of perceived peer norms against the prevalence of vaping in the network which has not been examined in e-cigarette use. Recent studies have demonstrated that regression analyses on social networks have not been shown to overestimate social influence compared with other methods, despite the non-independence of observations.<sup>44</sup> This study is the first to our knowledge to use social network analysis to examine both exposure and normative influences on e-cigarette use among a large and diverse adolescent cohort.

### Public health implications

Adolescents overestimate the acceptability of e-cigarette use among their peers, which has a significant impact on individual e-cigarette initiation and use. Findings from this study could

strengthen vaping prevention initiatives and be applied to youth interventions in different settings and countries. Targeting network norms surrounding vaping could lead to changes in attitudes, increased perceived behavioural control and may result in lower acceptance of vaping among adolescents. Leveraging social norms and network dynamics to achieve a shift in attitudes could ultimately lead to decreases in vaping behaviour even in the presence of network exposure to vaping.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## Data availability statement

Data are available upon reasonable request.

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**WHAT IS ALREADY KNOWN ON THIS TOPIC**

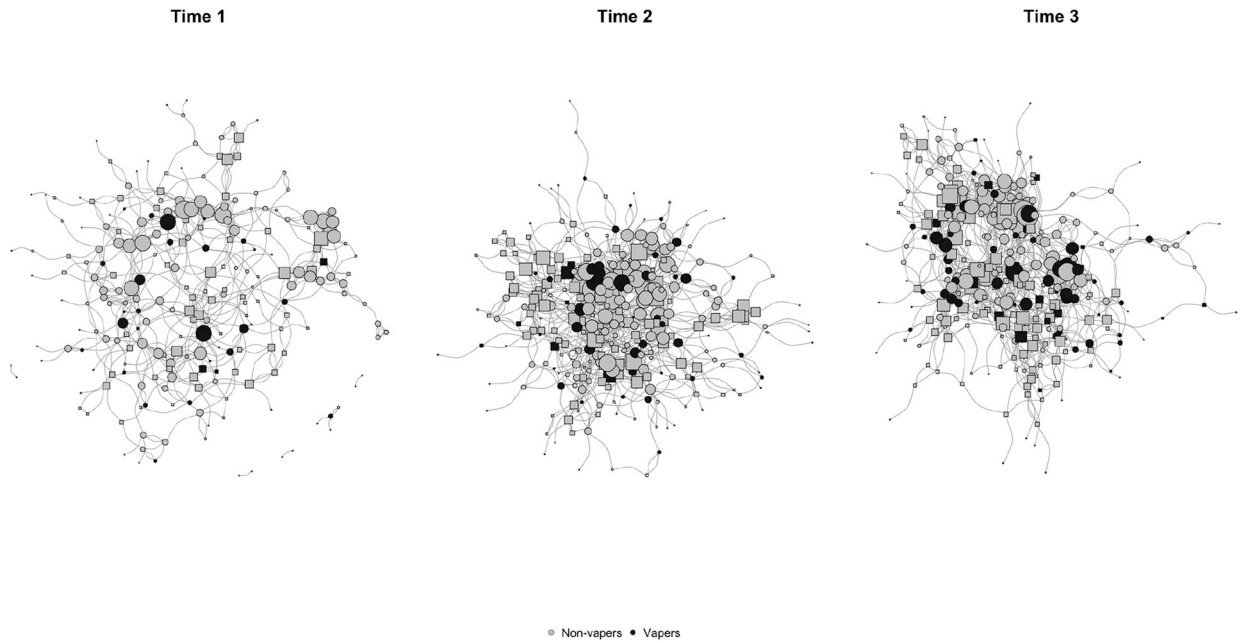
- There is an association between social network exposure to friends who smoke and individual combustible cigarette use.

### WHAT THIS STUDY ADDS

- This study is the first to examine social network exposure to friend e-cigarette use, perceived pro-vaping norms and individual e-cigarette initiation and continued use among a large adolescent cohort.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND POLICY

- Interventions that address the roles of network dynamics and social norms are likely to be more effective at reducing vaping among adolescents than those that do not.



**Figure 1.** School network plots at three time points. Nodes are sized by total degree (number of nominations sent and received). Circles are females and squares are males; dark nodes indicate being an e-cigarette user.



**Table 1**

Demographic characteristics of the analytic sample (N=1599)

	N (%)
Sex assigned at birth	
Male	667 (41.7)
Female	932 (58.3)
Sexual orientation*	
Heterosexual	1178 (73.7)
Sexual minority	224 (15.3)
Questioning	104 (6.5)
Prefer not to disclose	73 (4.6)
Hispanic ethnicity	718 (44.9)
Race	
American Indian/Alaska Native	19 (1.2)
Asian	569 (35.6)
Black or African American	24 (1.5)
Native Hawaiian/Pacific Islander	6 (0.4)
White	254 (15.9)
Multi-racial	391 (24.5)
Other	324 (20.2)
Missing	12 (0.8)
Past 6-month E-cig use prevalence	
Wave 1	38 (2.4)
Wave 2	98 (6.1)
Wave 3	126 (7.9)
	<b>Mean (SD)</b>
Baseline age (years)	14.4 (0.5)
Perceived pro-vaping norms <sup>†</sup>	
Wave 1	0.95 (0.5)
Wave 2	0.97 (0.5)
Comparative count of friends that use E-cigs at wave 3	<b>Mean (SD)</b>
All participants (n=1599)	
Respondent estimated count	0.53 (1.1)
Friends' self-report count	0.36 (0.7)
Among past 6-month e-cig users (n=126)	
Respondent estimated count	2.4 (1.7)
Friends' self-report count	0.83 (1.0)

\* Sexual minority, questioning, prefer not to disclose collapsed for analysis with heterosexual as reference.

<sup>†</sup> Range 0–2.

**Table 2**

Perceived pro-vaping norms wave 1 and wave 2 confirmatory factor analysis

Item	Standardised factor loadings*	
	Wave 1	Wave 2
People who are important to me use e-cigarettes	0.57	0.66
My friends don't mind when other people use e-cigarettes around them	0.48	0.55
E-cigarettes are more socially acceptable than smoking cigarettes	0.64	0.64
A lot of people vape e-cigarettes	0.67	0.73
Cronbach's alpha	0.58	0.64
Fit indices		
CFI	0.98	0.97
TLI	0.95	0.92
RMSEA	0.078	0.12
SRMR	0.040	0.057

\* Standardised by the SD of the factor and the item.

CFI, comparative fit index; LI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardised root mean squared residual.

Past 6-month vaping as a function of demographic characteristics, network exposure to vaping and perceived pro-vaping norms

**Table 3**

Fixed effects	Full model (N=1599)		Initiation model (N=1431)	
	AOR	95% CI	AOR	95% CI
Female	1.39	(0.84 to 2.31)	1.08	(0.55 to 2.10)
Hispanic	1.35	(0.82 to 2.23)	1.58	(0.82 to 3.08)
Sexual minority*	1.49	(0.91 to 2.45)	1.63	(0.81 to 3.31)
Age	1.57 <sup>†</sup>	(1.02 to 2.39)	1.59	(0.88 to 2.87)
Past 6-month vaping				
Wave 1	6.82 <sup>§</sup>	(2.66 to 17.5)	–	–
Wave 2	11.1 <sup>§</sup>	(6.42 to 19.3)	–	–
Network exposure to vaping				
Wave 1	1.36	(0.48 to 3.82)	0.74	(0.13 to 4.3)
Wave 2	2.65 <sup>†</sup>	(1.02 to 6.89)	12.2 <sup>§</sup>	(4.04 to 36.5)
Perceived pro-vaping norms				
Wave 1	1.61	(0.91 to 2.83)	0.89	(0.41 to 1.94)
Wave 2	1.81 <sup>†</sup>	(1.08 to 3.01)	2.63 <sup>†</sup>	(1.24 to 5.55)
Random effects	Variance		Variance	
School	0.15		0.25	

\* Sexual minority, questioning, prefer not to disclose collapsed for analysis with heterosexual as reference.

<sup>†</sup> p<0.05.

<sup>‡</sup> p<0.01.

<sup>§</sup> p<0.001.

AOR, adjusted OR for mixed logistic regression.