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Association Between Youth Smoking, Electronic Cigarette Use, and Coronavirus Disease 2019

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A B S T R A C T

Purpose: This study aimed to assess whether youth cigarette and electronic cigarette (e-cigarette) use are associated with coronavirus disease 2019 (COVID-19) symptoms, testing, and diagnosis.
Methods: An online national survey of adolescents and young adults (n = 4,351) aged 13–24 years was conducted in May 2020. Multivariable logistic regression assessed relationships among COVID-19–related symptoms, testing, and diagnosis and cigarettes only, e-cigarettes only and dual use, sociodemographic factors, obesity, and complying with shelter-in-place.
Results: COVID-19 diagnosis was five times more likely among ever-users of e-cigarettes only (95% confidence interval [CI]: 1.82–13.96), seven times more likely among ever-dual-users (95% CI: 1.98–24.55), and 6.8 times more likely among past 30-day dual-users (95% CI: 2.40–19.55). Testing was nine times more likely among past 30-day dual-users (95% CI: 5.43–15.47) and 2.6 times more likely among past 30-day e-cigarette only users (95% CI: 1.33–4.87). Symptoms were 4.7 times more likely among past 30-day dual-users (95% CI: 3.07–7.16).
Conclusions: COVID-19 is associated with youth use of e-cigarettes only and dual use of e-cigarettes and cigarettes, suggesting the need for screening and education.

IMPLICATIONS AND CONTRIBUTION

The findings from a national sample of adolescents and young adults show that electronic cigarette use and dual use of electronic cigarettes and cigarettes are significant underlying risk factors for coronavirus disease 2019. Health care providers, parents, schools, community-based organizations, and policymakers must help make youth aware of the connection between smoking and vaping and coronavirus disease.

As of June 2020, more than 2.1 million people have been infected, and approximately 116,000 have died from Coronavirus Disease 2019 (COVID-19) in the U.S. [1], and the numbers continue to rise. Both cigarette and electronic cigarette (e-cigarette) use damage the respiratory system [2–4], potentially increasing the risk of experiencing COVID-19–related symptoms, a positive diagnosis and exacerbated health outcomes [5]. A meta-analysis of studies mostly in China found that smokers were at elevated risk of COVID-19 progression compared with non-smokers [6]. Hospitalizations in the U.S. show that factors such as obesity, male sex, and older age are associated with COVID-19 [7]. Although youth are at relatively lower risk of contracting COVID-19 compared with older adults, given the proportion of youth using e-cigarettes [8], youth e-cigarette and cigarette use may pose an important risk factor for COVID-19.

Currently, there are no U.S. population-based studies assessing the relationship between cigarette smoking, e-cigarette use,

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and COVID-19–related outcomes. In the absence of information on smoking and e-cigarette use history of youth diagnosed with COVID-19, we conducted a population-level examination of whether youth cigarette and/or e-cigarette use is associated with increased likelihood of experiencing COVID-19–related symptoms, being tested, and being diagnosed with COVID-19.

Methods

We conducted a national cross-sectional online survey of adolescents and young adults aged 13–24 years from May 6 to 14, 2020 in the U.S., using Qualtrics [9], a leading enterprise survey technology platform. Participants were recruited from Qualtrics' existing online panels using a survey Web link on gaming sites, social media, customer loyalty portals, and through website intercept recruitment. Qualtrics panels are widely used to conduct social/behavioral research [10]. The online survey took 15–20 minutes to complete. Through quota sampling, we recruited e-cigarette ever-users (50.2%) and nonusers (49.8%); and adolescents (aged 13–17; 33.7%), young adults (aged 18–20 years; 41.6%), and adults (aged 21–24 years; 24.7%), while balancing gender and race/ethnicity. This study was approved by the Institutional Review Board at Stanford University.

Multivariable logistic regression was conducted to assess associations of ever-use and past 30-day use of cigarettes only, e-cigarettes only, and dual use of e-cigarettes and cigarettes with COVID-19 (self-reported symptoms, testing, and positive diagnosis). The model used weights for age group; gender; lesbian, gay, bisexual, transgender, and questioning; race/ethnicity; and e-cigarette ever-use per U.S. population-based data; accounted for clustering by region and state; and controlled for demographics, mother's education (as an indicator of socioeconomic status), body mass index (obesity as an underlying condition) [11,12], complying with county shelter-in-place orders and state percentage of COVID-19–positive cases [13]. All measures, percentages corresponding to weighted data in logistic regressions, and marginal population proportions used to calculate weight are included in Supplementary Material. Missing values were treated as not missing completely at random for Taylor series variance estimation. Statistical significance was set at $p < .05$, and all tests were two-tailed.

Results

A total of 4,351 participants completed the online survey from 50 U.S. states, the District of Columbia, and three union territories. Table 1 provides weighted sample characteristics. Table 2 shows factors associated with COVID-19–related symptoms, getting a COVID-19 test and a positive COVID-19 diagnosis.

As shown in Table 2, past 30-day dual-users were 4.7 times more likely to experience COVID-19–related symptoms (95% confidence interval [CI]: 3.07–7.16). Experiencing such symptoms was nearly twice more likely among African American/black, Hispanic, other/multiracial, underweight, and obese participants; 1.8 times more likely among lesbian, gay, bisexual, transgender, and questioning youth; and 1.6 times more likely among those not complying with shelter-in-place.

Ever-users of e-cigarettes only were 3.3 times (95% CI: 1.77–5.94), ever-dual-users were 3.6 times (95% CI: 1.96–6.54), and ever-users of cigarettes only were 3.9 times (95% CI: 1.43–10.86) more likely to get COVID-19 tested. Past 30-day dual-users were nine times (95% CI: 5.43–15.47) and past 30-day e-cigarette only users were 2.6 times (95% CI: 1.33–4.87) more likely to get COVID-19 tested. Testing was 2–3 times more likely among male, African American/black, other/multiracial, and those who were underweight.

Ever-dual-users were seven times (95% CI: 1.98–24.55), ever-users of e-cigarettes only were five times (95% CI: 1.82–13.96), and past 30-day dual-users were 6.8 times (95% CI: 2.40–19.55) more likely to be diagnosed with COVID-19. Sociodemographic factors associated with a positive COVID-19 diagnosis included being male, other/nonbinary gender, Hispanic, other/multiracial, and mother's completion of college- or graduate-level education. As a possible underlying risk factor for low immunity to COVID-19 among youth, being underweight was associated with 2.5 times greater risk of a positive COVID-19 diagnosis (95% CI: 1.05–6.20). In addition, being in a state with 11%–20% positive COVID-19 cases made a person nearly five times more likely to be diagnosed positive (95% CI: 1.19–21.39).

Discussion

Our population-based research provides timely evidence that youth using e-cigarettes and dual-users of e-cigarettes and cigarettes are at greater risk of COVID-19. Given the predominance of e-cigarette use among U.S. youth, our investigation informs public health concerns that the ongoing youth e-cigarette epidemic contributes to the current COVID-19 pandemic. Surprisingly, exclusive ever-use of combustible cigarettes was only associated with COVID-19–related testing, whereas both past 30-day use and ever-use of e-cigarettes and dual use were associated with COVID-19 testing and positive diagnosis.

There are a number of potential reasons why both dual use and e-cigarette use were associated with getting infected with COVID-19. Heightened exposure to nicotine and other chemicals in e-cigarettes adversely affects lung function [14], with studies showing that lung damage caused by e-cigarettes is comparable to combustible cigarettes [4,15,16]. COVID-19 spreads through repeated touching of one's hands to the mouth and face, which is common among cigarette and e-cigarette users [17]. Furthermore, sharing devices (although likely reduced while staying at home) is also a common practice among youth e-cigarette users [18].

Our finding that some racial/ethnic groups, especially among African American, Hispanic, and multirace youth, are at higher risk for COVID-19 is supported by evidence of densely populated living conditions that make social distancing challenging, greater economic stress, and service-industry work environments where working from home is less feasible and lower access to health care contribute to underlying health issues [19–21]. Both obesity and underweight conditions were associated with COVID-19 outcomes. Although at this point obesity is a more well-established risk factor for COVID-19 [7], being underweight also impacts lung function [22–25], and therefore it is not surprising that it is also a risk factor for COVID-19. We also found that other/nonbinary gender was associated with COVID-19 testing and diagnosis, a population that has received little attention so far. The significant relationship between mother's college or graduate education and a positive COVID-19 diagnosis needs further investigation.

We adjusted our sample to be representative of the U.S. population and included confounders such as sex and race/ethnicity to provide conservative estimates of association. Based on recommendations for studies on smoking and

Table 1
Participant characteristics (unweighted %) and COVID-19–related outcomes (weighted %) by never- and ever-e-cigarette users

	Participant characteristics[a] (unweighted)			COVID-19–related symptoms (weighted)		COVID-19 test (weighted)		COVID-19–positive diagnosis (weighted)	
	Sample (N)	Never-users (n = 2,168)	E-cigarette users (n = 2,183)	Never-users (n = 2,168)	E-cigarette users (n = 2,183)	Never-users (n = 2,168)	E-cigarette users (n = 2,183)	Never-users of e-cigarettes (n = 2,168)	E-cigarette users (n = 2,183)
Total	4,351	49.8	50.2	13.7	25.8	5.7	17.5	.8	2.3
Age									
Adolescents (13–17)	1,442	50.3	49.7	16.1	25.5	2.8	16.3	.1	1.2
Young adults (18–21)	1,810	49.3	50.7	13.4	23.5	7.2	16.1	1.0	3.1
Adults (22–24)	1,063	49.9	50.1	10.4	30.9	7.8	25.4	1.6	6.5
Sex									
Male	1,421	48.6	51.4	11.7	33.8	7.8	28.3	1.3	3.7
Female	2,832	50.4	49.6	15.5	17.4	3.8	6.1	.3	.9
Other[b]	71	51.5	48.5	18.0	21.7	6.0	21.7	.0	8.7
LGBTQ									
Yes	780	43.1	56.9	17.8	32.8	9.7	10.3	1.4	1.8
No	3,566	51.3	48.7	13.1	23.9	5.1	19.3	.7	2.5
Race/ethnicity									
White, non-Hispanic	2,611	57.5	42.5	11.4	15.8	4.4	10.3	.5	1.2
AA/black, non-Hispanic	602	46.5	53.5	21.2	42.3	11.5	29.6	1.8	1.2
Asian/Native Hawaiian or Pacific Islander, non-Hispanic	210	30.0	70.0	14.3	29.3	10.7	16.0	3.2	.8
Hispanic, non-AA/black	663	36.7	63.3	18.3	26.9	4.1	19.7	.8	3.3
Other/multiracial, non-Hispanic	265	30.6	69.4	9.1	54.6	17.3	37.5	.4	15.6
Complying with shelter-in-place									
Yes	3,463	50.7	49.3	19.1	39.5	9.2	30.8	2.3	4.3
No	709	43.5	56.5	12.6	22.9	5.4	14.7	.6	2.0
U.S. region									
Northeast	909	47.5	52.5	7.8	16.9	6.1	18.1	.6	2.4
Midwest	918	53.4	46.6	13.6	19.7	4.3	13.1	.3	4.1
South	1,505	48.1	51.9	14.3	27.7	5.3	16.9	.6	1.6
West	990	51.7	48.3	17.1	25.0	7.2	19.7	1.6	2.4
U.S. territories	11	27.3	72.7	.0	97.5	.0	35.9	.0	.0
BMI									
Underweight	350	38.9	61.1	29.40	40.37	22.90	47.69	2.00	12.85
Normal/healthy	2,939	50.9	49.1	15.12	20.16	5.29	15.99	.53	3.05
Overweight	615	53.5	46.5	7.80	20.09	8.06	11.42	1.25	1.95
Obese	381	48.1	51.9	17.45	49.56	3.74	18.88	1.06	3.47
Mother's highest level of education									
High school or below	998	49.0	51.0	19.59	25.2	8.07	16.12	.48	2.42
Started college	609	48.0	52.0	18.67	28.40	5.63	13.10	1.16	2.99
Completed college (2- or 4-y degree)	1,432	51.8	48.2	12.32	27.04	5.87	21.53	1.16	4.19
Graduate or professional degree (Masters, Ph.D., M.D., J.D., etc.)	885	48.0	52.0	14.86	31.15	10.87	26.57	.36	7.23
Don't know	410	51.2	48.8	12.02	22.10	1.50	18.87	.66	5.19

AA = African American; BMI = body mass index; COVID-19 = coronavirus disease 2019; LGBTQ = lesbian, gay, bisexual, transgender, and questioning.
[a] Unweighted percentages in observed sample.
[b] Other includes people whose sex is neither male or female, such people commonly describe themselves as non-binary or intersex.

Table 2
Association between COVID-19 and use of inhaled tobacco products, adjusting for sociodemographic factors, weighted

	Ever-use of inhaled tobacco and…			Past 30-day use of inhaled tobacco and…		
	COVID-19–related symptoms (n = 4,043)	COVID-19 test (n = 4,048)	COVID-19–positive diagnosis (n = 4,048)	COVID-19–related symptoms (n = 4,043)	COVID-19 test (n = 4,048)	COVID-19–positive diagnosis (n = 4,048)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Inhaled tobacco products						
Cigarettes only	1.40 (.83, 2.38)	**3.94 (1.43, 10.86)**	2.32 (.34, 15.86)	1.15 (.58, 2.27)	1.16 (.64, 2.12)	1.53 (.29, 8.14)
E-cigarettes only	1.18 (.80, 1.73)	**3.25 (1.77, 5.94)**	**5.05 (1.82, 13.96)**	1.43 (.84, 2.43)	**2.55 (1.33, 4.87)**	1.91 (.77, 4.73)
Dual use	1.36 (.90, 2.04)	**3.58 (1.96, 6.54)**	**6.97 (1.98, 24.55)**	**4.69 (3.07, 7.16)**	**9.16 (5.43, 15.47)**	**6.84 (2.40, 19.55)**
Never used	Ref	Ref	Ref	Ref	Ref	Ref
Age						
Adolescents (13–17)	.85 (.59, 1.23)	**.43 (.24, .78)**	.64 (.18, 2.30)	1.11 (.73, 1.68)	**.54 (.30, .97)**	.81 (.22, 2.96)
Young adults (18–21)	.79 (.50, 1.24)	.58 (.32, 1.07)	.52 (.22, 1.22)	.91 (.57, 1.44)	.66 (.36, 1.21)	.63 (.26, 1.54)
Adults (22–24)	Ref	Ref	Ref	Ref	Ref	Ref
Sex						
Male	1.34 (.95, 1.89)	**2.58 (1.70, 3.93)**	**4.75 (2.37, 9.50)**	1.15 (.82, 1.62)	**2.11 (1.33, 3.35)**	**3.65 (1.86, 7.15)**
Other	1.13 (.37, 3.42)	2.92 (.98, 8.70)	**6.38 (1.45, 28.03)**	1.19 (.38, 3.76)	3.10 (.90, 10.71)	**7.20 (1.49, 34.87)**
Female	Ref	Ref	Ref	Ref	Ref	Ref
LGBTQ						
Yes	**1.81 (1.04, 3.13)**	.78 (.52, 1.19)	.95 (.40, 2.23)	1.69 (.98, 2.90)	.71 (.43, 1.18)	.95 (.38, 2.39)
No	Ref	Ref	Ref	Ref	Ref	Ref
Race/ethnicity						
AA/black, non-Hispanic	**2.06 (1.22, 3.50)**	**1.87 (1.05, 3.34)**	1.18 (.45, 3.08)	**2.13 (1.32, 3.46)**	**1.97 (1.17, 3.33)**	1.18 (.51, 2.72)
Asian/Native Hawaiian or Pacific Islander, non-Hispanic	1.92 (.93, 3.98)	1.24 (.47, 3.28)	**.08 (.01, .49)**	1.89 (.98, 3.66)	1.26 (.47, 3.35)	**.10 (.02, .51)**
Hispanic, non-AA/black	**2.01 (1.28, 3.18)**	1.76 (.93, 3.33)	**2.84 (1.18, 6.87)**	**1.98 (1.30, 3.02)**	1.77 (.98, 3.21)	**2.97 (1.15, 7.71)**
Other/multiracial, non-Hispanic	**1.89 (1.16, 3.08)**	**2.74 (1.43, 5.25)**	**3.88 (1.27, 11.85)**	1.69 (.99, 2.88)	**2.57 (1.23, 5.35)**	**3.71 (1.14, 12.02)**
White, non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
Complying with shelter-in-place						
No	**1.54 (1.02, 2.34)**	.74 (.45, 1.22)	1.00 (.47, 2.13)	**1.62 (1.04, 2.51)**	.83 (.54, 1.26)	1.22 (.51, 2.95)
Yes	Ref	Ref	Ref	Ref	Ref	Ref
State % of COVID-19 positive cases						
21–30	.75 (.33, 1.70)	.94 (.17, 5.05)	4.07 (.84, 19.80)	.69 (.31, 1.54)	.85 (.19, 3.70)	3.54 (.70, 18.00)
11–20	1.29 (.56, 2.99)	1.16 (.21, 6.47)	4.91 (.90, 26.77)	1.30 (.58, 2.90)	1.26 (.28, 5.65)	**5.05 (1.19, 21.39)**
6–10	1.05 (.46, 2.38)	1.16 (.21, 6.27)	4.27 (.67, 27.34)	.93 (.41, 2.07)	.96 (.22, 4.18)	3.96 (.98, 16.01)
0–5	Ref	Ref	Ref	Ref	Ref	Ref
Body mass index						
Underweight	**2.50 (1.50, 4.20)**	**2.90 (1.63, 5.18)**	**2.56 (1.05, 6.20)**	**1.92 (1.05, 3.51)**	**2.12 (1.19, 3.77)**	1.95 (.82, 4.64)
Overweight	**.69 (.50, .95)**	.57 (.31, 1.03)	.65 (.24, 1.72)	.77 (.56, 1.06)	.74 (.38, 1.45)	.79 (.32, 1.96)
Obese	**2.19 (1.37, 3.51)**	.90 (.48, 1.71)	1.40 (.53, 3.71)	**1.87 (1.14, 3.01)**	.53 (.28, 1.02)	.90 (.31, 2.66)
Normal/healthy	Ref	Ref	Ref	Ref	Ref	Ref
Mother's highest level of education completed						
Started college	1.13 (.71, 1.80)	.76 (.39, 1.47)	1.61 (.65, 4.04)	1.06 (.67, 1.68)	.65 (.29, 1.45)	1.37 (.52, 3.60)
Completed college (2 or 4 year degree)	.97 (.57, 1.66)	1.06 (.62, 1.81)	**2.10 (1.08, 4.11)**	.93 (.54, 1.60)	.97 (.59, 1.61)	1.84 (.91, 3.75)
Graduate or professional degree (Masters, Ph.D., M.D., J.D., etc.)	1.29 (.78, 2.14)	1.83 (.98, 3.42)	**3.28 (1.20, 8.93)**	1.11 (.66, 1.68)	1.43 (.75, 2.70)	2.33 (.87, 6.22)
Don't know	.79 (.38, 1.65)	.83 (.40, 1.73)	2.42 (.55, 10.69)	.88 (.43, 1.81)	1.03 (.49, 2.18)	2.72 (.64, 11.60)
High school or below	Ref	Ref	Ref	Ref	Ref	Ref

Bold indicates $p < .05$; adjusted for state- and region-level clustering effects.
COVID-19 = coronavirus disease 2019; CI = confidence interval; LGBTQ = lesbian, gay, bisexual, transgender, and questioning; Ref = reference.

COVID-19 [26], our study adjusted for obesity, which we found was also an underlying risk factor among 13- to 24-year-olds. However, we did not include or adjust for other comorbid conditions such as hypertension due to low prevalence among 13- to 24-year-olds [27]. Furthermore, we did not ask participants about hospitalization or severity of symptoms and cannot ascertain asymptomatic respondents. We recommend biomarker-based studies to determine causality, as this study is based on self-report.

Conclusion

Our findings from a national sample of adolescents and young adults show that e-cigarette use and dual use of e-cigarettes and cigarettes are significant underlying risk factors for COVID-19 that has previously not been shown. The findings have direct implications for health care providers to ask all youth and COVID-19–infected youth about cigarette and e-cigarette use history; for parents, schools, and community-based organizations to guide youth to learn more about how e-cigarettes and dual use affect the respiratory and immune systems; for the Food and Drug Administration to effectively regulate e-cigarettes during the COVID-19 pandemic; and for the development and dissemination of youth-focused COVID-19 prevention messaging to include e-cigarette and dual use.

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Supplementary Data

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