

Prospective study of dual use of e-cigarettes and other tobacco products among school-going youth in rural Appalachian Tennessee

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Abstract:

INTRODUCTION: E-cigarettes have emerged as the most commonly used tobacco or nicotine products among youth in the United States (US), and usage with other products (dual use) is not well understood. This study assessed dual use and identified associated factors of usage in school-going youth in the high tobacco burdened region of rural Appalachian Tennessee.

METHODS: Two waves of data for the same cohort of students were collected in 2014 (Wave 1) and 2016 (Wave 2). Dual use of e-cigarettes with any other tobacco product was the dependent variable. The independent variables consisted of exposure to tobacco use at home, home smoking rules, smoking inside the vehicle, attitudes toward smoking, exposure to tobacco industry marketing/promotion, and peer/family pressure. Descriptive statistics and multivariate logistic regression analyses were conducted to determine the prevalence of dual use and delineate factors associated with usage.

RESULTS: Dual use increased from 13.3% in Wave 1 to 18.6% in Wave 2. Results of logistic regression show that exposure to tobacco industry marketing/promotion was significantly associated with dual use in the two waves, odds ratio (OR) = 4.18 (confidence interval [CI] = 1.69–10.38) and OR = 4.43 (CI = 2.03–9.67), respectively. While allowing smoking inside the vehicles, sometimes, significantly increased dual use in Wave 1 (OR = 3.18 [CI = 1.19–8.48]), exposure to tobacco use at home (OR = 2.94 [1.24–6.97]), and peer/family pressure (OR = 2.92 [1.87–7.19]) increased usage in Wave 2.

CONCLUSION: The increasing trend in dual use of e-cigarettes and other tobacco products among youth in Appalachia Tennessee suggests a critical need for comprehensive tobacco control programs to avert exacerbating disparities in tobacco use and tobacco-related diseases in the US.

Keywords:

Central Appalachia, cohort, dual use, e-cigarettes, tobacco products, youth

Nationwide, the regular use of e-cigarettes among middle and high school students in the United States (US) has increased from 1.1% to 5.3% and 1.5% to 16.0% from 2011 to 2015,^[1,2] respectively. There is, however, growing evidence at national^[1,3,4] and state^[5-7] levels indicating that e-cigarettes are used concurrently with other

tobacco products, known as dual use.^[8,9] Studies^[6,9,10-12] show that never-smoking youth who use e-cigarettes are more likely to become traditional cigarette users. The possibility of nicotine addiction from e-cigarettes raises concerns about eroding the public health gains in tobacco control of the last 50 years.^[13-18] However, limited information is available on exclusive

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e-cigarette use or concurrent use of e-cigarettes and other tobacco products in the Appalachian Tennessee youth population^[19] where the prevalence of tobacco use and tobacco-related diseases is higher^[19,20] than the national average and contributes to major health disparities in the US, leading to this study.

A prospective study involving middle school students in a rural county of Appalachian Tennessee was conducted, surveying participants biennially as follows: (1) to monitor the prevalence, knowledge, opinions, or perceptions about tobacco product use, including e-cigarettes and (2) to evaluate tobacco control interventions in the region. The study specifically aimed to (1) assess the concurrent or dual use of e-cigarettes and any other tobacco products, and (2) identify factors associated with dual use. In a region burdened with high tobacco use such as Appalachian Tennessee, this innovative study has the potential to inform public health efforts to incorporate e-cigarette use in tobacco control policies and school-based programs. Thus, disparities illuminated in the US National Cancer Institute (NCI) report Monograph 22: A socioecological approach to addressing tobacco-related health disparities^[21] can be addressed.

Methods

Study population

The study population, a cohort of youth from a rural county in Appalachian Tennessee,^[22] participated in a school-based baseline survey in 2014 while in Grades 4 and 5 (Wave 1), and a follow-up survey in 2016 while in grades 6 and 7 (Wave 2). The County Health Department, Regional Health Department, Health Council, Coordinated School Health, and the School System partnered to conduct the school survey, obtaining data on tobacco product use among school-going youth. This data will be used to inform the design and implementation of effective tobacco programs for the students in this high-risk environment. A passive consent procedure was used to obtain parental/guardian/caregiver consent for their children to participate in the survey. Participation in the study was voluntary, without any coercion, and students were free to withdraw without any negative consequences. Moreover, facilitating collection of the data and access to the student population, an agreement was made between the school administration and parents that the survey would be anonymous with no ability to trace responses to any individual student and to collect very limited demographic information. Thus, data were collected without identifiers. The classroom was the unit for data collection with all qualified students eligible to participate in the survey on the survey administration day. Therefore, the sample size and power calculation

were not performed before the administration of the survey. The analysis of the data for publication was approved by the Institutional Review Board of the corresponding author's institution (Blinded for Review).

Measurements

A 22-item questionnaire, comprised of standard and validated tobacco-related questions adapted from the National Youth Tobacco Survey and Global Youth Tobacco Survey,^[22,23] was agreed upon by the study partners, the school system, and parents/guardians/caregivers, and administered to the study cohort. This questionnaire included three demographic questions (age, sex, and grade) and 18 questions about the use of cigarettes, non-cigarettes combustible tobacco products, smokeless tobacco products, and e-cigarettes. Specifically, the tobacco use questions examined tobacco use status, age of smoking initiation, susceptibility to tobacco use, smoking inside home and vehicle, accessibility to tobacco products, peer and family smoking behavior, exposure to smoking and secondhand tobacco smoke, belief and knowledge about secondhand tobacco smoke, attitudes toward smoking, tobacco industry marketing, and education about tobacco use.

Dependent variable: Dual use of e-cigarettes and other tobacco products

The main outcome variable was the use of e-cigarettes and any tobacco product (cigarette, non-cigarettes combustible tobacco products, and smokeless tobacco products) or "dual use."^[17,24] The use of e-cigarettes was ascertained with the question "Have you ever tried electronic cigarettes, even one or two puffs?" (Yes/No). The use of the other tobacco products was ascertained by the question, "Which of the following (lists of) tobacco products have you ever tried, even just one time?" This list encompasses tobacco products provided in studies by the US Centers for Disease Control and Prevention and the Food and Drug Administration^[1-3] and those unique to the Central Appalachian region. A dual user in this study was any participant who responded "Yes" on ever using e-cigarettes in addition to the selection of any of the listed tobacco products.

Independent variables

Drawing on the extant literature^[5,6,8,11,12,25,26] and NCI Monograph 22's socioecological approach,^[21] the study's independent variables consisted of exposure to tobacco use at home, home smoking rules, smoking inside the vehicle, attitudes toward smoking, exposure to tobacco industry marketing/promotions, and peer/family influence. The exposure to tobacco use at home was ascertained with the Yes/No question, "Does anyone who lives with you now (use tobacco products?). Smoking inside the vehicle was assessed as "In the vehicles that you and your family members ride in,

smoking is ...” (always, sometimes, or never allowed). Attitudes toward smoking were ascertained by asking: “Do you think that smoking makes young people look cool or fit in?” or “do you think that young people who smoke cigarettes have more friends?” (Definitely, probably, probably not, and definitely not). Thus, the answer “definitely not” indicates a negative attitude. Exposure to tobacco industry marketing/promotions was assessed as “Have you ever bought or received anything such as a lighter, t-shirt, hat, sunglasses, or other items that have a tobacco brand name or picture on it?” (Yes/No). Peer/family pressure was assessed as “Have you ever felt pressured by a friend or family member to use tobacco products?” (Yes/No). Age was categorized as below 12 years or 12 years and above, sex was marked male or female, and grade was categorized as 4th, 5th, 6th, or 7th grade.

Statistical analysis

Descriptive and multiple logistic regression analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). Descriptive analysis was used to indicate participants’ characteristics by dual use of tobacco products in Wave 1 and Wave 2 data. The prevalence of other tobacco product use (e.g., cigarettes, non-cigarettes combustible tobacco products, and smokeless tobacco products) was determined by e-cigarette use status in each survey. Multiple logistic regression analyses were used to examine the associations between the risk factors and dual use after adjusting for covariates. The significance level was set at 0.05. The adjusted odds ratios (ORs) and the associated 95% confidence intervals (CIs) have been provided.

Results

Characteristics of study population

A total of 324 (Wave 1) and 312 students (Wave 2) participated in the study [Table 1]. Dual use increased from 13.3% in Wave 1 to 18.6% in Wave 2. Except for sex in Wave 1, there was a significant difference in non-dual users and dual users across all independent variables. The percentage of dual users who (1) were exposed to tobacco use at home and inside the vehicle, (2) had positive attitudes toward smoking, (3) were exposed to tobacco industry marketing/promotions, and (4) experienced peer/family pressure increased from Wave 1 to Wave 2. However, dual users who reported that smoking was sometimes allowed inside the vehicle decreased within the same period. Demographically, participants in Wave 1 ranged in age from 9 to 12 years old and participants in Wave 2 were between 11 and 14 years of age. Overall, the largest proportion of dual users for both Wave 1 and Wave 2 was participants aged 12 and 13 years old, respectively. Males constituted the largest proportion of dual users in both waves. Finally,

the proportion of dual users in higher grades (5th grade in Wave 1; 7th grade in Wave 2) was larger than those in the lower grades.

Prevalence of dual use of e-cigarettes and other tobacco products

Table 2 shows that the rate of participants that have ever tried e-cigarettes and smoked traditional cigarettes increased from 30.4% in Wave 1 to 50% in Wave 2. Similarly, the rate of ever users of e-cigarettes who used non-cigarette combustible tobacco products increased from 8.7% to 13.0% from Wave 1 to Wave 2, and for those who used smokeless tobacco products increased from 13.0% to 32.6% between waves.

Factors associated with dual use of e-cigarettes and other tobacco products

Table 3 shows in Wave 1, that both allowing smoking inside the vehicle some of the time and exposure to tobacco industry marketing/promotion, significantly increased the odds of dual use by 3.18 (95% CI = 1.19–8.48) and 4.18 (95% CI = 1.69–10.38) times, respectively. Table 3 shows that in Wave 2, exposure to tobacco use at home, exposure to tobacco industry market/promotions, and peer/family pressure all significantly increased the odds of dual use by 2.94 (95% CI = 1.24–6.79), 4.43 (95% CI = 2.03–9.67), and 2.92 (95% CI = 1.18–7.19) times, respectively. Overall, the demographic variables considered in the study (age, sex, and grade) were not significant in either wave.

Discussion

The prevalence rate of e-cigarette use has more than doubled since the mid-2000s^[27-29] and e-cigarette use has been increasing among adolescents, becoming the most common form of tobacco among youth.^[1,3,14] While e-cigarette use for smoking cessation among adults can be debated, growing evidence indicates that a significant number of never smokers who use e-cigarettes will transition to the use of traditional tobacco products^[18] and a large proportion of e-cigarette users consume other tobacco products.^[9,17] This trend in dual use among youth threatens efforts to achieve the Healthy People 2020^[30] goals of 12% adult smoking rate and reduced disparities in tobacco use and tobacco use-related diseases in the US^[20,21] providing the impetus for this study.

A prospective study involving a cohort of school-going youth in Grades 4 and 5 at baseline was conducted in a rural county in Appalachian Tennessee.^[31] Overall, dual use increased from 13.3% in Wave 1 when the participants were in Grades 4 and 5, to 18.6% in Wave 2 when the participants were in Grades 6 and 7. While this increased trend is consistent with national trends,^[1,3,29] the prevalence rate in the Central

Table 1: Characteristics by dual use of e-cigarettes and other tobacco products in Wave 1 (2014) and Wave 2 (2016) surveys

Variables	Wave 1 (n=324)			Wave 2 (n=312)		
	Dual use (no, n=281)	Dual use (yes, n=43)	P	Dual use (no, n=254)	Dual use (yes, n=58)	P
Exposure to tobacco use at home (%)						
Yes	146 (52.0)	36 (83.7)	<0.0001	127 (50.0)	47 (81.0)	<0.0001
No	135 (48.0)	7 (16.3)		127 (50.0)	11 (19.0)	
Home smoking rule (%)						
Allowed	82 (29.2)	25 (58.1)	0.0007	64 (25.2)	27 (46.6)	0.0053
Never allowed	191 (68.0)	18 (41.9)		182 (71.7)	30 (51.7)	
Missing	8 (2.9)	0 (0.0)		8 (3.2)	1 (1.7)	
Smoking inside vehicle (%)						
Always allowed	45 (16.0)	11 (25.6)	<0.0001*	27 (10.6)	12 (20.7)	0.0255*
Sometimes allowed	55 (19.6)	20 (46.5)		50 (19.7)	17 (29.3)	
Never allowed	178 (63.4)	12 (27.9)		172 (67.7)	29 (50.0)	
Missing	3 (1.1)	0 (0.0)		5 (2.0)	0 (0.0)	
Positive attitudes toward smoking (%)						
Yes	33 (11.7)	14 (32.6)	0.0003	34 (13.4)	18 (31.0)	0.0011
No	248 (88.3)	29 (67.4)		220 (86.6)	40 (69.0)	
Exposure to tobacco industry market/promotions (%)						
Yes	24 (8.5)	17 (39.5)	<0.0001*	24 (9.5)	23 (39.7)	<0.0001*
No	256 (91.1)	26 (60.5)		227 (89.4)	35 (60.3)	
Missing	1 (0.4)	0 (0.0)		3 (1.2)	0 (0.0)	
Peer/family pressure (%)						
Yes	29 (10.3)	11 (25.6)	0.0129	20 (7.9)	16 (27.6)	<0.0001*
No	246 (87.5)	32 (74.4)		229 (90.2)	42 (72.4)	
Missing	6 (2.1)	0 (0.0)		5 (2.0)	0 (0.0)	
Controlling factors (%)						
Age (years)						
10	1 (0.4)	0 (0.0)	0.0008*	N/A	NA	<0.0001*
11	62 (22.1)	7 (16.3)		52 (20.5)	6 (10.3)	
12	132 (47.0)	18 (41.9)		118 (46.5)	26 (44.8)	
13	75 (26.7)	18 (41.9)		79 (31.1)	20 (34.5)	
14	5 (1.8)	0 (0.0)		2 (0.8)	5 (8.6)	
Missing	6 (2.1)	0 (0.0)		3 (1.2)	1 (1.7)	
Sex (%)						
Female	132 (47.0)	15 (34.9)	0.2643	126 (49.6)	19 (32.8)	0.0046*
Male	139 (49.5)	27 (69.8)		126 (49.6)	39 (67.2)	
Missing	10 (3.6)	1 (2.3)		2 (0.8)	0 (0.0)	
Grade (%)						
4 th	136 (48.4)	18 (41.9)	0.0309*	-	-	
5 th	143 (50.9)	24 (55.8)		-	-	
Missing	2 (0.7)	1 (2.3)		-	-	
Grade (%)						
6 th	-	-		133 (52.4)	18 (31.0)	0.0007*
7 th	-	-		119 (46.9)	39 (67.2)	
Missing	-	-		2 (0.8)	1 (1.7)	

*Fisher's exact test was used. N/A=Not applicable

Appalachian region is higher than the national prevalence^[1,3,4] and elsewhere in the country.^[5,6,11,12,25,26] These results suggest that e-cigarettes may be creating a new generation of addicts among youth, with concomitant tobacco use-related disparities, which implies the need to incorporate opposition toward

e-cigarette use in programs and policies to address youth tobacco use in the region.

In separate multivariate analyses identifying factors associated with dual use for the two waves of data (2014, 2016), the demographic variables (age, sex, and grade)

Table 2: Dual use of e-cigarette and other tobacco products in Wave 1 (2014) and Wave 2 (2016) surveys

Product	Wave 1			Wave 2		
	Never-users of e-cigarette	Ever-users of e-cigarette	P	Never-users of e-cigarette	Ever-users of e-cigarette	P
Cigarettes (%)						
Yes	8 (2.7)	7 (30.4)	<0.0001	8 (3.0)	23 (50.0)	<0.0001
No	291 (97.3)	16 (69.9)		256 (97.0)	23 (50.0)	
Noncigarette combustible tobacco products (%)						
Yes	6 (2.0)	2 (8.7)	0.1488	3 (1.1)	6 (13.0)	0.0004
No	293 (98.0)	21 (91.3)		261 (98.9)	40 (87.0)	
Smokeless tobacco products (%)						
Yes	15 (5.0)	3 (13.0)	0.2224	11 (4.2)	15 (32.6)	<0.0001
No	284 (95.0)	20 (87.0)		253 (95.8)	31 (67.4)	

Table 3: Logistic regression analysis of the association between risk factors and dual use of e-cigarettes and other tobacco products in Wave 1 (2014) and Wave 2 (2016) surveys

Variables	OR (95% CI)	
	Wave 1	Wave 2
Exposure to tobacco use at home		
Yes versus no	2.88 (0.96-8.64)	2.94 (1.24-6.97)*
Home smoking rule		
Allowed	1.39 (0.56-3.44)	1.01 (0.42-2.45)
Never allowed (reference)		
Smoking inside vehicle		
Always allowed	1.23 (0.39-3.93)	1.56 (0.52-4.72)
Sometimes allowed	3.18 (1.19-8.48)*	0.88 (0.35-2.20)
Never allowed (reference)		
Positive attitudes toward smoking		
Yes versus no	2.55 (1.00-6.53)	1.10 (0.48-2.54)
Exposure to tobacco industry marketing/promotions		
Yes versus no	4.18 (1.69-10.38)**	4.43 (2.03-9.67)***
Peer/family pressure		
Yes versus no	2.16 (0.81-5.75)	2.92 (1.18-7.19)*
Age (years)		
<12 (reference)		
12	1.14 (0.37-3.51)	1.15 (0.37-3.59)
>12	2.50 (0.57-10.84)	1.13 (0.28-4.53)
Sex		
Male versus female	0.75 (0.34-1.69)	0.69 (0.34-1.38)
Grade		
4 th versus 5 th	1.03 (0.36-2.97)	--
6 th versus 7 th	--	0.35 (0.14-0.90)

*P<0.05, **P<0.01, ***P<0.001. OR=Odds ratio, CI=Confidence interval

were not significant, concurring with results from an earlier study involving high school students in the region.^[32] This study suggests a need to explore non-demographic factors and to dedicate more resources to understanding the underlying factors that predispose youth in the region to tobacco use.

The non-demographic factors significantly associated with increased dual use in Wave 1 (2014) or Wave

2 (2016) (1) include exposure to tobacco industry marketing/promotions, (2) exposure to tobacco use at home, and (3) peer/family pressure. Exposure to tobacco industry advertising, marketing, and other promotional activities contribute to tobacco use among youth.^[33] Research suggests that e-cigarettes are being marketed similarly to the way cigarette companies historically marketed conventional cigarettes in the 1950s and 1960s,^[17] including television and radio ads that have since been prohibited.^[34] In this regard, studies have demonstrated for decades that youth exposure to cigarette advertising causes youth smoking.^[33] Similarly, emerging studies show that exposure to e-cigarette marketing increases the odds of usage among youth.^[17] Advertising expenditures on e-cigarette marketing and promotions have been rising since the mid-2000s,^[17,35] resulting in the U.S. Surgeon General reporting an expected increase in marketing expenditures from \$12 million in 2011 to \$125 million in 2014.^[17] This trend indicates more youth are likely to be exposed to marketing activities, making them susceptible to tobacco use. Furthermore, e-cigarettes come in attractive varieties and flavorings.^[13,14,16,17,36,37] A study by Zhu *et al.* found that as of January 2014, there were 466 brands and 7764 unique flavors.^[36] The current study shows that exposure to these industry marketing/promotional efforts increased dual use among youth in the Central Appalachian region. As such, a comprehensive tobacco program that limits or prohibits the marketing/promotion of e-cigarettes is needed to prevent their use among youth.

Exposure to tobacco use at home, allowing smoking in vehicles, and peer/family pressure were the variables shown to significantly increase dual use in at least one wave of survey data. Exposure to tobacco use at home increases tobacco use among youth because it normalizes tobacco use and makes the behavior socially acceptable.^[33,38] In this study, the results for Wave 2 data show that the odds of dual use increased by nearly three-fold when the participant was exposed to tobacco use at home. Similarly, the likelihood of dual use is increased by more than three-fold (Wave 1) among

children that ride in vehicles where smoking is allowed some of the time. Thus, smoke-free home and/or vehicle policies will be required to reduce youth exposure and the negative implications of social acceptance of tobacco use, affirming the US Surgeon General's suggestion that the coverage of smoke-free policies should be extended to include e-cigarettes.^[17] Education for smoke-free environments within the home, combined with a total prohibition of smoking in vehicles carrying minors, may be an effective policy to reduce dual use among youth in this high-risk rural environment.

Peer/family pressure increased dual use in Wave 2 of the survey data. The influence of peers and familial relations on the tobacco use behavior of youth has already been established in the literature.^[33] Similarly, research suggests that peer and/or family influences are among the reasons why youth initiate e-cigarette use.^[17,39] This study's results, consistent with the extant literature, suggest that addressing dual use among youth in Central Appalachia requires understanding the tobacco use behavior and social acceptance of tobacco use within this population. Particularly critical in this region, a sociocultural environment receptive to tobacco use and resistant to change, is understanding the touchstones of this behavior.^[37] Accordingly, it will require research and interventions to understand the youth behavior, the home environment, and the social network, wherein youth are faced with intractable social pressure to engage in tobacco use.

Study limitations to be considered include the interpretation of the results, including unexplained missing data points and the use of self-reporting, which is subject to recall and social desirability biases. In addition, the study cohort of school-going youth surveyed has been selected from a single rural county in Appalachian Tennessee, creating concerns about generalizability. Finally, unlike previous studies that controlled for a wide range of factors such as parental education, parental support, and rebelliousness,^[12] the study agreement between researchers, the school system, and parents/guardians/caregivers only allowed us to collect very limited demographic information (age, sex, and grade). Nevertheless, this study on tobacco use involves the only known youth cohort in the Central Appalachian region, implying that the results provide an added value to closing the gap in the scientific literature on dual use among hard-to-reach youth in high-risk rural environs.^[17,24]

Conclusion

Among youth in the US, e-cigarette usage has surpassed that of other conventional tobacco products. Research suggests that e-cigarettes are used concurrently with

other conventional tobacco products, leading to the escalating public health problem of dual use. This study examined dual use among a cohort of students in a high-risk rural environment biennially (Waves 1 and 2). Dual use increased from 13.3% in Wave 1 to 18.6% in Wave 2, suggesting that e-cigarettes may be creating a new generation of tobacco addicts. The significant factor associated with increased dual use in both Wave 1 and Wave 2 was exposure to tobacco industry marketing/promotion. Exposure to tobacco use at home or inside the vehicle and peer/family pressure increased dual use in both Wave 1 and Wave 2. These findings suggest the need for incorporating e-cigarettes into a comprehensive tobacco intervention as suggested by the US Surgeon General.^[17] Considering the strong influence of sociocultural factors in the Central Appalachian region in particular, such an intervention should be consistent with the socioecological approach to addressing disparities in tobacco use and tobacco use-related diseases espoused by NCI in Monograph 22^[21] through the involvement of the friends and families of youth tobacco users.

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Conflicts of interest

There are no conflicts of interest.

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