Binge Drinking Moderates the Association Between Chronic Lung Disease and E-Cigarette Use

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BACKGROUND: There is a paucity of research on e-cigarette use among adults with chronic lung disease. Accordingly, little is known about the factors that may contribute to e-cigarette use in this population. The purpose of this study was to evaluate the relationship between chronic lung disease and e-cigarette use and to determine whether binge drinking moderates this relationship. METHODS: Data were derived from the 2018 Behavioral Risk Factor Surveillance System (BRFSS). Logistic regression was used to test the association between chronic lung disease status and e-cigarette use, controlling for demographic variables and chronic health conditions. We conducted moderation analyses to test the hypothesis that the association between chronic lung disease and lifetime e-cigarette use would be modified by binge drinking. RESULTS: The prevalence of lifetime e-cigarette use was higher among adults with chronic lung disease than among those without, and more frequent binge drinking was associated with an increased likelihood of lifetime e-cigarette use independent of chronic lung disease status. Binge drinking moderated the relationship between chronic lung disease and lifetime use of e-cigarettes such that the association between chronic lung disease and e-cigarette use was weaker among those who engaged in more episodes of binge drinking in the past 30 d. Among those without chronic lung disease, binge drinking was associated with an increased likelihood of e-cigarette use. CONCLUSIONS: E-cigarette use appears to be more common among adults with chronic lung disease. Although binge drinking was positively associated with e-cigarette use, more frequent binge drinking weakened the relationship between chronic lung disease and e-cigarette use. Though future studies are needed to determine precisely how binge drinking affects this association, it is possible that individuals with chronic lung disease who binge drink more frequently use e-cigarettes less frequently, despite an increased likelihood of having ever used an e-cigarette. (ClinicalTrials.gov registration NCT04135404.) *Key words: asthma; COPD; chronic lung disease; e-cigarette; alcohol.*
[Respir Care 0;0(0):1–●. © 0 Daedalus Enterprises]

Introduction

Chronic lung diseases such as COPD and asthma significantly diminish the health and well-being of affected individuals[1] and together constitute the fourth leading cause of death in the United States.[2] Smoking is a leading cause of COPD and is known to increase the risk of asthma development.[1,3] Moreover, smoking negatively affects pulmonary function and increases the frequency of respiratory exacerbation among adults with chronic lung disease.[4,5] Smoking, therefore, is strongly discouraged in individuals with chronic lung disease.[6]

Recently, several forms of alternative tobacco products have become available. Notable among these are electronic cigarettes (e-cigarettes), which deliver nicotine by vaporizing nicotine-containing fluid.[7] First retailing in 2004, e-cigarettes were initially marketed as less dangerous substitutes for conventional combustible tobacco cigarettes.[8]

E-cigarette use is prevalent among adults who have never smoked combustible cigarettes and may serve as a gateway to combustible cigarette smoking.[9] Some studies have reported that e-cigarette users continue to smoke combustible cigarettes as well, and meta-analyses support this finding.[8] Furthermore, e-cigarette use is prevalent among vulnerable populations, including individuals with chronic lung disease.[10] In a recent study among adults in the United States, the age-adjusted prevalence of e-cigarette use was an estimated 7.1% higher in individuals with COPD and

1.9% higher in those with asthma than in those with no history of chronic lung disease.[11] This may be because individuals with smoking-related chronic lung disease perceive e-cigarettes to be a safer alternative to combustible cigarettes.[10] Indeed, smokers with COPD or asthma report using e-cigarettes to quit or reduce combustible cigarette consumption or to reduce the harm from smoking.[12,13]

There is, however, evidence that e-cigarettes have detrimental side effects. For instance, e-cigarette vapor contains poisonous combinations of formalin, acetaldehyde, acrolein, propanol, acetone, and butanal.[14] Acrolein, a product found in cigarette smoke, e-cigarette liquid, and e-cigarette vapor, reduces host defense responses and induces lung inflammation, mucus hypersecretion, neutrophil inflammation, and protease-mediated lung tissue damage.[8] Moreover, e-cigarettes adversely affect airway physiology and respiratory symptoms among patients with chronic lung diseases such as asthma and COPD, causing throat irritation, cough, and increased airway resistance.[9]

Modifiable health behaviors that may affect e-cigarette use among those with chronic lung disease are poorly understood. One important health behavior is alcohol consumption.[15] Alcohol use is the second leading cause of preventable death in the United States, after smoking.[16] Alcohol and tobacco are often used together, and individuals dependent on alcohol are 3 times more likely to smoke than those in the general population.[17]

Binge drinking can place a heavy burden on society and is considered to be the most common, costly, and deadly pattern of excessive alcohol consumption, contributing to over half of the deaths and three fourths of the economic costs incurred by excessive drinking.[18,19] The positive association between binge drinking and combustible cigarette use has been well documented,[20] and, mirroring these findings,

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QUICK LOOK

Current knowledge

There is limited research on the relationship between chronic lung disease and e-cigarette use and on whether other health behaviors, including binge drinking, moderate this relationship.

What this paper contributes to our knowledge

We found that binge drinking moderates the association between chronic lung disease and e-cigarette use. Though somewhat counterintuitive, the association between chronic lung disease and e-cigarette use was weaker among more frequent binge drinkers. This finding might reflect the impact of binge drinking on pulmonary function and concerns about the compounding effects of e-cigarette use. Our results suggest that health care providers should not only screen for e-cigarette use but also binge drinking when treating patients with chronic lung disease due to the deleterious effects of excessive alcohol intake on pulmonary health.

recent results indicate a positive relationship between binge drinking and e-cigarette use among adults in the United States.[21] Notably, substantial evidence suggests that binge drinking negatively affects lung health, with independent additive negative effects on lung function in smokers.[22]

Given the relationship between binge drinking and e-cigarette use,[21] it is important to know whether a similar relationship exists among people with chronic lung disease. Importantly, scientific evaluation of the relationship between binge drinking and e-cigarette use among people with chronic lung disease may suggest methods to prevent e-cigarette use, and thus prevent further lung damage, among these individuals. The aims of this study were to evaluate the association between chronic lung disease and e-cigarette use, and to determine whether this association is moderated by binge drinking. We hypothesized that the association between e-cigarette use and chronic lung disease would be stronger among those who reported more frequent binge drinking.

Methods

Design and Data Sources

Data from adult subjects were obtained from the cross-sectional Behavioral Risk Factor Surveillance System (BRFSS),[23] the nation's foremost system of health-related telephone surveys that collects self-reported data from United States residents age $\geq$ 18 y regarding their health-related risk behaviors, chronic health conditions, and use of

preventive services. Landline telephone numbers were randomly selected using a disproportionate stratified sample design, and data were collected from a randomly selected adult in a household. Cellular telephone numbers were also randomly selected using cellular telephone sampling frames, and data were collected from an adult who answered the cellular telephone if he or she resided in a private residence or college housing. The full description of sampling and questionnaire methodology can be found on the BRFSS web site (https://www.cdc.gov/brfss/annual_data/annual_2018. html *Accessed February 1, 2021*).[24]

Weighting Process

Data were collected in 2018 in 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands via landline or cellular telephone calls. The Centers for Disease Control and Prevention use raking methodology to weight BRFSS data; this methodology allows the incorporation of landline and cellular telephone survey data and the introduction of additional characteristics that enhance the degree to which the BRFSS sample represents the make-up of the U.S. population. More details on the weighting process are available elsewhere.[23]

Measures

Independent Variable: Chronic Lung Disease. Survey participants were asked "Has a doctor, nurse, or other health professional ever told you that you had any of the following?," with COPD and asthma among the lung conditions listed. A response of "No" regarding asthma and COPD was coded as negative for chronic lung disease (dummy code = 0), whereas a response of "Yes" to either asthma or COPD was coded as positive for chronic lung disease (dummy code = 1).

Dependent Variable: Lifetime E-Cigarette Use. Participants were asked if they had ever used an e-cigarette or other electronic "vaping" product, even 1 time, in their entire life. Responses were dummy coded as follows: No = 0, Yes = 1. The other BRFSS variable pertaining to e-cigarette use, current e-cigarette use, was also considered for inclusion in the analyses, but this variable was endorsed by so few respondents that it was excluded from the present report. In response to reviewer comments, current e-cigarette use was evaluated as a dependent variable and yielded no significant associations.

Moderating Variable: Binge Drinking. Participants were asked to report the number of times in the past 30 d they consumed 5 or more drinks (for men) or 4 or more drinks (for women) on a single occasion (continuous variable).

Covariates. Sociodemographic variables, including age (18–24, 25–34, 35–44, 45–54, 55–64, and $\geq$ 65 y), gender (female or male), yearly income (< $15,000; $15,000–$25,000; $25,000–$35,000; $35,000–$50,000; $\geq$ $50,000), cannabis use, cigarette use, and chronic health conditions (ie, stroke, kidney disease, cancer, arthritis, or depressive disorder) were included in our analysis to control for possible confounding.

Statistical Analysis

All data analyses were completed with Stata 16.1 (StataCorp, College Station, Texas). Logistic regression was used to test the association between chronic lung disease and e-cigarette use, controlling for demographic variables and other chronic health conditions. Moderation was assessed by including interaction terms for the number of binge-drinking episodes in the past 30 d by chronic lung disease status. β coefficients, standard errors, odds ratios (OR), and P values are reported, with $P < .05$ indicating statistical significance.

Results

Individuals who reported a history of chronic lung disease were more likely to be female, white, older, and have lower income and educational attainment levels than those who did not report a history of chronic lung disease (Table 1). Participants with chronic lung disease reported greater lifetime e-cigarette use and fewer binge-drinking episodes than those without chronic lung disease (Table 2).

A statistically significant interaction was found between chronic lung disease and the number of binge-drinking episodes in the past 30 d; this interaction was such that the association between chronic lung disease and e-cigarette use was weaker among those who engaged in more episodes of binge drinking (β –0.056 [95% CI –0.108 to –0.004]). Further, chronic lung disease was associated with a higher odds of using e-cigarettes (OR 1.39 [95% CI 1.19–1.63]). Binge drinking was associated with a higher odds of lifetime e-cigarette use in individuals without chronic lung disease (OR 1.018 [95% CI 1.00–1.037]); however, binge drinking was not associated with odds of lifetime e-cigarette use in individuals with chronic lung disease (OR 0.963 [95% CI 0.918–1.01]) (Table 3).

Discussion

Using the 2018 BRFSS dataset, our results indicate that chronic lung disease was associated with an increased odds of e-cigarette use in the U.S. adult population. This finding is consistent with prior research indicating that e-cigarette use was more prevalent in individuals with chronic lung disease than in individuals without chronic lung disease.[11] This finding may be related to the high rate of combustible

BINGE DRINKING, CHRONIC LUNG DISEASE, AND E-CIGARETTES

Table 1.   Sociodemographic Characteristics

Variable	Chronic Lung Disease Not Reported	Chronic Lung Disease Reported	Chi-Square Test	P
Respondents, n	209,104,888	4,708,808		
Gender			1,626.98	.001
Female	49.94	57.85		
Male	50.06	42.15		
Age, y			1,086.59	< .001
18–24	12.12	13.33		
25–34	17.83	15.60		
35–44	16.84	13.88		
45–54	16.54	15.62		
55–64	16.35	17.94		
≥ 65	20.32	23.62		
Annual income			4,336.09	< .001
< $15,000	9.132	15.21		
$15,000–$25,000	15.05	20.46		
$25,000–$35,000	9.966	10.79		
$35,000–$50,000	12.99	11.9		
≥ $50,000	52.86	41.65		
Chronic health conditions				
Stroke			3,406.39	< .001
No	97.22	93.00		
Yes	2.60	6.66		
Kidney disease			1,775.99	< .001
No	97.43	94.56		
Yes	2.57	5.44		
Skin cancer			613.17	< .001
No	94.21	91.87		
Yes	5.79	8.13		
Arthritis			1.05e + 04	< .001
No	77.55	59.98		
Yes	22.45	40.02		
Depressive disorder			1.37e + 04	< .001
No	85.03	67.28		
Yes	14.97	32.72		
Current smoking status			3,777.50	< .001
Noncurrent smoker	86.19	77.34		
Current smokers	13.81	22.66		
Cannabis use, mean (SD)	0.966 (4.817)	1.529 (6.104)	−14.54	< .001

Data are presented as percentages unless otherwise noted.

Table 2.   Lifetime E-Cigarette Use and Binge Drinking in Individuals With and Without Chronic Lung Disease

	No Reported Chronic Lung Disease	Reported Chronic Lung Disease	T-test/Chi-Square Test	P
Lifetime e-cigarette use, %				.001
No	79.05	69.64	2,021.60	
Yes	20.95	30.36		
Binge-drinking episodes in the past 30 d, mean ± SD	1.16 ± 3.83	1.45 ± 4.68	−12.330	< .001
Respondents, n	174,328	34,960		

Table 3. Weighted Multivariable Models of the Association Between Chronic Lung Disease and Lifetime E-Cigarette Use With Binge Drinking as a Moderating Variable

Results of Logistic Regression Model	β (95% CI)	Standard Error	P	Odds Ratio (95% CI)
Chronic lung disease	0.330 (0.171–0.489)	0.081	<.001	1.391 (1.186–1.631)
Binge drinking for those without chronic lung disease	0.018 (0.001–0.063)	0.009	.044	1.018 (1.00–1.037)
Binge drinking for those with chronic lung disease	−0.038 (−0086 to 0.010)	−1.54	.123	0.963 (0.918–1.01)
Chronic lung disease status × binge drinking frequency (interaction)	−0.056 (−0.108 to −0.004)	0.026	.033	0.945 (0.898–0.995)
Cannabis use	0.059 (0.01–0.049)	0.004	<.001	1.061 (1.052–1.069)
Cigarette smoking	2.121 (1.976–2.266)	0.074	<.001	8.336 (7.211–9.637)
Male	0.236 (0.121–0.351)	0.059	<.001	1.267 (1.129–1.421)
Age, y				
25–34	−0.886 (−1.091 to −0.682)	0.104	<.001	0.412 (0.336–0.505)
35–44	−1.615 (−1.823 to −1.407)	0.106	<.001	0.199 (0.162–0.245)
45–54	−2.038 (−2.259 to −0.1.818)	0.112	<.001	0.130 (0.104–0.162)
55–64	−2.427 (−3.327 to −2.857)	0.116	<.001	0.088 (0.070–0.111)
≥ 65	−3.092 (−3.327 to −2.857)	0.119	<.001	0.045 (0.0359–0.057)
Income				
$15,000–$25,000	0.151 (−0.127 to 0.429)	0.142	.286	1.163 (0.881–1.535)
$25,000–$35,000	0.197 (−0.076 to 0.470)	0.139	.159	1.217 (0.926–1.601)
$35,000–$50,000	0.384 (0.122–0.647)	0.133	.004	1.468 (1.129–1.909)
≥ $50,000	0.165 (−0.055 to 0.386)	0.112	.141	1.179 (0.946–1.471)
Chronic health conditions				
Stroke	−0.315 (−0.138 to 0.767)	0.231	.173	1.369 (0.871–2.153)
Kidney disease	−0.319 (−0.750 to 0.113)	0.220	.148	0.727 (0.472–1.119)
Cancer	−0.041 (−0.296 to 0.214)	0.130	.751	0.959 (0.474–1.238)
Arthritis	0.091 (−0.142 to 0.324)	0.119	.442	1.202 (1.037–1.395)
Depressive disorder	0.438 (0.295–0.581)	0.073	<.001	1.54 (1.343–1.788)
Intercept	−0.411 (−0.675 to −0.148)	0.134	.002	0.663 (0.509–862)

N = 27,170,843.

cigarette use among individuals with chronic lung disease.[25] It seems likely that individuals with chronic lung disease use e-cigarettes for the same reasons as other adults, such as to quit using or to reduce the harm of combustible cigarettes.[12,13] The increased frequency of e-cigarette use among participants with chronic lung disease may also be explained by a prominent model of addiction motivation described by Baker et al,[26] which contends that the avoidance or escape from negative effect may form the motivational basis for using substances such as e-cigarettes. Perhaps those with chronic lung disease turn to e-cigarettes to temporarily alleviate the emotional distress associated with their health condition.

We also noted that more frequent binge drinking was associated with e-cigarette use among adults, independent of chronic lung disease status. Notably, for those without chronic lung disease, binge drinking was associated with an increased likelihood of e-cigarette use. Consistent with this finding, a prior study reported that weekly, monthly, and occasional binge drinkers were more likely to use e-cigarettes than are non-binge drinkers.[27]

Contrary to our hypothesis, however, the association between chronic lung disease and e-cigarette use was weaker among those who reported more frequent binge-drinking episodes. Similar to e-cigarette use, binge drinking aggravates respiratory symptoms and decreases lung function parameters.[28] Thus, individuals with chronic lung disease who reported more frequent binge drinking may use e-cigarettes less frequently, despite an increased likelihood of having ever used e-cigarettes, due to concerns that e-cigarette use could further worsen the adverse pulmonary effects of binge drinking (perhaps as a result of direct experience).[28] Alternatively, individuals with chronic lung disease may be unaware of the lung damage caused by binge drinking and thus may consider binge drinking as a safer alternative to using e-cigarettes. Nevertheless, future experimental and longitudinal studies are necessary to explore this possibility.

Our study has 2 primary implications. First, because individuals with chronic lung disease are more likely to use e-cigarettes, targeted interventions ranging from cessation treatments (eg, nicotine replacement therapy and behavioral counseling) to public health messaging are needed to reduce this deleterious behavior in this population. Second, because individuals with chronic lung disease who do not use e-cigarettes may be more likely to engage in binge drinking, clinicians and public health professionals need to

carefully attend to alcohol consumption in this population, as this behavior may be easily overlooked considering the obvious relevance of inhaled tobacco products.

This study has a number of limitations. First, our findings are based on self-reported responses, which increase the potential for response bias. Chronic lung disease status was determined on the basis of a subjective measure, not a clinical diagnosis that would indicate the degree of severity and acuity. Second, we used a cross-sectional design, which provides a snapshot of what is occurring at the time of data collection and thus only allows conclusions about associations, not causality. Indeed, the temporal relationships between chronic lung disease, binge drinking, and e-cigarette use cannot be definitively established. Third, current e-cigarette use was not included in the analyses because it was endorsed by so few respondents (post hoc evaluation of current e-cigarette use as a dependent variable yielded no significant associations). Our primary outcome variable, lifetime e-cigarette use, further limited causal inferences insofar as, for many respondents, this outcome would have preceded the moderating variable of binge drinking. Fourth, the association between binge drinking and lifetime e-cigarette was modest, as was the modifying effect of binge drinking on the relationship between chronic lung disease and e-cigarette use; however, these small effects may be meaningful at the population level.[29] Fifth, we did not explore all possible interactions among tobacco, cannabis, alcohol, and e-cigarette use. These are topics for future research. Finally, the study findings are specific to people in the United States and may not be generalizable to populations in other countries.

Conclusions

In summary, our findings suggest that lifetime e-cigarette use is elevated among adults with a history of chronic lung disease. Our findings also indicate that binge drinking was positively associated with e-cigarette use among individuals without chronic lung disease, whereas the association was negative in individuals with chronic lung disease, even though binge drinking negatively moderates the relationship between chronic lung disease and e-cigarette use. The latter finding necessitates further study to determine causal mechanisms.

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