

# Perceptions and Use of E-cigarettes among Young Adults with Cystic Fibrosis: An Observational Study

SARAH RHOADS, MD; ROGER AUTH, MD; ALISON CHAMBERS, PhD; MICHAEL BLUNDIN, MD; LINDSEY MAHONEY, MD; SUZANNE MCLAUGHLIN, MD; DEBASREE BANERJEE, MD, MS

## ABSTRACT

While smoking prevalence has decreased among the general population, the use of electronic cigarettes (E-cigarettes) has risen significantly and can cause significant lung injury. We sought to determine if persons with cystic fibrosis (PwCF) have similar rates of E-cigarette use as compared with age-matched peers, and to understand perceptions of E-cigarette safety through a survey-based study. A total of 29 PwCF and 26 age-matched control patients participated in this study. There was no significant difference between PwCF and control patients regarding perceptions of the negative impact of E-cigarette use on one's health. Overall, both PwCF and control patients reported a good quality of life. PwCF were equally likely to identify E-cigarettes as harmful to one's lung health as healthy controls but were significantly more likely to have heard of EVALI. While small, our study has demonstrated the need for further education of both PwCF and healthy young adults.

**KEYWORDS:** vaping, EVALI, Cystic Fibrosis, cigarettes

## BACKGROUND

In the last several decades, smoking prevalence has decreased among the general population.<sup>1</sup> However, new generations of tobacco and non-tobacco products are being increasingly used, particularly in the young adult population.<sup>2</sup> Since their introduction in 2007, the use of electronic cigarettes (E-cigarettes), battery-powered devices that vaporize nicotine and marijuana, has risen significantly.<sup>3</sup> According to the Surgeon General's office, E-cigarettes are the most common tobacco product used by U.S. youth for the past 5 years and in 2018, more than 3.6 million youth used E-cigarettes.<sup>3</sup>

Tobacco product use amongst adolescents has significant implications for long-term morbidity and mortality. Users of tobacco products are more likely to report poor health, have higher rates of hospitalizations, and greater healthcare expenditures than never smokers.<sup>4</sup> Given current smoking rates, 5.6 million youth will die prematurely of smoking-related illness.<sup>4</sup>

While conventionally thought to be less harmful than traditional cigarettes, E-cigarettes can cause significant

lung injury requiring hospitalization and even endotracheal intubation for respiratory failure. Between 2018 and February 2020, there were 2800 reported cases of E-cigarette or Vaping Associated Lung Injury (EVALI) with 68 deaths.<sup>3,5</sup> This new entity is currently the subject of an ongoing CDC investigation as well as multiple General Advisories from the Surgeon General's office resulting in bans of E-cigarettes in several states.<sup>4,5</sup> EVALI is associated with a spectrum of acute lung injury including eosinophilic pneumonia, interstitial lung disease, diffuse alveolar hemorrhage, lipid pneumonia with pathology consistent with acute fibrinous pneumonitis, diffuse alveolar damage or organizing pneumonia, and bronchiolitis.<sup>6</sup> While the etiology of lung injury remains unknown, there are several possible culprits including Vitamin E acetate (VEA), a condensing agent frequently used by manufacturers to alter the consistency of vaping liquids.<sup>7</sup> VEA has been found in injured lung fluid samples from up to 94% of patients diagnosed with EVALI, and is thought to contribute to lung damage through multiple mechanisms, including disruption of surfactant membranes.<sup>7-10</sup> In addition to Vitamin E acetate, flavor additives and nicotine use have been implicated in the development of airway hyperreactivity, decreased antimicrobial activity, and decreased alveolar development.<sup>11</sup>

While the prevalence of E-cigarette use, and the rise of EVALI has been studied in the general population, to our knowledge there is no existing data about the prevalence of E-cigarette use in a population of patients with childhood onset chronic lung disease. Individuals with Cystic Fibrosis (CF), an inherited disease which causes progressive decline in lung function, offer a unique perspective on the impact of E-cigarette use. The condition is typically diagnosed before the age of 2, and currently has a life expectancy of 44 years in the United States.<sup>12</sup> This young population is aware of their respiratory vulnerability at an early age and typically has close connection with the healthcare system and high health literacy.<sup>13, 14</sup>

The general decline of tobacco product use over the past several decades has been attributed in large part to increased educational efforts among the general population. Research on smoking cessation in populations with chronic illnesses is more limited, but prior studies among PwCF suggest that the prevalence of cigarette smoking is lower than the general population (8% vs 27% of adults).<sup>15-18</sup> There is limited

understanding of what prompts the use of tobacco products among adolescents and adults with chronic illness, particularly PwCF.

According to the results of the 2020 National Youth Tobacco Survey (NYTS), a bi-annual nationwide assessment of over 14,000 adolescents, 26.8% reported using E-cigarettes on at least one occasion.<sup>19</sup> Of those who have tried E-cigarettes, 10% stated that the primary reason was that E-cigarettes were safer than other cigarette or tobacco products. For PwCF, E-cigarette use may be perceived as a safer alternative to cigarette use, and therefore less likely to cause deleterious effects on lung function. Despite growing awareness of the possible harms, several studies suggest that individuals who are not susceptible to cigarette smoking may be more likely to initiate E-cigarette use.<sup>20</sup> Tobacco product use in young adults is most frequently driven by social reasons such as peer pressure, as well as a desire for stress relief and the ready availability of tobacco products in their environment.<sup>21, 22</sup>

Given the compromised lung function of PwCF and the popularity of non-cigarette inhalation products, it is imperative to understand the prevalence of vaping in this population. While patients with worse lung function may be less likely to use traditional cigarettes, the lack of general awareness regarding the potential harms of E-cigarette use and the desire to fit in amongst peers may result in PwCF seeking out E-cigarettes as a less harmful alternative to traditional tobacco products. We hypothesized that PwCF have similar rates of E-cigarette use as compared with age-matched peers and were more likely to use E-cigarettes than conventional cigarettes.

## METHODS

We conducted a case-control observational study comparing PwCF and age matched patients from a Medicine-Pediatrics clinic (control).

**Case Definition:** PwCF seen at the Rhode Island Cystic Fibrosis Center between February 2020 and December 2020. PwCF who are on hospice or transplant waiting lists were not called.

**Control Definition:** Young adult patients of the Medicine-Pediatrics Primary Care Clinic that were age and sex matched +/- 2 years.

**Clinical Data:** The most recent spirometry data was collected from PwCF at the time of enrollment.

### Surveys used:

**E-cigarette use:** This survey was created from the CDC National Youth Tobacco Survey (NYTS) and National Adult Tobacco Survey (NATS).<sup>23, 24</sup>

**Social desirability:** The Marlowe-Crowne Social Desirability Scale (MC-SDS) was used to account for the effect of social desirability on respondents' answers.<sup>25</sup> The MC-SDS is a validated 33-item self-reporting tool designed to assess

respondents' concern with having social approval. A higher score indicates higher social desirability, and that a respondent may alter their response to provide a "good" answer.

**CF questionnaire revised (CFQR)<sup>26</sup>:** PwCF completed this questionnaire, a validated tool to assess overall and disease-specific quality of life.

**Quality of Life for Control:** This survey was completed by control participants. This survey was the MOS 36-item Short Form Health Survey (SF-36).<sup>27</sup>

Study design was approved by institutional IRB prior to data collection (IRB #1523061-5). Data was collected from February until December 2020 at Rhode Island Hospital. Study authors (SR, RA) administered the surveys in person and via telephone. These authors were physicians in training at time of survey administration and did not make clinical decisions regarding patient care to help mitigate participant hesitancy in reporting unhealthy behaviors. Participants were provided with a \$5 e-gift card following completion of the survey. Additional clinical data was collected on PwCF by chart review.

**Statistical Analysis:** Social desirability score category was compared between the group that reported using an E-cigarette and the group that reported no E-cigarette use using a Fishers exact test.

Using a generalized linear model, FEV1 % predicted was modeled as a proportion of the total possible FEV1 % predicted (100%: binomial distribution) and compared between the groups reporting E-cigarette use versus no E-cigarette use. Similarly, survey responses were modeled as binomial distributions and compared between the group that reported using E-cigarettes and the group that reported no E-cigarette use. From the models, estimated mean FEV1 and reported lung function were determined and compared between the two groups. P-values <0.05 were reported as significant.

As an additional check to survey responses, a generalized linear model was used to model survey responses (binomial distribution) to check the association between reported lung function and tested FEV1. P-values less than 0.05 were reported as a significant relationship between FEV1 and survey outcomes. Classic sandwich estimation was used to adjust for any model misspecification. All models were run using Proc Glimmix, allowing for modeling of generalized linear models and deriving p-values for model fixed effects and mean group comparisons (SAS: Version 9.2; SAS Institute Inc, Cary, NC)

## RESULTS

### Demographics

A total of 29 PwCF and 26 age-matched control patients of the Medicine-Pediatrics clinic participated in this study. 62 adult patients (out of 67) of the Cystic Fibrosis Center were called up to three times or approached in clinic to complete the study. Twenty-nine PwCF did not return calls and four

declined participation. Twenty-nine Medicine-Pediatrics clinic patients were then identified, of whom three declined participation (Figure 1). Participants were predominantly male. The average age for study participants was 30 for PwCF and 28 for control subjects. Among PwCF, there was a mean FEV1 % predicted of 63% (Table 1).

Figure 1. Patient Participation Flow Diagram

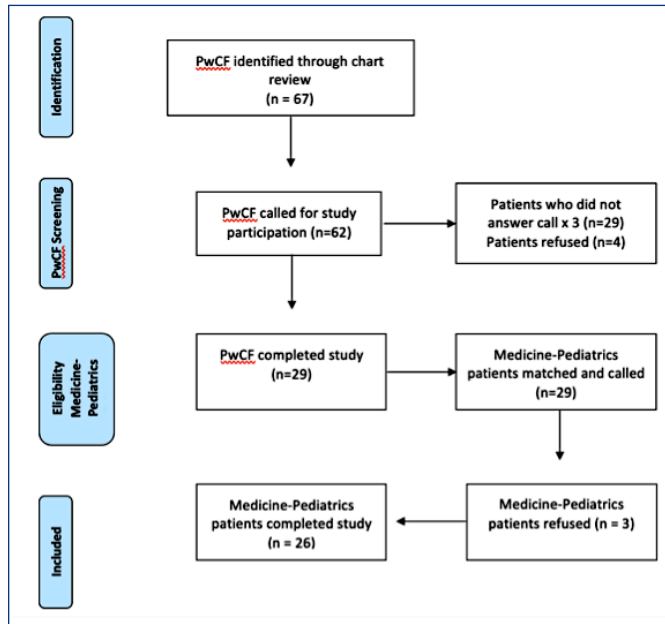


Table 1. Patient Demographics

Patient Characteristics	PwCF (n = 29)	Non-CF (control, n = 26)
Age (mean, range in years)	30.3 (18–49)	26.8 (18–40)
Sex, Female N (%)	13 (45)	10 (38)
BMI (mean)	22.9	27.0
FEV1 (% average, range)	63 (23–100)	
Modulator therapy (% taking)	89.7%	
Non-CF Lung Disease	4 (2 asthma, 1 MAC, 1 ABPA)	2 (mild intermittent asthma, 7.7%)
Pseudomonas aeruginosa sputum culture (%)	18 (62%)	
Lung transplant recipient (%)	2 (6.9%)	
CF Exacerbation Prior Year (%)	5 outpatient (17%), 16 inpatient (55%)	
Anxiety Diagnosis (%)	16 (55%)	15 (57.9%)

MAC = Mycobacterium avium complex.  
ABPA = Allergic Bronchopulmonary aspergillosis

Social desirability

Social desirability was categorized as low scorers (0–8: more willing than most people to respond truthfully), average scorers (9–19: average degree of conformity), and high scorers (20–33: highly concerned about social approval).

Three respondents among PwCF didn’t answer all the social desirability questions. However, given their completed responses and assuming negative or positive responses to the questions they didn’t answer, participants were categorized as average responders.

No significant difference was detected in social desirability responses between the PwCF participants who reported trying E-cigarettes and those who reported never trying E-cigarettes (p=0.2076). Approximately half of high scorers among PwCF reported never trying an E-cigarette (11/26) and there were no high scorers (0/3) among PwCF who reported having tried E-cigarettes (Table 2).

Perceptions of Health

Both PwCF and patients of the Medicine-Pediatrics clinic were asked to rate their overall health on a scale of 1–4, with 4 being excellent. PwCF and control participants reported similar overall health (2.8 in PwCF vs 2.9 in control). There was a positive correlation between FEV1 % predicted and participant-reported activity tolerance for PwCF (p = 0.0085) (Figure 2). FEV1 % predicted correlated with self-perceived ability to breathe among all PwCF, irrespective of E-cigarette use (p=0.0498).

Figure 2. Correlation between CFQR and FEV1 for patients with CF

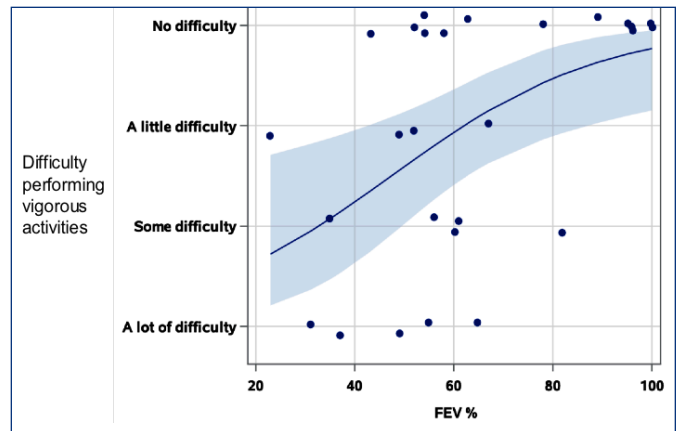


Table 2. Participant-Reported Tobacco Product Use

Tobacco Product Use	PwCF (n = 29)	Non-CF (control, n = 26)
Active smokers	0	0
Former use of conventional cigarette	6 (20.6%)	7 (27%)
Tried any E-cigarette product	3 (10.3%)	7 (27%)

### Conventional cigarette use vs E-cigarette use

Among control participants, an equal number have used conventional and electronic cigarettes (n=7, 27% each). For PwCF, however, twice as many individuals reported using conventional cigarettes as compared to E-cigarettes (n=6, 20.6% vs n=3, 10.3%). Among PwCF, 20% have tried conventional cigarettes at least once. There was no significant difference between PwCF and healthy controls' report of conventional cigarette use.

### FEV1% predicted and E-cigarette Use

FEV1% predicted for PwCF who reported trying E-cigarettes was higher than the group that reported never trying an E-cigarette (83.7% [54.4, 95.7] versus 60.4% [51.4, 68.7] FEV1% predicted). This difference did not reach significance (p=0.1088).

PwCF that used an E-cigarette reported a significantly better ability to breathe than those who had never tried an E-cigarette (mean 100 [100, 100] versus [76.8, 96.6], respectively, p<0.0001). The correlation between FEV1% predicted and question 44, 'Have you been wheezing?' approached significance but did not reach it (p=0.0566)

### Perceptions of E-cigarette use

There was no statistically significant difference between PwCF and Medicine-Pediatrics patients regarding perceptions of the negative impact of E-cigarette use on one's health. There was also high agreement between PwCF and the control population with regards to the increased impact of E-cigarettes on the health of individuals with existing chronic lung disease. The two groups differed, however, in their estimation of the time required to demonstrate evidence of lung damage from E-cigarette use, with the majority of PwCF identifying lung health as affected within one year of use (n = 25, 86%), compared with only 39% of healthy controls (n = 9). To date, there is no clear timeline for the development of EVALI, although frequent (>5 times daily) use of E-cigarettes has been associated with increased risk.<sup>5</sup> Interestingly, the majority of PwCF indicated prior knowledge of EVALI (n = 21, 72.4%) but a significantly smaller number of healthy controls indicated that they had heard of EVALI prior to study enrollment (n = 5, 21.7%) (Table 3).

**Table 3.** Perceptions of E-Cigarette Use

Perceptions of E-Cigarette Use Impact	CF (n = 29)	Non-CF (control, n = 23*)
Impact of electronic cigarettes on individuals' health (0-100, 100 being significant negative impact)	86.6	80.3
Impact of electronic cigarettes on those with chronic lung disease (0-100, 100 significantly worse impact)	88.1	85.5
Length of time for electronic cigarettes to affect health	82.7% (24/29) said e-cigarette use would affect lung health within one year	39% (9/23) said e-cigarette use would affect lung health within one year
Heard about EVALI	72.4% (21/29)	21.7% (5/23)

\*3 individuals did not respond to these specific questions

### CONCLUSIONS

This single-center observational study helps to clarify the use and perceptions of E-cigarette use among young adults, both with CF and without this illness, as well as highlight general perceptions of health among these populations. Overall, both PwCF and our control population reported a generally good quality of life with regards to their physical health. This is consistent with national data for this age group, but our PwCF population had much higher quality of life metrics compared with many young adults with chronic diseases, who overwhelmingly tend towards lower reported quality of life.<sup>28,29</sup> The overall quality of life reported by PwCF correlated positively with the individuals' lung function as measured by FEV1% predicted, consistent with known data regarding lung function and quality of life, which supports the internal validity of our study.<sup>30</sup>

With regards to conventional cigarette use, the control population indicated cigarette use at a prevalence comparable to the national population.<sup>1</sup> PwCF were less likely to use cigarettes which is consistent with prior studies.<sup>17</sup> While the control population indicated E-cigarette use comparable with or slightly above national data, fewer PwCF reported E-cigarette use compared to conventional cigarettes. These findings demonstrate that PwCF are less likely than their counterparts without CF to use any inhalational products. This may be due to PwCF being acutely aware of their lung function and being engaged in the healthcare system from an early age. Counter to our hypothesis, PwCF were more likely to use conventional cigarettes than E-cigarettes. Further studies are needed to better understand why this might be the case.

PwCF were equally likely to identify E-cigarettes as harmful to one's lung health as healthy controls but were more likely to identify harm occurring within one year of E-cigarette use and were significantly more likely to have heard of EVALI than control peers. This discrepancy may be due to the newer development of E-cigarettes, and exposure among PwCF to more recent media coverage on the risks of EVALI, particularly compared with the anti-smoking campaigns of the early 2000s. EVALI is also promoted as affecting a younger population compared with conventional cigarettes, which may influence PwCF's choice on initiation of inhaled products.

While the low prevalence of E-cigarette use amongst PwCF may be reassuring to providers caring for this patient population, the use of conventional cigarettes amongst this group and the prevalence of use in the control population indicates a need for targeted assessment and education on inhalational product use.

Interestingly, PwCF expressed greater knowledge regarding EVALI. The lack of knowledge in the control population indicates that educational tools on the detrimental effects of E-cigarettes are also needed for healthy adolescents and young adults.

Limitations of this study include its small sample size, single-center and retrospective design. We did not have coincident FEV1% predicted data and E-cigarette or conventional cigarette use, nor was chronicity of use assessed. Participants willing to engage in a telephone-based survey may have self-selected and thus may not be truly representative of the population. While the state of Rhode Island has had <10 cases of EVALI according to CDC data, the rates of EVALI may be variable between different states and thus may limit generalizability.

This is the first study to our knowledge to look at the use and perceptions of E-cigarette use amongst young adults with CF, a progressive lung disease in which the mainstay of care is the preservation of lung function. While small, our study has demonstrated the need for further education of both PwCF and healthy young adults regarding E-cigarette use and conventional cigarette use and the potential impact on their health.

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### Authors

Sarah Rhoads, MD, Pulmonary Sciences and Critical Care Medicine, University of Colorado, Denver, CO

Roger Auth, MD, Department of Medicine, Alpert Medical School of Brown University, Providence, RI

Alison Chambers, PhD, Department of Medicine, Alpert Medical School of Brown University, Providence, RI

Michael Blundin, MD, Department of Medicine, Alpert Medical School of Brown University, Providence, RI

Lindsey Mahoney, MD, Internal Medicine-Pediatrics Program, Alpert Medical School of Brown University, Providence, RI

Suzanne McLaughlin, MD, Internal Medicine-Pediatrics Program, Alpert Medical School of Brown University, Providence, RI

Debasree Banerjee, MD, MS, Department of Medicine, Alpert Medical School of Brown University, Providence, RI

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### Disclosures

We confirm that there are no Conflicts of Interest or disclosures to report for all authors of this study.

### Correspondence

Debasree Banerjee, MD, MS  
 Division of Pulmonary, Critical Care & Sleep Medicine  
 Rhode Island Hospital  
 593 Eddy Street, POB Suite 224  
 Providence, RI 02903  
 401-444-4191  
 Fax 401-444-0094  
[debasree\\_banerjee@brown.edu](mailto:debasree_banerjee@brown.edu)