Published in final edited form as:

Tob Control. 2021 January ; 30(1): 103–107. doi:10.1136/tobaccocontrol-2019-055338.

Impact of e-cigarette use among a cohort of American Indian cigarette smokers: associations with cigarette smoking cessation and cigarette consumption

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Abstract

Introduction—Despite American Indian/Alaska Native (AI/AN) people having the highest prevalence of cigarette smoking nationwide, few studies have evaluated e-cigarette use among AI/AN adults who smoke. The primary objective of this observational pilot cohort study was to determine if e-cigarette use is associated with cigarette smoking cessation or reduction among adult AI individuals who smoke.

Methods—In 2016, we collected baseline survey and biomarker data among AI adults who smoke. The survey included questions about cigarette consumption and use of e-cigarettes and biomarkers, such as salivary cotinine markers and exhaled carbon monoxide. After 18 months, we repeated data collection, and asked about changes in cigarette smoking status and cigarettes per

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Competing interests JDD, coauthor, receives salary and equity interests from Bayesic Technologies.

Patient consent for publication Not required.

Ethics approval This study was approved by the Institutional Review Boards from Cherokee Nation and the University of Oklahoma Health Sciences Center.

Provenance and peer review Not commissioned; externally peer reviewed.

day (CPD). Comparisons between groups were performed using the χ^2 test, Fisher's exact test or Wilcoxon rank-sum test.

Results—Of 375 baseline participants, 214 (57.07%) returned for follow-up and were included in analyses. Of these, 20 (9.3%) reported having stopped cigarette smoking and had biochemical verification of cigarette smoking abstinence. Among those who quit smoking, 15% were baseline e-cigarette users; while among those who continued to smoke at follow-up, about 11% were baseline e-cigarette users. This difference was not statistically significant (p=0.48). Among all those who continued to smoke at follow-up, there was no overall decrease in CPD, nor a significant difference in change in CPD between baseline e-cigarette users and non-users (p=0.98).

Conclusions—E-cigarette use at baseline was not associated with smoking cessation or a change in CPD in this cohort of AI adults who smoke after an 18-month follow-up period.

INTRODUCTION

E-cigarettes are increasingly popular and are often used as a way to quit or reduce cigarette smoking,[12] even though the US Food and Drug Administration has not approved such products as cigarette smoking cessation aids.[3] E-cigarettes create a vapour by heating a liquid that usually contains nicotine, flavourings and other chemicals.[4] E-cigarettes may resemble conventional tobacco products or may even resemble items, such as pens or USB memory sticks.[4] Common names for e-cigarettes include e-cigs, vapes, vape pens, vape pods, or mods and tank systems.[4] E-cigarettes may be potentially beneficial as harm reduction devices since e-cigarettes are thought to have substantially lower levels of toxicants, including carcinogens, compared with conventional cigarettes.[56] However, on initial e-cigarette use, many people who smoke do not switch completely to e-cigarettes. Instead, they use e-cigarettes and cigarettes concurrently.[67]

E-cigarette use and its association with cigarette smoking cessation is a rapidly growing area of research. So far, research regarding this association has been mixed.[6] Some longitudinal studies have indicated that e-cigarette use is associated with cigarette smoking cessation[8] or reduction in cigarettes smoked per day (CPD).[89] Yet, other studies have shown no association with either cigarette smoking cessation[910] or reduction in CPD.[10] One study indicated that intense e-cigarette use rather than intermittent or experimental e-cigarette use is associated with cigarette smoking cessation.[11]

Despite indigenous populations having higher prevalence of cigarette smoking compared with non-indigenous populations,[12] very few studies have evaluated e-cigarette use among American Indian/Alaska Native (AI/AN) adults.[713–15] Evaluating the cigarette smoking cessation implications of e-cigarette use in this population is of importance because AI adults have a lower cigarette smoking cessation and higher cigarette smoking relapse rates compared with other populations.[16–18] Racial minority groups also have lower prevalence/rates of use of nicotine replacement therapy compared with non-Hispanic whites.[1920] AI/AN individuals who smoke report the lowest utilisation of tobacco quit aids including the use of nicotine products, cigarette smoking cessation medication, telephone quit lines or support groups compared with other racial groups.[16] Thus, the effect of e-cigarette use on cigarette smoking cessation among AI/AN individuals may not be comparable to other populations.

The primary objective of this study was to determine if baseline e-cigarette use affects cigarette smoking cessation or reduction in CPD among AI cigarette smokers over an 18-month period.

METHODS

Setting

Oklahoma has one of the highest numbers of e-cigarette retailers in the nation and 27% of all Oklahomans have tried e-cigarettes at least once in their life.[2122] The state is also home to 39 tribes and has one of the largest AI populations in the USA.[23]

Headquartered in Tahlequah, Oklahoma, Cherokee Nation encompasses 14 predominantly rural counties in northeastern Oklahoma. Approximately 1419000 Cherokee citizens reside in the area under tribal administration.[24]

Cherokee Nation operates the Cherokee Nation Health Services (CNHS), the largest tribally operated healthcare system in the USA. Patients must show proof of AI/AN descent, such as possession of a Certificate of Degree of American Indian or Alaska Native Blood card from a federally recognised tribe, to receive services at CNHS. Whereas Cherokee Nation citizens comprise the largest group of patients seen in the CNHS, patients from more than 300 AI tribes are seen at CNHS facilities.

Sample population

Research staff recruited the study cohort from a high-traffic waiting area within Cherokee Nation's W.W. Hastings primary care outpatient facility in Tahlequah, Oklahoma, in 2016. Details of the setting, sample, baseline recruitment, data collection methods and baseline results have been previously reported.[15] During baseline data collection, participants provided contact phone numbers (home, work and cell), home addresses, email addresses and contact information (phone and email) of two relatives or friends. Research staff sent reminder letters for the 18-month follow-up survey data collection dates at 4, 8, 12 and 17 months after baseline data collection. For participants who did not show up for their 18-month follow-up survey collection date, research staff called, mailed and emailed them to inform them about additional data collection dates. For participants who had missing, wrong or incorrect contact information, research staff attempted to contact the listed relative or friend to inform the participant about the follow-up survey. Participants who completed the 18-month follow-up survey and biomarker data collection received a US$40 department store gift card. The number of participants at baseline was 375. This sample size was calculated assuming an estimated prevalence of 26% of e-cigarette use at baseline with a margin of error in a 95% CI of 4.4%. Of the 375 baseline participants, 215 (57.3%) returned for follow-up data collection. Of those who returned for follow-up, 1 individual was excluded from analyses due to missing cigarette smoking cessation status. All participants provided written informed consent prior to data collection.

Main dependent variables

The main dependent variables included cigarette smoking cessation, as defined by self-report and biochemically verified smoking abstinence, and CPD. All respondents were current cigarette smokers at baseline (smoking at least 100 cigarettes in lifetime and smoked at least one cigarette in the previous 30 days). Follow-up cigarette smoking status was assessed with the question, 'In the past 30 days, how many cigarettes per day did you usually smoke? (1 pack is about 20 cigarettes)'. Respondents were given the option to input number of cigarettes per day or check 'I have not smoked in the past 30 days.' Cigarette smoking cessation was defined as self-reported abstinence from cigarettes for at least 1 month. Confirmation of self-reported abstinence was biochemically verified using an exhaled carbon monoxide level of less than 6 ppm. This level has been shown to be a good indicator of cigarette smoking abstinence.[25] CPD were calculated based on the question, 'How many cigarettes per day did you usually smoke? (1 pack is about 20 cigarettes)'. We then computed the difference between the baseline and follow-up responses for each individual.

Main independent variable

The main independent variable was e-cigarette use (yes/no) at baseline. Status of e-cigarette use at baseline was assessed with the following questions during the baseline survey: 'Have you ever vaped or used an e-cig, even one or two times?' and 'On how many of the past 30 days did you use an e-cig or vape even one or two times?' These questions were preceded by the following description of e-cigarettes and vaping: 'Vaping refers to using products that create a vapour that is inhaled, such as electronic cigarettes (e-cigs). There are three major kinds of e-cigs, also known as vapes.' We also included pictorial examples of the three major kinds: cigalike, tank system and modified tank systems. Pictorial e-cigarette products were provided to help respondents recognise e-cigarette products.[26] Individuals were considered baseline e-cigarette users if they reported e-cigarette use within the past 30 days. Individuals were considered non-e-cigarette users at baseline if (1) they had ever used e-cigarettes, but did not use within the past 30 days or (2) had never used e-cigarettes, even one or two times.

Covariates

Baseline characteristics were used to define covariates. We included variables that have previously been associated with cigarette smoking cessation, attempted cessation or use of e-cigarettes.[2728] We also included variables that were found to be significant in our previous analyses.[15] Age groupings were categorised as years 18–44 and 45+. Sex was categorised as male or female. Education was defined as the highest level of school completed and categorised as: less than high school versus more than or equal to high school graduate/GED. Household income was defined as annual household income from all sources and was categorised as≤=US$309000 and >US$309000. Marital status was categorised as married or living with partner (yes) versus divorced/separated/widowed/single (no). Respondents self-reported their health status as excellent, very good, good, fair or poor. Those reporting excellent, very good or good health were grouped for analysis to compare with fair/poor. Chronic medical history was dichotomised (yes/no) based on respondent's self-reported

history of having any one or more of the following: cancer, cardiovascular or heart disease, diabetes, chronic obstructive pulmonary disease or emphysema. History of depression was dichotomised (yes/no) based on self reported history of having had a diagnosis of depression. Other tobacco use (yes/ no) was based on baseline use of the following: cigars, cigarillos, filtered cigars, hookahs or dissolvable tobacco. Participants who reported daily, weekly or monthly use of any of the above listed other tobacco products were categorised as yes. Intention to quit smoking was based on the question, 'How soon are you likely to quit smoking?' Individuals who reported a likelihood of quitting within the next 30 days, within the next 6 months or within a year were classified as intending to quit smoking (yes). Individualsw owho reported: More than a year or I am not likely to quit smoking were classified as not intending to quit smoking (no). Participants provided saliva samples to determine salivary cotinine levels. Methods for collecting and analysing salivary cotinine levels were previously publish[ed].15 We also included a variable looking at frequency ofe-cigarette use at baseline. Participants answered the following question: 'On how many of the past 30 days did you use a-e- cig or vape even one or two times?' Participants were provided the following options and the variable was categorised as follows: 0 days, 1–10 days, 10–20 days and 21–20 days.

Statistical analyses

Data were descriptively summarised (count, percentage, median and IQR). Comparisons between groups were performed by using the χ^2 test for independence (or Fisher's exact test in the presence of small cell counts) for categorical variables and the Wilcoxon rank-sum test for continuous variables. Given the exploratory nature of this study, p-values were not adjusted for multiple testing. Missing data were not imputed. A two-sided p-value of <0.05 defined statistical significance. All statistical analyses were conducted in R (V.3.5.1).

RESULTS

Compared with participants who returned for follow-up persons who did not return were significantly younger but did not differ by sex, income or education (online supplementary table S1). They also had significantly higher baseline cigarette consumption but similar cotinine levels, and a higher prevalence of e-cigarette use at baseline (online supplementary table S1).

Table 1 presents the sociodemographic and tobacco-related characteristics by cigarette smoking cessation status of those who provided follow-up data. Of the 214 adults whose cigarette smoking cessation status could be determined at follow-up, 20 (9.3%) participants quit smoking cigarettes by the 18-month follow-up period. Among those who quit cigarette smoking, 15% were e-cigarette users at baseline. Among those who did not quit cigarette smoking, about 11% were e-cigarette users at baseline. This difference was not statistically significant (p=0.48). Baseline frequency of days of e-cigarette use was also not significantly different between those who quit smoking and those who did not. Participants who quit smoking cigarettes did not differ significantly from those who continued to smoke on any of the baseline sociodemographic characteristics. However, participants who quit cigarette smoking had lower baseline salivary cotinine levels (p=0.02) when compared with those

who did not quit cigarette smoking. Additionally, persons who quit were more likely to report an intention to quit cigarette smoking at baseline compared with those who did not quit ($p<0.01$).

Table 2 presents the change in CPD by baseline sociodemographics and tobacco-related characteristics among those who did not quit at the time of follow-up data collection. Among the 194 non-quitters, 185 reported their number of CPD for both baseline and follow-up. Overall, there was no change in CPD among these 185 participants. There was no statistically significant difference in change of CPD among current and non-current e-cigarette users at baseline ($p=0.98$). Income and marital status were the only variables that were significantly related to a change in CPD ($p<0.05$).

DISCUSSION

We did not detect a significant association with current e-cigarette use at baseline and biochemically verified cigarette smoking cessation after an 18-month follow-up period. There was also no statistically significant difference in frequency of baseline e-cigarette use among those who quit cigarette smoking compared with those who did not quit cigarette smoking. Further, we did not find a difference in change of CPD based on e-cigarette use at baseline. Our findings on cigarette smoking cessation are comparable to several previous studies[929–32] but different from others.[33] Additionally, studies have found mixed results regarding the association of e- cigarette use with a reduction in CPD. Some studies have found that dual use of cigarettes and e-cigarettes was associated with a decrease in CPD[93134–36]; while another found no association with e- cigarettes and change in CPD.[37]

Even though our findings that e-cigarettes did not affect cigarette smoking cessation or reduction in cigarette consumption among this population, our previously reported baseline analyses suggest e-cigarette use is associated with intentions to quit cigarette smoking and having a previous quit attempt.[15] Other studies have found similar results showing an association between readiness to quit, previous quit attempts and e-cigaretteuse.[38–41] While more research is needed to ascertain the association between e-cigarette use and cigarette smoking cessation, clinicians should be aware that e-cigarette use may be an indication that some cigarette smokers use them in hopes of quitting smoking. However, more research is needed to better understand how e-cigarettes may mitigate or modify readiness to quit smoking. This is particularly salient, as our study showed that baseline intentions to quit smoking cigarettes was one of the few characteristics associated with cigarette smoking cessation after an 18-month follow-up; yet, baseline e-cigarette use did not show a significant association with cessation. Research using a larger sample size would be needed to better understand what role, if any, e-cigarettes have in the pathway from intentions to quit to actual cigarette smoking cessation.

As this was an observational pilot study, this study has several limitations, including differences between participants who did not return for follow-up and those who did. Particularly, the proportion of persons who were e-cigarette users at baseline was higher for persons who did not return compared with persons who did return. This may bias the results of our study if e-cigarette users were either more likely or less likely to quit cigarette

smoking after 18 months. Another limitation is that the retention for our study was 57.6%. Nevertheless, this retention rate was similar or better than reported in other cohort studies.[810113133] Another limitation is that most of the measures used in these analyses were based on participant self-reported information. Thus, results may have been affected by recall bias. However, we used an accepted method to biochemically verify cigarette smoking cessation, the major outcome of interest.

Additionally, we used a convenience sample of AI cigarette smokers at the Cherokee Nation hospital outpatient clinic, which may limit the generalisability. However, one advantage of using clinic-based sampling is that this primary care setting could serve as an important platform for cigarette smoking cessation services among users of both e-cigarettes and cigarettes. In other words, primary care clinics provide ideal settings for future follow-up research and tobacco cessation interventions. Because of the small sample size for the cigarette smoking cessation group, we did not attempt multivariate analyses accounting for baseline characteristics that differ between those who quit and those who did not. Despite these limitations, this is the first longitudinal study to evaluate e-cigarette use among AI adults who smoke in a geographic region of the USA with a high prevalence of both cigarette smoking and e-cigarette use.[21] More importantly, this pilot study showed that it was feasible to recruit and retain AI smokers that would be necessary to conduct future successful research projects. This pilot project provides data that could be used for future larger longitudinal studies studying the effect of e-cigarettes on smoking cessation. It also provides important information that could be used to develop effective cigarette smoking cessation interventions among AI smokers.

In conclusion, current use of e-cigarettes at baseline was not associated with smoking cessation or a change in CPD among AI adults who smoke after an 18-month follow-up period. Future studies should include a more consistent definition of e-cigarette use and account for intensity of use and reasons for use to fully understand e-cigarette's potential role in reducing smoking rates. Although our research, at this time, does not suggest e-cigarette use is effective as a cigarette smoking cessation aid among a smoking population, identifying e-cigarette users among this population may be an effective way to identify those who are more interested in cigarette smoking cessation, as our baseline study indicated.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

The authors acknowledge the research staff at Cherokee Nation, University of Oklahoma, and the staff at the University of Oklahoma Health Sciences Center for their support of this project.

Funding

This project was supported by grants (P20CA202921, 5P20CA202923 and U54GM104938) from the National Institutes of Health.

Data availability statement

No data are available.

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What this paper adds

- This is the first study, to our knowledge, that observes the effect of e-cigarettes on cigarette smoking cessation among American Indian adults, a population with a high prevalence of tobacco use.
- Using biochemically verified cigarette smoking cessation and survey data, we found that e-cigarettes were not associated with cigarette smoking cessation or reduction in cigarettes smoked per day in this sample of American Indian adults who were current cigarette smokers at baseline.
- While e-cigarette use was not associated with cigarette smoking cessation or reduction in cigarettes per day, more research is needed to better understand the role e-cigarettes may have on cigarette smoking cessation and readiness for cigarette smoking cessation among American Indian populations.

Table 1

Sociodemographic and tobacco-related characteristics by smoking cessation status of an American Indian cigarette smoker cohort

	Overall (N=214)	1. Quit (n=20)	2. non-quit (n=194)	P-value
Age group				0.49 *
18–44 years	114 (53.27%)	9 (45.00%)	105 (54.12%)	
45+years	100 (46.73%)	11 (55.00%)	89 (45.88%)	
Sex				1.00 *
Female	135 (63.08%)	13 (65.00%)	122 (62.89%)	
Male	79 (36.92%)	7 (35.00%)	72 (37.11%)	
Education level				1.00 *
Less than HS	41 (19.16%)	4 (20.00%)	37 (19.07%)	
≥HS	173 (80.84%)	16 (80.00%)	157 (80.93%)	
Income category				0.39 *
US$0–USS30K	166 (78.67%)	14 (70.00%)	152 (79.58%)	
>US$30K	45 (21.33%)	6 (30.00%)	39 (20.42%)	
Marital status				0.64 *
Yes	123 (57.75%)	13 (65.00%)	110 (56.99%)	
No	90 (42.25%)	7 (35.00%)	83 (43.01%)	
Chronic medical history				0.07 *
Yes	95 (51.35%)	12 (75.00%)	83 (49.11%)	
No	90 (48.65%)	4 (25.00%)	86 (50.89%)	
History of depression				0.45 *
Yes	82 (39.81%)	9 (50.00%)	73 (38.83%)	
No	124 (60.19%)	9 (50.00%)	115 (61.17%)	
Other tobacco use				0.51 *
Yes	32 (14.95%)	4 (20.00%)	28 (14.43%)	
No	182 (85.05%)	16 (80.00%)	166 (85.57%)	
CPD				
Median (25% to 75%)	10 (6 to 20)	6.5 (1.75 to 20)	10 (6 to 20)	0.07t
Salivary cotinine levels				
Median (25% to 75%)	316.7 (87.6 to 527.4)	90.9 (0.9 to 376.1)	333.6 (108.4 to 529.2)	0.02 †
Intent to quit smoking ‡				<0.01 *
Yes	113 (53.05%)	16 (84.21%)	97 (50.00%)	
No	100 (46.95%)	3 (15.79%)	97 (50.00%)	
Baseline e-cigarette use				0.48 *
Yes	24 (11.21%)	3 (15.00%)	21 (10.82%)	
No	190 (88.79%)	17 (85.00%)	173 (89.18%)	
Baseline e-cigarette frequency				0.61 †
0 days	190 (88.79%)	17 (85.00%)	173 (89.20%)	

	Overall (N=214)	1. Quit (n=20)	2. non-quit (n=194)	P-value
1–10 days	13 (6.07%)	2 (10.00%)	11 (5.70%)	
10–20 days	6 (2.49%)	1 (5.00%)	5 (2.60%)	
21–30 days	5 (2.33%)	0 (0.00%)	5 (2.60%)	

[*] χ^2 test or Fisher's exact test.

[†] Wilcoxon rank-sum test.

[‡] Refers to quilting smoking only (not necessarily all tobacco products).

CPD, cigarettes per day; HS, high school.

Table 2

Change in CPD among American Indian cigarette smokers over an 18-month period

	Change in CPD, median (25% to 75%)	P-value
Overall	0 (−5 to 1)	
Age group		0.58
18–44 years	−0.3 (−4.8 to 2.4)	
45+ years	0 (−5 to 0.5)	
Sex		0.26
Male	−1 (−10 to 2.0)	
Female	0 (−4.3 to 1.0)	
Education level		0.42
Less than HS	−1 (−7.4 to 0)	
≥HS	0 (−5 to 1.5)	
Income category		0.02
US$0–US$30K	−0.5 (−6 to 0)	
>US$30K	0 (−2.3 to 4.5)	
Marital status		0.02
Yes	0 (−3 to 2.1)	
No	−1.5 (−8.5 to 0)	
Chronic medical history		0.56
Yes	0 (−5.3 to 1)	
No	0 (−4 to 1)	
History of depression		0.06
Yes	0 (−5 to 0)	
No	0 (−5 to 3)	
Other tobacco use		0.81
Yes	0 (−10 to 2.9)	
No	0 (−5 to 0.5)	
Intent to quit smoking (1 year)		0.81
Yes	0 (−5 to 1.5)	
No	0 (−4 to 1)	
Baseline e-cigarette use		0.98
Yes	0 (−10.5 to 3)	
No	0 (−5 to 1)	

CPD, cigarettes per day; HS, high school.