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Short communication

Motives for using electronic nicotine delivery systems (ENDS) as a cessation tool are associated with tobacco abstinence at 1-year follow-up: A prospective investigation among young adults in the United States Air Force

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ABSTRACT

Introduction: Smokers use electronic nicotine delivery systems (ENDS), including e-cigarettes, as a harm reduction strategy even though the Food and Drug Administration (FDA) has not approved them for tobacco cessation. The limited literature about ENDS use for cigarette cessation is concerning for the U.S. military, which is largely comprised of young adults at increased risk for tobacco use. Thus, the current study aims to evaluate use of ENDS products as a cessation tool in relation to point-prevalence tobacco abstinence at one-year follow-up in a cohort of 8,901 U.S. Air Force personnel attending entry-level job training from March 2016 to April 2019.

Methods: A propensity-score adjusted multinomial logistic regression model was used to assess the association between the baseline motives for ENDS use (i.e., for cigarette cessation versus alternative reasons) and tobacco use at the one-year follow-up (cigarette use, non-cigarette tobacco product use, and tobacco abstinence) among those reporting history of cigarette use at baseline.

Results: Smokers reporting ENDS use for cigarette cessation were more likely to be abstinent at one-year follow-up (Odds Ratio[OR] = 1.62, 95% CI: 1.06–2.49, P =.03) as well as quit using non-cigarette tobacco products (OR = 2.11, 95% CI: 1.65–2.70, P <.001) than those reporting ENDS use for alternative reasons.

Conclusions: Current tobacco users are recommended to use FDA-approved products for smoking cessation, such as nicotine replacement therapy. However, given the high prevalence of cigarette use among military populations, ENDS may provide a useful alternative harm reduction strategy for this high-risk population.

1. Introduction

Military personnel have historically high levels of tobacco use compared to the general population of U.S. adults. (Little et al., 2015; Meadows et al., 2018) Cultural, economic, and environmental factors drive this disparity. (Kong et al., 2022; Smith and Malone, 2009; Little et al., 2021) The first year of service is a high-risk period for incident tobacco use among military personnel, with around 10% initiating cigarette use for the first time after the tobacco ban that is enforced during entry-level training is lifted. (Little et al., 2019) This same study found that the majority of former cigarette smokers (64.1%) and former smokeless tobacco users (60.6%) re-initiate use following this ban. However, little is known regarding what strategies Airmen (i.e., a generic term used to describe Air Force personnel regardless of rank, gender, or specialty) are using to maintain their abstinence after they are eventually allowed to choose whether to use/resume tobacco after several months of entry-level military training. Given that the prevalence estimates for electronic nicotine delivery systems (ENDS) have been observed as high as 15.3% in this population, (Little et al., 2021) it is possible ENDS are being used to attempt cigarette cessation.

A recent *meta*-analysis of 78 studies observed that individuals randomized to electronic cigarettes were 1.63 times as likely (95% CI 1.30

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to 2.04) to quit smoking tobacco as compared to those who were randomized to nicotine replacement therapy. (Hartmann-Boyce et al., 2021) However, longitudinal studies evaluating ENDS use among young adult cigarette users are limited in number and are primarily samples of college students. (Glasser et al., 2019; Mantey et al., 2017) To date, there has been no research exploring how young, military personnel use ENDS as a harm reduction strategy to remain abstinent from cigarettes subsequent to entry-level military training.

Despite the lack of Food and Drug Administration (FDA) approval and the insufficient evidence supporting the efficacy of ENDS for cigarette cessation in treatment-seeking smokers, (Patnode et al., 2021) many smokers use these products to quit smoking. (Caraballo et al., 2017; El Dib et al., 2017; Farsalinos, 2017) In fact, ENDS are more commonly used to aid a tobacco quit attempt than FDA-approved products, especially among younger smokers. (Caraballo et al., 2017; Benmarhnia et al., 2018) Yet, the use of ENDS as a harm reduction or cessation tool remains controversial, (Farsalinos, 2017; Glasser et al., 2017) particularly given the potential for adverse health effects of ENDS use. (Jonas, 2022; Heydari et al., 2017) Additionally, it is often unclear in prior research on the motives for using ENDS, including whether individuals are using these products specifically for cigarette cessation (El Dib et al., 2017; Farsalinos, 2017).

The current study seeks to address these gaps in the previous literature by examining the use of ENDS as a cigarette cessation aid in a longitudinal sample of young adults. Specifically, the current study reports on the association between motives for ENDS use as a cessation tool as compared to alternative reasons and tobacco abstinence at a one-year follow-up in a cohort of entry-level Airmen who use cigarettes at baseline.

2. Method

2.1. Participants and procedure

Participants were Airmen attending entry-level job training (i.e., "Technical Training") at one of five Air Force bases across Texas and Mississippi between March 2016 and April 2019. Study staff provided information and answered questions about the study in groups of approximately 50 Airmen. Consent and HIPAA forms were signed in accordance with 59th Medical Wing Institutional Review Board's requirements who oversaw human subjects' safety. Out of 37,230 Airmen approached to participate in the study, 80.9% consented to participate and completed the baseline questionnaire (n = 30,122). The remaining 7,108 were excluded due to being uninterested in participating (n = 6,703; 18.0%), ineligible due to being less than 18 years of age (n = 226; 0.01%), or missing data for age or military status (n = 179, 0.01%). At baseline, Airmen were surveyed during a period of enforced abstinence, so they were asked to report their tobacco use prior to entering Basic Military Training (approximately 7.5 weeks prior).

We completed one-year follow-ups with a stratified random sample of Airmen on either active duty, National Guard, or Reserve status via telephone. At follow-up, Airmen were no longer in training status and thus no longer under a tobacco ban. A list of randomly selected participants was sent to the Defense Manpower Data Center (DMDC) to obtain the participants' contact information. The DMDC maintains the largest archive of personnel, workforce, training, and financial data in the Department of Defense. Among the 13,993 participants selected for the one-year follow-ups, 11,654 (83.3%) were eligible and 2,339 participants were either ineligible (n = 2252, 13.0%) or withdrew from the study (n = 87, 3.7%). The reasons for ineligibility included being stationed overseas (n = 1,493, 63.8%), deployed (n = 372, 15.9%), deceased (n = 5, 0.2%), or separating from the military (n = 382, 16.3%). The one-year assessment was completed by 8,901 (76.4%) of selected Airmen.

2.2. Measures

Demographics. At baseline, participants provided information on sex (as depicted on official military records), marital status, income, military status, rank, years of education, and ethnicity.

Tobacco use. At baseline and follow-up, Airmen reported the frequency of their tobacco use, which included cigarettes, smokeless tobacco (chewing tobacco and snuff), snus, cigars, cigarillos (little cigars, e.g., Black & Mild, Swisher Sweet, White Owl), pipe, hookah (waterpipe, shisha, narghile, kalian, and hubble-bubble), and roll-your-own cigarettes/ compressed tobacco in the form of orbs, sticks, and strips. Response categories ranged from "never," "quit prior to basic military training," "less than monthly," "monthly," "weekly," to "daily." Ever use of a tobacco product was defined as including all categories except 'never' use of the product. At one-year follow-up, abstinence was defined as point-prevalence abstinence at the time of assessment (Piper et al., 2020).

Motives for ENDS use. At baseline, all Airmen were asked if they had ever attempted to quit smoking cigarettes by using ENDS. The specific question was, "Have you ever used e-cigarettes to try to quit smoking cigarettes?" Responses to this question were categorized as either use for cigarette cessation vs. alternative reasons.

2.3. Data analysis

All eligible randomly selected Airmen who completed the follow-up survey were included in the final analysis. The outcome variable at one-year follow-up was defined as any cigarette use, any use of non-cigarette tobacco products, and point-prevalence tobacco abstinence. Thus, a multinomial logistic regression model was used to assess an association between the motives for ENDS use and tobacco abstinence at one-year follow-up. To minimize selection bias or confounding based on one's ENDS use motives so that the distributions of observed baseline characteristics were similar across the two motive groups, a propensity score was developed as the probability of the motive for cigarette cessation conditional on individuals' characteristics that may influence their reasons for ENDS use. The propensity score was created using a logistic regression model with the motive for ENDS use as a dependent variable, and the model was adjusted for age, sex, race, education, marital status, and military status. The propensity-score adjusted multinomial logistic model was also adjusted for the imbalanced covariates using these same factors. (McCaffrey et al., 2013) Odds ratios were used to quantify the relative effect of the ENDS use motives on the 1-year tobacco abstinence with cigarette use and non-cigarette tobacco use as the reference categories. Since eligible Airmen were recruited in squadrons across bases, the model was also adjusted for the complex sample design. This model included both stratification and clustering where the strata were the bases and the clusters were squadrons, and the sampling weights due to different selection probabilities of one-year follow-up for the different bases and military status. Because we were primarily interested in the subsample of Airmen who endorsed cigarette use at baseline and who responded to the 'Motives for ENDS use' questionnaire (n = 1406), a domain analysis of the multinomial logistic model was employed to incorporate the variability of the formation of different domains of use of tobacco products at baseline into the variance estimation. The two-sided significance level was specified at 0.05. All statistical analyses were performed in SASv9.4 (Cary, NC, USA).

3. Results

Table 1 summarizes the baseline characteristics of participants by motives for ENDS use. There were significant differences between the motives in ethnicity, race, education, military status, and marital status (all P <.01). Of the 1406 cigarette smokers that responded to the motives for ENDS use item, 864 (61.5%) reported using ENDS for cigarette cessation.

Table 1
Descriptive statistics of U.S. Air Force Trainees' demographics by ENDS use motives among ever cigarette smokers at baseline (N = 1406).

Demographic information	Motives for ENDS use at baseline			
	Overall (n = 1406)	For cigarette cessation (n = 864)	For other reasons (n = 542)	*P*-value
Age (Mean [1st quartile, median, 3rd quartile])	21.5 (19, 20, 23)	21.4 (19, 20, 23)	21.6 (19, 21, 23)	0.35
Sex, %:				
Female	295 (21.1)	118 (21.9)	177 (20.5)	0.67
Male	1106 (78.9)	421 (78.1)	685 (79.5)	
Race, %:				
Black/African American	80 (5.7)	57 (6.6)	23 (4.2)	0.009
White	1099 (78.2)	659 (76.3)	440 (81.2)	
More Than One Race	117 (8.3)	85 (9.8)	32 (5.9)	
Other Races	110 (7.8)	63 (7.3)	47 (8.7)	
Ethnicity, %:				
Non-Hispanic	1150 (87.3)	684 (80.3)	466 (86.9)	0.001
Hispanic	138 (12.7)	168 (19.7)	70 (13.1)	
Education, %:				
Bachelor's Degree or Higher	90 (6.4)	63 (7.4)	27 (5.0)	0.004
High School Graduate/ GED	677 (48.6)	394 (46.0)	283 (52.6)	
Some College Education	627 (45.0)	399 (46.6)	228 (42.4)	
Marital Status, %:				
Married/Cohabitating	195 (13.9)	101 (11.7)	94 (17.4)	0.006
Single/Separated/ Divorced/Widowed	1210 (86.1)	763 (88.3)	447 (82.6)	
Military Status, %:				
Active Duty	1098 (83.23)	661 (76.5)	437 (80.6)	0.002
National Guard	155 (8.07)	108 (12.5)	47 (8.7)	
Reserve	153 (8.70)	95 (11.0)	58 (10.7)	

Note: Frequency (%) or mean (quantiles) displayed in Table were unweighted. *P*-value was estimated from a domain univariate multinomial logistic regression analysis, which was also adjusted for the complex sample design including stratification, clustering, and sampling weights.

From the propensity-score adjusted model, there was a significant association between the baseline ENDS use motives and tobacco abstinence at one-year follow-up among baseline ever cigarette smokers ($P < .001$, see Table 2). Cigarette smokers who were motivated to use ENDS for cigarette cessation were more likely not only to quit smoking cigarettes at one-year (OR = 1.62, 95% CI: 1.06–2.49, $P = .03$) but also more likely to quit using the other tobacco product(s) (OR = 2.11, 95% CI: 1.65–2.70, $P < .001$) than those who were motivated to use ENDS for alternative reasons.

4. Discussion

The current study examined ENDS use motives in relationship to cigarette and other tobacco products use in a large sample of young Airmen. Results indicate that cigarette smokers who reported the motive of using ENDS for cigarette cessation were more likely to report abstinence from both cigarettes and non-cigarette tobacco products at a one-year follow-up compared those who used ENDS products for other reasons (see Table 2). These findings contribute to a growing literature,

Table 2
The propensity-score adjusted association between motives for ENDS use at baseline and predicted probability of abstinence of any tobacco products use at one-year follow-up among ever cigarette smokers (N = 1406).

Baseline Motives for ENDS Use	Abstinence from any tobacco products use at one-year follow-up					
	Abstinence vs. Cigarette Use (Reference)			Abstinence vs. Non-cigarette Tobacco Use (Reference)		
	Odds Ratio	95% CI	*P*-value	Odds Ratio	95% CI	*P*-value
Motives for Cigarette Cessation vs. Alternative Reason	1.62	1.06 ~ 2.49	0.03	2.11	1.65 ~ 2.70	< 0.001

Note: There was a significant association between motives for ENDS use at baseline and abstinence of any tobacco products use at one-year follow-up ($P < .001$). The propensity-score adjusted multinomial logistic regression model was adjusted for the imbalanced covariates and the complex sample design including stratification and clustering and sampling weights.
At follow-up, "abstinence" referred to point-prevalence abstinence from all tobacco products while "cigarette use" and "non-cigarette tobacco use" referred to those specific tobacco products.

indicating that young military personnel who are cigarette users may be able to use ENDS for cigarette cessation. Previous civilian research found that using ENDS to quit smoking was positively associated with smoking cessation. (Hartmann-Boyce et al., 2021; El Dib et al., 2017; Farsalinos, 2017) Similarly, another study found that young adult college students using ENDS for cigarette cessation were more likely to be quit from cigarettes at six and 12-month follow-ups compared to those who did not use e-cigarettes (Mantey et al., 2017).

Key strengths of this study include the prospective one-year design with a large cohort of racially and ethnically diverse young Airmen who are at heightened risk for tobacco use. A limitation is that the motives for ENDS use item did not specify a time frame. Thus, it is unclear whether individuals were currently trying to quit or if they were currently using ENDS to quit. Rather, the findings may be reflecting participants' perceptions about the usefulness of ENDS in cessation attempts and motives for using these products. Further, the comparison group may have been less interested in quitting in general since they were using ENDS for other reasons. This potential selection bias was partially mitigated through incorporating the propensity score method. Another limitation is that baseline assessment was limited to "ever use" of a tobacco product, given the nature of the parent study design. It is important to replicate these findings solely within a military population of current tobacco users. Finally, because tobacco use at baseline and the one-year follow-up were defined in such way that we did not differentiate dosages of tobacco use, the overall model did not have particularly strong predictive discriminative power. The null polytomous discrimination index (PDI) (Li et al., 2018) of the overall model is 1/3 = 0.33 (viz., random guess), and the estimated PDI of 0.44 (bootstrapped 95% confidence interval: 0.40 ~ 0.46) from our overall model is about 1.33 times of the lower bound which corresponds to no discriminative ability. Results are based on longitudinal associations; thus, a causal relationship between ENDS use and cigarette cessation cannot be determined. However, results suggest that among Airmen motivated to quit, ENDS in fact did not hinder their likelihood of reporting abstinence a year later.

5. Conclusion

The U.S. military has taken active steps to reduce tobacco in its personnel; however, there was a long history of a culture within the military that supported tobacco use, (Smith and Malone, 2009) and there is a higher tobacco use prevalence in this population compared to civilians. (Little et al., 2015; Meadows et al., 2018) Thus, it is important to identify effective tobacco cessation strategies for young Airmen.

Future research should examine whether the addition of behavioral support or combination treatment (behavioral plus pharmacotherapy) interventions among individuals using ENDS to quit enhances cessation efforts among this high-risk group. Given the comparable cessation effect sizes among individuals using ENDS to quit smoking and approved over the counter smoking cessation medications, such as nicotine replacement therapy, (Hartmann-Boyce et al., 2021) and the uncertain long-term health effects of vaping, (Jonas, 2022; Heydari et al., 2017) public health campaigns should continue to promote FDA-approved evidence-based treatments to smokers interested in quitting. However, the current study is in line with a growing literature that suggests ENDS products could be an effective harm reduction strategy for cigarette users, including those who are active duty military.

Disclosures

Comment: The views expressed are those of the authors and do not reflect the official views or policy of the Department of Defense or its Components. The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DODI 3216.02_AFI 40-402.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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