E-cigarette and dual product use as an emerging health threat to the US military

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ABSTRACT

INTRODUCTION Cigarette and e-cigarette use are threats to the health and readiness of the US military. The study objective was to determine the prevalence and factors associated with e-cigarette, cigarette, and dual use among active duty service members (SMs).

METHODS We used data from the 2015 Health Related Behaviors Survey—a cross-sectional survey weighted to represent the US military (n=16699). Weighted prevalence and odds ratios assessed associations between risk factors and e-cigarette/cigarette use via weighted multinomial logistic models.

RESULTS The prevalence of cigarette use in the US military declined from 24% in 2011 to 13.8% in 2015. However, e-cigarette use (12.4%) and dual product use (4.7%) increased during this period. Additionally, prevalence of e-cigarette use was higher in the military compared to the general population (12.4% vs 3.5%), particularly among those aged 17–24 years (22.8% vs 5.2%); cigarette use was also higher in the military in this age group (19.3% vs 13.0%). After adjustment, SMs who were enlisted, lacked a Bachelor's degree, and/or had probable alcohol use disorder had significantly greater odds of cigarette, e-cigarette, and dual use. While SMs aged 17–24 years had the highest prevalence of all types of product use, only being aged ≥45 years was significantly associated with decreased odds of product use in adjusted models.

CONCLUSIONS Military efforts to control cigarette use among SMs seem to have been successful, as demonstrated by the dramatic declines in its use and the lower prevalence seen in the military compared to the general population. However, the concurrent increases in e-cigarette use are concerning, particularly among the youngest members of the military. The US military must continue to monitor emerging trends in e-cigarette, cigarette, and dual use and rapidly take steps to address them as threats to health and readiness.

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INTRODUCTION

Although cigarette use in the United States is declining, with a prevalence of 14.0% among adults in 2019[1], it remains a major public health threat with long-term health consequences. While the prevalence of electronic cigarette (e-cigarette) – otherwise known as electronic nicotine delivery system (ENDS) – use is lower (4.5%), its use has been increasing over time and was higher than conventional cigarette use in younger populations[1]. Among people aged 18–24 years, the prevalence of cigarette use was lower (8.0%) but ENDS use was higher (9.3%). In addition to its correlation with negative mental health outcomes and substance use patterns, ENDS use can compromise the human respiratory system[2]. Several populations exhibit higher prevalence of ENDS use, including men, non-Hispanic Whites, persons aged 18–24 years, those with lower education levels, persons who are

lesbian, gay, or bisexual, and people living in poverty[3]. ENDS use is associated with increased risk of cigarette use initiation and past 30-day cigarette smoking[4], and the use of more than one tobacco product is also increasingly being described.

Historically, cigarette use has been a disproportionately larger public health problem in military populations. Military service members (SMs) have been targeted by the tobacco industry for decades, and rates of cigarette initiation have been shown to be increased in recruit and deployed settings[5-7]. In 2011, the prevalence of cigarette use was higher in the military (24%) than in the civilian (19%) population[8]. While the overall prevalence of ENDS use in the military has not been reported in the peer-reviewed literature, it has been published as a report to the Defense Health Agency[9]. Additionally, studies among several military subpopulations and locations suggest that the prevalence of ENDS use may also be higher than that found in civilian populations[10-14]. This may be because many of the factors listed above which are associated with its use, particularly younger age and male sex, are widely present in military populations. For example, Air Force trainees in 2013–2014 were found to have a prevalence of cigarette and ENDS use of 11.2% and 5.9%, respectively, prior to entry into military service[10]. Although current DoD policies limit the use, promotion, and sales of ENDS[15], many SMs are confused about or actively avoid these policies[16], and a leading ENDS company has targeted marketing and promotions for active duty soldiers and veterans[17]. Concomitant ENDS use and cigarette smoking, commonly referred to as 'dual product use,' has been associated with an increased risk of acute respiratory infection among SMs[18]. It is not known whether dual use differs from isolated ENDS or cigarette use with respect to demographics and prevalence of underlying health behaviors.

The dynamic nature of the trends in cigarette, ENDS, and dual use over the past decade has led to rapidly changing health risks in both military and civilian populations. Gaining a better understanding of the prevalence of and risk factors for these health behaviors among SMs is essential to preserving a healthy and readily deployable military force. The primary objective of this study was to determine the prevalence of, and identify demographic and health factors associated with, cigarette smoking, e-cigarette use, and dual product use in the US military.

METHODS

Study design and population

This study was approved by the Uniformed Services University Institutional Review Board as Protocol DBS.2020.074, and the study was completed in 2021. The Health Related Behaviors Survey (HRBS) is a cross-sectional survey established by the Department of Defense (DoD) to better understand the health behaviors of SMs across all five Branches of the US Armed Forces. The HRBS was initiated in 1980 to evaluate substance use among active duty SMs[19], and it is currently sponsored by the Defense Health Agency (DHA). The 2015 HRBS is the most recent survey for which publicly-available data have been released. The final analytic sample size was N=16699 among 195220 contactable SMs, resulting in a response rate of 8.6%. Sampling weights by post-stratification were used to represent the population[20].

Measures

The outcomes were self-reported ENDS and cigarette use. We defined current users of either product as those who reported any use within the past 30 days. We further categorized our outcomes into four groups: those who used neither ENDS nor cigarettes, those who used only ENDS, those who used only cigarettes, and those who used both ENDS and cigarettes ('dual' use). Exposures included demographic information (age, race, sex, service, pay grade, and education level), health behaviors (probable alcohol use disorder and high impulsivity), and health outcomes (history of respiratory condition or conditions). HRBS questions pertaining to alcohol use were identical to those contained in the Alcohol Use Disorders Identification Test (AUDIT-C)[21]. Scores of ≥3 for women or ≥4 for men met the criteria for probable alcohol use disorder (AUD). High impulsivity was assessed using a series of four statements regarding impulsive actions, risk taking, acting on the spur of the moment, and hasty actions. Respondents then had to identify whether these statements described them 'a great deal' (5 points), 'a lot' (4 points), 'somewhat' (3 points), 'a little' (2 points), or 'not at all' (1 point). Respondents with mean scores of ≥3 points on these items, which were adapted from the 2011 HRBS[8], were categorized as being highly impulsive[20].

Statistical analysis

The methods used in this study were adapted from those used previously to analyze HRBS data[9]. Weighted prevalence and standard error (SE) were reported for all exposure groups. Weighted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using multinomial logistic regression models to assess associations between an exposure and groups of respondents who used ENDS, cigarette, and dual product, compared to the group who used neither cigarettes nor ENDS. The Wald chi-squared (χ^2) method was used to assess if there was a significant association between use of ENDS/cigarette and an exposure. Statistical significance was set at 0.05 for all statistical tests. SAS and SAS callable SUDAAN® statistical software (RTI International, Research Triangle Park, NC) was used in all analyses.

RESULTS

Table 1 shows the characteristics of the study population and the weighted prevalence of these

Table 1. Weighted prevalence and standard error of demographic characteristics and underlying health behaviors, 2015 Department of Defense Health Related Behaviors Survey (N=16699)

Characteristics	Unweighted (n)	Weighted prevalence (%)	SE
Age (years)			
Missing	17	0.08	0.03
17–24	1987	28.72	0.83
25–34	6116	41.86	0.82
35–44	6089	22.51	0.59
≥45	2490	6.83	0.28
Total	16699	100.00	0.00
Sex			
Missing	0	0.00	0.00
Male	10368	84.43	0.36
Female	6331	15.57	0.36
Total	16699	100.00	0.00
Race			
Missing	34	0.14	0.04
Non-Hispanic White	10869	58.33	0.82
Non-White Hispanic	2083	16.47	0.66
Non-White Minority	3713	25.06	0.72
Total	16699	100.00	0.00

Table 1. Continued

Characteristics	Unweighted (n)	Weighted prevalence (%)	SE
Service branch			
Missing	0	0.00	0.00
Air Force	4150	22.30	0.52
Army	3197	37.33	0.88
Marine Corps	2184	13.98	0.55
Navy	3016	23.40	0.67
Coast Guard	4152	2.99	0.07
Total	16699	100.00	0.00
Rank			
Missing	0	0	0.00
Enlisted	10204	84.14	0.34
Officer	6495	15.86	0.34
Total	16699	100.00	0.00
Education level			
Missing	3	0.01	0.00
High school or less	1623	20.44	0.75
Some college	6202	48.53	0.82
Bachelor's degree or more	8871	31.03	0.69
Total	16699	100.00	0.00
High impulsivity			
Missing	2020	15.31	0.61
Yes	1017	10.76	0.57
No	13662	73.93	0.76
Total	16699	100.00	0.00
History of respiratory condition			
Missing	8	0.05	0.04
Yes (within past 2 years)	972	4.70	0.29
Yes (2 or more years ago)	948	4.77	0.32
No	14771	90.47	0.43
Total	16699	100.00	0.00
Currently taking medication for respiratory condition			
Missing	14775	90.51	0.43
Yes	715	3.30	0.25
No	1209	6.19	0.35
Total	16699	100.00	0.00
Probable alcohol use disorder			
Missing	313	2.38	0.27
Yes	5626	34.45	0.79
No	10760	63.17	0.80
Total	16699	100.00	0.00

SE: standard error.

characteristics in the US military. The US military is a mostly male, young, enlisted, and ethnically diverse population. Of note, nearly 11% of respondents were considered highly impulsive, and over 34% suffered from probable AUD. Roughly 9% of respondents had a history of a respiratory condition, but only 3% were currently taking medication for a respiratory condition.

Overall, 13.8% of SMs used cigarettes (9.1% used cigarettes only and 4.7% used both), 12.4% used ENDS (7.7% used ENDS only and 4.7% used both), and 21.5% used one or both of these products (Table 2), as reported previously[9]. Increased prevalence of all types of product use was generally associated with younger age, male sex, lower rank, lower education levels, higher impulsivity, and probable AUD. SMs

Table 2. Weighted prevalence of current cigarette, ENDS, dual use, and neither cigarette nor ENDS use, by characteristic, 2015 Department of Defense Health Related Behaviors Survey (N=16699)

Characteristics	Cigarette use only			ENDS use only			Both cigarette and ENDS use (Dual use)			Neither cigarette nor ENDS use (None)		
	n	%	SE	n	%	SE	n	%	SE	n	%	SE
Total*	939	9.06	0.54	670	7.67	0.52	354	4.72	0.42	13880	78.53	0.77
Age (years)												
17–24	131	10.03	1.21	191	13.56	1.37	103	9.23	1.21	1431	67.17	1.85
25–34	367	8.98	0.85	281	7.48	0.77	132	3.37	0.49	4971	80.17	1.14
35–44	368	9.88	0.95	163	2.65	0.37	89	2.6	0.48	5213	84.88	1.07
≥45	73	2.91	0.65	35	1.13	0.31	30	1.41	0.38	2265	94.55	0.8
Total	939	9.06	0.54	670	7.67	0.52	354	4.72	0.42	13880	78.55	0.77
Sex												
Male	598	9.32	0.63	466	8.02	0.61	223	4.94	0.49	8591	77.72	0.9
Female	342	7.69	0.57	204	5.7	0.54	131	3.51	0.41	5304	83.1	0.82
Total	940	9.07	0.54	670	7.66	0.52	354	4.72	0.42	13895	78.55	0.77
Race												
Non-Hispanic White	632	9.97	0.73	427	7.87	0.67	227	4.52	0.54	9092	77.64	1.01
Non-White Hispanic	117	7.79	1.37	102	9.31	1.49	47	6.47	1.38	1683	76.44	2.17
Non-White Minority	191	7.82	0.97	141	6.14	0.94	80	4.07	0.64	3090	81.97	1.39
Total	940	9.08	0.54	670	7.67	0.52	354	4.73	0.42	13870	78.53	0.77
Service branch												
Air Force	172	5.86	0.58	170	7.48	0.69	69	3.05	0.45	3487	83.61	0.94
Army	217	10.74	1.14	89	6.81	1.04	62	4.25	0.8	2686	78.2	1.54
Marine Corps	143	12.58	1.54	75	8.31	1.29	53	7.79	1.33	1797	71.31	2.08
Navy	164	7.66	0.88	118	8.95	1.07	78	5.54	0.86	2502	77.85	1.47
Coast Guard	244	6.62	0.45	218	6.73	0.48	92	2.54	0.29	3453	84.12	0.68
Total	940	9.07	0.54	670	7.66	0.52	354	4.72	0.42	13895	78.55	0.77
Rank												
Enlisted	821	10.37	0.64	597	8.91	0.62	329	5.56	0.5	7863	75.16	0.91
Officer	119	2.37	0.29	73	1.23	0.18	25	0.43	0.11	6033	95.97	0.36
Total	940	9.07	0.54	670	7.66	0.52	354	4.72	0.42	13895	78.55	0.77
Education level												
High school or less	181	13.38	1.51	131	11.75	1.57	108	11.24	1.52	1099	63.63	2.21
Some college	525	9.86	0.77	391	9.8	0.82	183	4.38	0.54	4724	75.96	1.12
Bachelor's degree or more	234	5.1	0.79	148	1.76	0.27	63	1.05	0.24	8069	92.09	0.85
Total	940	9.07	0.54	670	7.66	0.52	354	4.72	0.42	13892	78.55	0.77

Table 2. Continued

Characteristics	Cigarette use only			ENDS use only			Both cigarette and ENDS use (Dual use)			Neither cigarette nor ENDS use (None)		
	n	*%*	*SE*	*n*	*%*	*SE*	*n*	*%*	*SE*	*n*	*%*	*SE*
High impulsivity												
Yes	108	14.49	2.14	81	12.97	2.04	55	8.53	1.72	773	64.01	2.84
No	768	8.59	0.58	531	7.01	0.56	253	3.7	0.4	12109	80.7	0.82
Total	876	9.34	0.58	612	7.77	0.55	308	4.31	0.42	12882	78.58	0.81
History of respiratory condition												
Yes (within past 2 years)	65	8.69	1.89	31	5.43	2.03	24	4.06	1.11	808	81.82	2.75
Yes (2 or more years ago)	59	9.69	2.39	37	5.57	1.62	24	6.51	1.83	794	78.23	3.1
No	816	9.06	0.58	601	7.89	0.56	306	4.66	0.45	12286	78.39	0.83
Total	940	9.07	0.54	669	7.66	0.52	354	4.72	0.42	13888	78.54	0.77
Currently taking medication for respiratory condition												
Yes	34	6.02	1.79	26	3.42	1.04	15	3.37	1.15	609	87.19	2.31
No	90	10.95	2.14	43	6.65	1.9	32	6.3	1.55	997	76.1	2.88
Total	124	9.19	1.53	69	5.5	1.29	47	5.25	1.08	1606	80.06	2.08
Probable alcohol use disorder												
Yes	462	14.21	1.15	315	11.01	1.07	184	7.98	0.92	4466	66.81	1.5
No	478	6.32	0.54	355	5.87	0.55	170	2.98	0.4	9425	84.83	0.81
Total	940	9.08	0.54	670	7.67	0.52	354	4.72	0.42	13891	78.53	0.77

*Numbers may not add up to the total due to missing data. n: unweighted sample size. SE: standard error.

who were aged ≥45 years, officers, and who had a Bachelor's degree, had the lowest prevalence of all types of product use. Of note, while the youngest SMs (age 17–24 years, with 17 years being the youngest age at which a soldier can enlist in the US military[22]) had a higher use of ENDS only (13.6%) than cigarette only (10.0%), this was reversed in the oldest SMs (aged ≥45 years), who had a higher use of cigarette only (2.9%) than ENDS only (1.1%). Including the dual product users, 19.3% of the youngest group used cigarettes and 22.8% ENDS, compared to 4.3% and 2.5% of the oldest group, respectively. The Air Force and the Navy had higher prevalence of ENDS use than cigarette use, whereas the Army and Marine Corps had the opposite – higher prevalence of cigarette than ENDS use. The Marine Corps had the highest prevalence of every type of product use except ENDS use only; nevertheless, after including dual product use, their use was also highest in overall ENDS use. Hispanics had the highest prevalence of ENDS only and dual

product use, but lower cigarette use; the overall use of any product was similar to non-Hispanic Whites. The prevalence of all types of product use were generally lower in non-Hispanic minority groups.

Table 3 shows unadjusted ORs to assess the associations of each characteristic with cigarette, ENDS, and dual use, comparing with none (neither cigarette nor ENDS use). SMs aged 17–24 years had a significantly increased odds of ENDS and dual use in unadjusted models, but cigarette use was only significantly higher than those aged ≥45 years. Age greater than 45 years was significantly associated with decreased odds of cigarette (OR=0.21; 95% CI: 0.12–0.35), ENDS (OR=0.06; 95% CI: 0.03–0.11), and dual (OR=0.11; 95% CI: 0.06–0.20) use. Similarly, female sex was correlated with decreased odds of cigarette (OR=0.77; 95% CI: 0.62–0.96), ENDS (OR=0.66; 95% CI: 0.51–0.86), and dual (OR=0.67; 95% CI: 0.49–0.91) use. Serving in the Marine Corps was associated with increased odds of dual use (OR=2.01; 95% CI: 1.18–3.42). Compared

Table 3. Crude odds ratios via multinomial logistic regression analysis of each characteristic associated with cigarette, ENDS, and dual use, versus reference group (none), 2015 Department of Defense Health Related Behaviors Survey (N=16699)

Characteristics	Cigarette use only		ENDS use only		Both cigarette and ENDS use	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age (years) (n=15843)						
17–24 (Ref.)	1		1		1	
25–34	0.75	(0.54–1.05)	0.46	(0.34–0.64)	0.31	(0.20–0.46)
35–44	0.78	(0.56–1.09)	0.15	(0.11–0.22)	0.22	(0.14–0.35)
≥45	0.21	(0.12–0.35)	0.06	(0.03–0.11)	0.11	(0.06–0.20)
Wald chi-squared (p)	$\chi^2_9 = 245.22$ (p<0.001)					
Sex (n=15859)						
Male (Ref.)	1		1		1	
Female	0.77	(0.62–0.96)	0.66	(0.51–0.86)	0.67	(0.49–0.91)
Wald chi-squared (p)	$\chi^2_3 = 19.73$ (p<0.001)					
Race (n=15829)						
Non-Hispanic White (Ref.)	1		1		1	
Non-White Hispanic	0.79	(0.53–1.19)	1.2	(0.81–1.78)	1.45	(0.87–2.42)
Non-White Minority	0.74	(0.55–1.01)	0.74	(0.51–1.07)	0.85	(0.57–1.28)
Wald chi-squared (p)	$\chi^2_6 = 11.41$ (p=0.08)					
Service branch (n=15859)						
Air Force	0.57	(0.44–0.75)	1.03	(0.71–1.50)	0.67	(0.41–1.09)
Army (Ref.)	1		1		1	
Marine Corps	1.29	(0.89–1.85)	1.34	(0.84–2.13)	2.01	(1.18–3.42)
Navy	0.72	(0.51–1.01)	1.32	(0.87–2.00)	1.31	(0.79–2.17)
Coast Guard	0.57	(0.44–0.75)	0.92	(0.64–1.31)	0.55	(0.35–0.87)
Wald chi-squared (p)	$\chi^2_{12} = 89.06$ (p<0.001)					
Rank (n=15859)						
Enlisted (Ref.)	1		1		1	
Officer	0.18	(0.13–0.24)	0.11	(0.08–0.15)	0.06	(0.03–0.11)
Wald chi-squared (p)	$\chi^2_3 = 394.75$ (p<0.001)					
Education level (n=15856)						
High school or less	3.8	(2.52–5.74)	9.64	(6.29–14.79)	15.54	(9.95–27.01)
Some college	2.35	(1.63–3.37)	6.74	(4.73–9.61)	5.08	(3.00–8.61)
Bachelor's degree or more (Ref.)	1		1		1	
Wald chi-squared (p)	$\chi^2_6 = 252.73$ (p<0.001)					
High impulsivity (n=14678)						
Yes	2.13	(1.46–3.09)	2.33	(1.57–3.47)	2.91	(1.78–4.75)
No (Ref.)	1		1		1	
Wald chi-squared (p)	$\chi^2_3 = 42.00$ (p<0.001)					
History of respiratory condition (n=15851)						
Yes (within past 2 years)	0.92	(0.56–1.49)	0.66	(0.30–1.46)	0.83	(0.46–1.51)
Yes (2 or more years ago)	1.07	(0.62–1.87)	0.71	(0.38–1.32)	1.4	(0.75–2.61)
No (Ref.)	1		1		1	
Wald chi-squared (p)	$\chi^2_6 = 4.00$ (p=0.68)					

Table 3. Continued

Characteristics	Cigarette use only		ENDS use only		Both cigarette and ENDS use	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Currently taking medication for respiratory condition (n=1846)						
Yes	0.48	(0.22–1.02)	0.45	(0.19–1.07)	0.47	(0.20–1.11)
No (Ref.)	1		1		1	
Wald chi-squared (p)	χ^2_3 = 8.75 (p=0.033)					
Probable alcohol use disorder (n=15855)						
Yes	2.86	(2.21–3.70)	2.38	(1.78–3.18)	3.4	(2.35–4.92)
No (Ref.)	1		1		1	
Wald chi-squared (p)	χ^2_3 = 123.79 (p<0.001)					

n: unweighted number of respondents from the sample were used; the comparison group was those individuals who neither used cigarettes nor ENDS. OR: odds ratio. Ref.: reference group.

to enlisted SMs, officers had significantly lower odds of cigarette (OR=0.18; 95% CI: 0.13–0.24), ENDS (OR=0.11; 95% CI: 0.08–0.15), and dual (OR=0.06; 95% CI: 0.03–0.11) use. High impulsivity was associated with increased odds of cigarette (OR=2.13; 95% CI: 1.46–3.09), ENDS (OR=2.33; 95% CI: 1.57–3.47), and dual (OR=2.91; 95% CI: 1.78–4.75) use. Lastly, probable AUD was correlated with increased odds of cigarette (OR=2.86; 95% CI: 2.21–3.70), ENDS (OR=2.38; 95% CI: 1.78–3.18), and dual (OR=3.40; 95% CI: 2.35–4.92) use.

In the multivariate multinomial regression model shown in Table 4, adjusted odds ratios (AORs) were generally similar to unadjusted odds ratios. Significant associations remained after adjustment for age, sex, service, rank, education, and probable AUD. Being 45 years or older was strongly correlated with decreased odds of cigarette (AOR=0.53;

Table 4. Adjusted odds ratios using multinomial logistic regression model* of characteristics associated with cigarette, ENDS, and dual use, 2015 Department of Defense Health Related Behaviors Survey (N=16699)

Characteristics	Cigarette use only* (n=875)		ENDS use only* (n=612)		Both cigarette and ENDS use* (n=308)	
	AOR	(95% CI)	AOR	(95% CI)	AOR	(95% CI)
Age (years)						
17–24 (Ref.)	1		1		1	
25–34	1.23	(0.85–1.77)	0.74	(0.51–1.05)	0.64	(0.39–1.05)
35–44	1.49	(1.00–2.22)	0.29	(0.19–0.45)	0.65	(0.37–1.14)
≥45	0.53	(0.29–0.97)	0.14	(0.07–0.28)	0.39	(0.19–0.80)
Wald chi-squared (p)	χ^2_9 = 73.39 (p<0.001)					
Sex						
Male (Ref.)	1		1		1	
Female	0.98	(0.77–1.24)	0.66	(0.50–0.88)	0.88	(0.61–1.26)
Wald chi-squared (p)	χ^2_3 = 8.11 (p=0.044)					
Race						
Non-Hispanic White (Ref.)	1		1		1	
Non-White Hispanic	0.57	(0.36–0.92)	0.95	(0.63–1.44)	1.04	(0.56–1.94)
Non-White Minority	0.79	(0.56–1.10)	0.83	(0.56–1.25)	1.04	(0.66–1.63)
Wald chi-squared (p)	χ^2_6 = 7.22 (p=0.30)					

Table 4. Continued

Characteristics	Cigarette use only* (n=875)		ENDS use only* (n=612)		Both cigarette and ENDS use* (n=308)	
	AOR	(95% CI)	AOR	(95% CI)	AOR	(95% CI)
Service branch						
Air Force	0.51	(0.36–0.71)	0.93	(0.61–1.42)	0.67	(0.38–1.17)
Army (Ref.)	1		1		1	
Marine Corps	0.82	(0.55–1.24)	0.62	(0.36–1.08)	0.8	(0.41–1.54)
Navy	0.62	(0.43–0.89)	1.06	(0.67–1.67)	1.11	(0.63–1.96)
Coast Guard	0.48	(0.35–0.64)	0.87	(0.59–1.28)	0.51	(0.32–0.82)
Wald chi-squared (p)	χ^2_{12} = 52.28 (p<0.001)					
Rank						
Enlisted (Ref.)	1		1		1	
Officer	0.24	(0.15–0.39)	0.55	(0.32–0.94)	0.2	(0.08–0.45)
Wald chi-squared (p)	χ^2_3 = 49.25 (p<0.001)					
Education level						
High school or less	2.5	(1.46–4.29)	5.28	(2.87–9.71)	5.14	(2.48–10.66)
Some college	1.54	(0.97–2.45)	4.84	(2.93–8.00)	2.52	(1.27–4.98)
Bachelor's degree or more (Ref.)	1		1		1	
Wald chi-squared (p)	χ^2_6 = 63.23 (p<0.001)					
High impulsivity						
Yes	1.42	(0.95–2.14)	1.43	(0.94–2.18)	1.47	(0.87–2.51)
No (Ref.)	1		1		1	
Wald chi-squared (p)	χ^2_3 = 5.89 (p=0.12)					
Probable alcohol use disorder						
Yes	2.61	(1.98–3.45)	2.06	(1.50–2.82)	3.36	(2.17–5.20)
No (Ref.)	1		1		1	
Wald chi-squared (p)	χ^2_3 = 81.95 (p<0.001)					

*The comparison group was those individuals who neither used cigarettes nor ENDS; variables in the multinomial logistic model included age, sex, race, service branch, rank, education level, high impulsivity, and probable alcohol use disorder; total N=14634 respondents, including n=12839 in the reference group. AOR: adjusted odds ratio. Ref.: reference group.

95% CI: 0.29–0.97), ENDS (AOR=0.14; 95% CI: 0.07–0.28), and dual (AOR=0.39; 95% CI: 0.19–0.80) use. Furthermore, those aged 35–44 years had decreased odds of ENDS use (AOR=0.29; 95% CI: 0.19–0.45). With respect to race, non-White Hispanics had lower odds of cigarette use relative to non-Hispanic Whites after adjustment (AOR=0.57; 95% CI: 0.36–0.92). Being an officer was correlated with decreased cigarette (AOR=0.24; 95% CI: 0.15–0.39), ENDS (AOR=0.55; 95% CI: 0.32–0.94), and dual (AOR=0.20; 95% CI: 0.08–0.45) use. Compared to soldiers in the Army, Air Force (AOR=0.51; 95% CI: 0.36–0.71), Navy (AOR=0.62; 95% CI: 0.43–0.89), and Coast Guard (AOR=0.48; 95% CI: 0.35–0.64) SMs possessed lower odds of cigarette

use. Serving in the Coast Guard was also associated with decreased odds of dual use (AOR=0.51; 95% CI: 0.32–0.82). With respect to sex, being female was associated with decreased ENDS use (AOR=0.66; 95% CI: 0.50–0.88). Having probable AUD was strongly associated with increased cigarette (AOR=2.61; 95% CI: 1.98–3.45), ENDS (AOR=2.06; 95% CI: 1.50–2.82), and dual (AOR=3.36; 95% CI: 2.17–5.20) use. Compared to those with a bachelor's degree or more, having a high school education or less was strongly correlated with increased odds of cigarette (AOR=2.50; 95% CI: 1.46–4.29), ENDS (AOR=5.28; 95% CI: 2.87–9.71), and dual (AOR=5.14; 95% CI: 2.48–10.66) use. In addition, having some college education was associated with

increased odds of ENDS (AOR=4.84; 95% CI: 2.93–8.00) and dual (AOR=2.52; 95% CI: 1.27–4.98) use but to a lesser extent than what was observed for those with only a high school education or less.

DISCUSSION

The prevalence of cigarette use in the US military declined dramatically from 24% in 2011 to 13.8% in 2015. However, ENDS and dual use also increased during that period, particularly among younger SMs. This study provides the first published estimate in the peer-reviewed literature of the prevalence of ENDS use (12.4%), dual product use (4.7%), and use of one or both products (21.5%) among active duty SMs across all five Branches of the US military. While SMs aged 17–24 years had the highest prevalence of all types of product use, only being aged ≥45 years was significantly associated with decreased odds of product use in adjusted models. Associations were stronger for ENDS use only compared to cigarette use only for age, sex, and education. Associations were stronger for cigarette use compared to ENDS use for race, rank, and service in the Navy or Coast Guard. Dual use associations generally fell in between the exclusive use associations, except that race showed no association with dual use and both rank and probable AUD had a stronger association with dual use than with either cigarette or ENDS use alone. In both unadjusted and adjusted models, SMs who were younger, lower educated, lower ranking, and who reported higher levels of impulsivity and probable AUD had a higher prevalence of cigarette, ENDS, and dual product use. Hispanic SMs had the highest prevalence of ENDS use but lower levels of cigarette use compared to non-Hispanic Whites. Non-Hispanic minorities generally had lower use of all products. SMs in the Marine Corps had the highest prevalence of all types of product use.

While the prevalence of cigarette use declined in the US military from 24% in the 2011 HRBS to 13.8% in 2015, previous studies did not include estimates of current ENDS or dual use. Another recent study suggested similar US military prevalence estimates in 2018 of 14.1% cigarette use, 7.5% ENDS use, and 2.7% dual use[18], although these administrative data are expected to be underestimates. The prevalence of cigarette use in 2015 among the general US population (15.1%)

was slightly higher than that found in this report (13.8%)[23]. It is notable that this is the first time that military estimates of cigarette use have been found to be lower than in the civilian population. Other similarities with the general US population include associations with sex, education, and socioeconomic status (i.e. rank in the military). However, significant differences in prevalence of cigarette, ENDS, and dual product use were seen according to age. For example, the prevalence of cigarette use in those aged 25–44 years was 17.7% in the general population but only 12.5% in the same age group in the US military[23]. In contrast, the prevalence of ENDS use was higher in the US military (12.4%) than that observed in the general US population (3.5%)[23]. Particularly troubling is the much higher prevalence of ENDS use among those aged 17–24 years in the military (22.8%) compared to the general population (5.2%)[23]. This does not appear to be compensatory switching from cigarette to ENDS use due to smoke-free DoD policies[15], as this same age group also had a much higher prevalence of cigarette use (19.3%) than the US population of the same age (13.0%)[23]. Other relevant differences include the low prevalence of both cigarette and ENDS use in Hispanic populations seen in the general population, whereas this study found higher prevalence of ENDS use among Hispanics. Other studies of other military and civilian populations have found lower use of ENDS among Hispanics[10,23].

Most other prior research on this topic in the military has been restricted by service and geographical location. For example, an analysis of seven Air Force technical trainee recruitment cohorts between April 2013 and December 2014 demonstrated a 6% prevalence of ENDS use among trainees[10]. A small Navy study in Jacksonville, Florida, concluded that nearly 30% of Naval SMs had tried ENDS, and 9.3% were current users[12]. That study found similar associations between ENDS use and income and education as found in this study[12]. An analysis of US Army infantry soldiers in Hawaii found 20% prevalence of ENDS use[11]. Finally, 14% prevalence of ENDS use among active duty soldiers stationed at Fort Bragg Army Base, North Carolina, and Lackland Air Force Base, Texas[13]. The authors also reported similar associations of higher prevalence of ENDS use with younger age, enlisted

military rank, former and current cigarette smoking, former smokeless tobacco use, and former and current cigar or pipe smoking[13].

Strengths and limitations

The most important strengths of this study are its large sample size and complex survey design, which resulted in estimates which are representative of the entire US military population. Additionally, it includes a diverse sample with robust representation from underrepresented minorities. This work also has several important limitations. Most importantly, product use is highly dynamic in the US, and these trends have likely changed since 2015. For example, the prevalence of ENDS use among people aged 18–24 years in the US nearly doubled from 5.2% in 2015 to 9.3% in 2019[1,23]. The release of the 2018 HRBS is anticipated soon and should allow further assessment of these trends. Incorporating similar methods when analyzing 2018 HRBS data (when they are released) will allow the assessment of the extent to which cigarette and ENDS use have continued to change within the US military since the release of the 2015 HRBS. Additionally, as a cross-sectional study, this study generates estimates of prevalence rather than risk, and it is impossible to determine temporality from the data. Several potentially confounding variables were also unavailable in the original dataset, including more precise racial and ethnic groups and sexual orientation[1,24]. Efforts to obtain these additional data are ongoing and will be examined in future studies. Importantly, the response rate for the 2015 HRBS was low (8.6%). As noted by the authors of the 2015 HRBS report, low response rates do not necessarily translate to biased results, but they increase the probability that study participants possess qualitative differences from non-participating US SMs[20]. The low response rate is certainly a limitation of this study, but the final sample was robust and diverse with respect to age, sex, race, rank, and education level, and there were no major differences in these characteristics in comparison with the overall active duty population[25]. Moreover, the use of HRBS data facilitates comparisons across all five Branches of the US military throughout the world, while most previous studies on this topic are service and/or location specific[10-14,16,26]. It must also be noted that the definition of 'dual use' varies considerably in tobacco literature. A common definition has been

proposed, which classifies dual-users as those with daily or non-daily use of cigarettes and any smokeless tobacco product[27]. A core objective of this study was to estimate prevalence of cigarette smoking and ENDS use specifically, as ENDS use has evolved into a major public health threat in the 21st century. As a result, the definition of 'dual-use' in the present contribution may differ from that of other studies and invalidate comparisons of prevalence estimates. Additional studies have analyzed[28], and should continue to analyze, demographic trends and prevalence patterns with respect to the use of non-ENDS smokeless tobacco products in military populations. It is also worth noting that the true prevalence of probable AUD may be underreported in soldiers aged <21 years, as consumption of alcohol is illegal in this population and is a punishable offense under the Uniformed Code of Military Justice. Finally, this study cannot be generalized to the US population due to differences in underlying demographics and health status.

Concerning trends and perceptions

Tobacco use remains an important health problem in the US military, as it is in the general US population, although the trends in both populations are highly dynamic. The use of tobacco products, particularly cigarettes, decreased dramatically in the US military between 2011 and 2015, and overall use was lower than in the general population for the first time. However, there are concerning trends of higher use of ENDS and dual use in the military, particularly in younger populations, which have a higher prevalence than in the general US population. There are several possible explanations for this. Recent literature suggests low harm perception may be driving ENDS use among military personnel. A September 2020 DHA brief revealed that only 48% of beneficiaries aged 18–24 years believe vaping poses a great risk to their health[16]. While 87% of beneficiaries believed cigarette use poses a great risk to health, only 68% held the same belief with respect to vaping. Interestingly, three times as many beneficiaries were unsure about the risk of vaping compared to the risk of cigarette smoking[16]. Other studies reported similar findings of low risk perception in military populations[10-13]. While ENDS have a low risk perception in civilian populations as well, military populations may have differing risk perceptions and tolerance due to characteristics and

behaviors which are more common in this population, such as education, socioeconomic status, alcohol use, and impulsivity.

CONCLUSIONS

Cigarette and ENDS use are dynamic, changing health threats to the US military. Military efforts to control cigarette use among SMs seem to have been successful, as demonstrated by the dramatic declines in its use and the lower prevalence seen in the military compared to the general population. However, the concurrent increases in ENDS use are concerning, particularly among the youngest members of the military. Recent qualitative research among Air Force trainees suggests some additional attitudes which may contribute towards ENDS use in military populations, including perceived benefits such as help with emotion management, social benefits as a way of fitting in, and the ability to avoid enforcement of military tobacco control policies[16]. The US military must continue to monitor emerging trends in ENDS, cigarette, and dual use and rapidly take steps to address them. Better communication of the health threat of ENDS and the DoD restrictions and prohibitions regarding their use are necessary but insufficient first steps. While the DoD has eliminated ENDS sales from its exchanges[29], and Federal Law now prohibits the sale of ENDS to anyone under 21 years (including military SMs)[30]; these measures are also insufficient as they only apply to the minority of SMs under 21 years and can be easily avoided by having others purchase these products for them. Further prohibitions of all on-base use, along with better communication and enforcement policies, as well as comprehensive tobacco control programs, have been recommended since 2009[5]. Responsive policies and programs, which are informed by knowledge of current behaviors and trends, are needed to counter and mitigate the impact of this emerging threat on health and force readiness. Finally, military efforts to reduce cigarette and ENDS use must be aligned and integrated with community and societal efforts. The effects of military control programs will be reduced if community or societal postures are more permissive and cigarette and/or ENDS use is prevalent.

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