



Review

A literature review on prevalence of gender differences and intersections with other vulnerabilities to tobacco use in the United States, 2004–2014



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ABSTRACT

This report describes results from a systematic literature review examining gender differences in U.S. prevalence rates of current use of tobacco and nicotine delivery products and how they intersect with other vulnerabilities to tobacco use. We searched PubMed on gender differences in tobacco use across the years 2004–2014. For inclusion, reports had to be in English, in a peer-reviewed journal or federal government report, report prevalence rates for current use of a tobacco product in males and females, and use a U.S. nationally representative sample. Prevalence rates were generally higher in males than in females across all products. This pattern remained stable despite changes over time in overall prevalence rates. Gender differences generally were robust when intersecting with other vulnerabilities, although decreases in the magnitude of gender differences were noted among younger and older users, and among educational levels and race/ethnic groups associated with the highest or lowest prevalence rates. Overall, these results document a pervasive association of gender with vulnerability to tobacco use that acts additively with other vulnerabilities. These vulnerabilities should be considered whenever formulating tobacco control and regulatory policies.

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Introduction

The substantial decreases in the prevalence of cigarette smoking that have transpired since the landmark 1964 Surgeon General's Report (U.S. Department of Health, Education, Welfare, 1964) have been associated with growing interest in gender and other individual differences in vulnerability to tobacco use for at least two related reasons. First, these overall decreases in smoking prevalence are unevenly distributed in the general population. Smoking prevalence has decreased substantially in some subpopulations (e.g., more affluent White males), while changing relatively little in others (e.g., those with substance use or other psychiatric disorders), and increasing in still others (e.g., economically disadvantaged women) (e.g., Higgins and Chilcoat, 2009; Chilcoat, 2009). This unevenness in changes in prevalence of cigarette smoking underscores the need to better understand individual differences underpinning vulnerability to tobacco use including gender. Second, in response to these decreases in the prevalence of cigarette smoking and related revenue loss, tobacco manufacturers continue to invest in new marketing strategies to promote cigarette smoking. They also invest in the development of new tobacco and other nicotine delivery products that cater to the preferences of a particular gender or other subpopulations of potential users (e.g., females, youth, racial/ethnic minorities, gay/lesbian/bisexual/transgender persons).

Monitoring differences in smoking, other tobacco use, and nicotine delivery product use by gender and other vulnerabilities is crucial to effective tobacco control and regulation. The 2009 Family Smoking Prevention and Tobacco Control Act, for example, grants the U.S. Food and Drug Administration (FDA) regulatory authority over the manufacture, marketing, and distribution of tobacco products in order to protect the U.S. public health (Ashley and Backinger, 2012; Ashley, Backinger, van Bommel, and Neveleff, 2014). To carry out that charge in an effective, evidence-based manner, the FDA needs to consider evidence about the impact of tobacco use by gender as well as other markers of vulnerability (Ashley and Backinger, 2012).

Another important gender-related difference in tobacco use patterns was highlighted in the 2014 U.S. Surgeon General's report. As discussed in that report (see Chapters 15 & 16), combusted tobacco products are the most harmful, with cigarettes accounting for the vast majority of tobacco related morbidity and premature mortality (US DHHS, 2014). Without question, the most well documented path to improved health is complete abstinence from all tobacco products. However, for those unable to quit tobacco use, abstaining from the use of combusted products is also a potentially viable step towards reducing morbidity and mortality (US DHHS, Chapters 15 and 16; Zeller and Hatsukami, 2009). Yet, noncombustible tobacco products are rarely used by women in place of cigarettes with the possible exception of e-cigarettes (US DHHS, Chapter 13 [see Other Tobacco Products section]).

The overarching purpose of this review is to examine (1) gender differences in prevalence of current cigarette smoking and use of other tobacco and nicotine delivery products and (2) how gender intersects with other markers of vulnerability to tobacco use. Gender differences in the prevalence of current smoking have clearly decreased from where they once stood (Chilcoat, 2009), but it is important to examine where they currently stand and how differences seen in cigarette smoking extend to other tobacco products. In addition to gender, some other important markers of vulnerability to tobacco use include age, race/ethnicity, socioeconomic status (educational attainment, poverty status, disability status, income), sexual orientation, psychiatric or other medical co-morbidities, and active military/veteran status. While gender is inevitably expressed in the context of these other

characteristics, to our knowledge, there has been relatively little systematic examination of the intersection of these vulnerabilities. Are the changes in risk associated with these characteristics independent of each other? Does risk increase in an additive or perhaps a synergistic manner when multiple vulnerabilities co-occur? Such knowledge is important to the development of evidence-based tobacco control and regulatory policies and thus is examined in this review.

We know of no definitive or exhaustive list of vulnerabilities to tobacco or nicotine use. The list used in the present study was chosen to align with vulnerabilities identified by the FDA as relevant to tobacco regulatory science, acknowledging that the list is not meant to be exhaustive (Ashley and Backinger, 2012). Each of the vulnerabilities examined has a well-established association with greater prevalence of cigarette smoking compared to the general population. The present review is focused on the U.S. due to (a) the relative abundance of reports available on tobacco use patterns in nationally representative samples and (b) our interest in potential U.S. policy implications. We characterize gender differences across cigarette smoking and use of other tobacco and nicotine delivery products. We focus on cigarette smoking in examining the intersection of gender with other vulnerabilities because it is the form of tobacco use for which the greatest amount of information is available across the various vulnerabilities of interest in nationally representative samples. We also largely focus on adults in examining intersections with other vulnerabilities as relatively little information is available in youth aside from differences by academic grade and race/ethnicity, which are included.

Methods

Search strategy

A search of the U.S. National Library of Medicine search engine PubMed was conducted on gender differences in tobacco use for the years 2004–2014. PubMed was deemed to be the appropriate search engine for locating studies of tobacco use in nationally representative samples of the U.S. population. The 2004–14 timeframe was deemed to be sufficiently large to capture current U.S. tobacco use practices and also to assess literature published before and following passage of the 2009 Family Smoking Prevention and Tobacco Control Act, an event of considerable importance to U.S. tobacco research. Two PubMed searches were conducted. First we searched using the following search string: (((((((("Tobacco, Smokeless"[Majr] OR ("smokeless tobacco"[tiab] OR "oral tobacco"[tiab] OR "dipping tobacco"[tiab] OR "chewing tobacco"[tiab] OR "spit tobacco"[tiab] OR snuff[tiab] OR snus[tiab] OR "dissolvable tobacco"[tiab] OR dissolvables[tiab])))) OR (((Smoking/epidemiology[Majr] OR (Smoking[Majr] AND Prevalence[MeSH])) OR ("Tobacco Products"[Majr:NoExp] AND "Prevalence"[Mesh])))) OR (((waterpipe*[TIAB] OR hookah*[TIAB] OR cigar*[TIAB] OR tobacco*[TIAB] OR "pipe smoking"[TIAB])) AND (prevalen*[TIAB] OR epidemiolog*[TIAB])))) AND (((("Sex Factors"[Mesh] OR "Sex Distribution"[Mesh])) OR gender[tiab])) AND ((United States[MeSH] OR ("united states"[TIAB] OR "u.s."[TIAB] OR "u.s.a."[TIAB])). Second, we conducted a complimentary search using the following terms "MMWR, cigarette smoking, tobacco use, United states" because of the high frequency of reports on prevalence of tobacco use in the CDC's Morbidity and Mortality Weekly Report (Centers for Disease Control and Prevention (CDC), 2015, <http://www.cdc.gov/mmwr/>). Lastly, we reviewed bibliographies of reports located through the above search strategy and also consulted colleagues on potentially relevant sources.

Reports identified were reviewed by four of the authors (STH, ANK, RR, TJW). For inclusion, reports had to be judged by those four authors to be in English, report on prevalence of current use of a tobacco product or e-cigarettes, use data from a U.S. nationally representative sample (or an entire national subpopulation such as all individuals in a branch of the U.S. military over a designated time period), and be published in a peer-reviewed journal or a publication of the U.S. Federal Government (e.g., CDC). 850 reports were reviewed.

Table 1Percentage of adults (aged ≥ 18 years) who were current cigarette smokers^a – National Health Interview Survey, United States, 2005 and 2013.

	Males		Females		Male:Female Ratio	
	2005 (n = 13,762)	2013 (n = 15,440)	2005 (n = 17,666)	2013 (n = 19,117)	2005	2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
Overall	23.9 (22.9–24.8)	20.5 (19.5–21.4)	18.1 (17.4–18.9)	15.3 (14.6–16.1)	1.32	1.34

Notes. Adapted from Jamal et al. (2014). CI = confidence interval.

^a Persons who reported smoking ≥ 100 cigarettes during their lifetime and who, at the time of interview, reported smoking every day or some days. Excludes 296 (2005) and 121 (2013) respondents whose smoking status was unknown.

Disagreements were resolved through discussion until consensus was reached. Seventy-three reports were selected for inclusion in this review.

A gender difference was judged to be present if the reported prevalence rates and associated measures of variance for males and females did not overlap. When measures of variance were not reported, decisions were based on a comparison of the respective point estimates of prevalence. We also calculated male to female prevalence ratios to aid in discerning patterns in gender differences despite variations in overall prevalence rates. We did not conduct a meta-analysis.

Results

Prevalence of current cigarette smoking

Adults

To illustrate prevalence rates of current smoking among U.S. adults, Table 1 shows results from a national survey (National Health Interview Survey, NHIS) conducted relatively early (2005) and late (2013) in the time period of interest in this review (Jamal et al., 2014). Prevalence rate point estimates were between 5.8 and 5.2 percentage points higher among males than females across the 2005 and 2013 survey years, respectively. Male to female ratios of use were stable across survey years at approximately 1.3:1 despite decreases in smoking prevalence rates across surveys. The results reported in Table 2 (adults) illustrate the generality of the gender differences shown in Table 1 to results from two years of another national survey of the general adult population (National Adult Tobacco Survey, NATS; Agaku, King, Husten, et al., 2014; King, Dube, and Tynan, 2012). Consistent with results described in Table 1, smoking prevalence was higher among adult males than females across both survey years. Also consistent were the ratios of male to female smoking for the 2009–10 and 2012–13 surveys, which were approximately 1.3:1 and 1.4:1.

Including the reports shown in Tables 1 & 2, we reviewed a total of 44 reports on prevalence of current cigarette smoking in adult males and females (see all citations in Reference section related to Table 1 and adult section of Table 2). Smoking prevalence rates were higher among males than females in 41 of the 44 reports (93%) consistent with the patterns shown in Tables 1 and 2. The ratio of male to female

smoking rates in the range of 1.3–1.4:1 was consistent as well. The three reports noting exceptions involved the following: (a) higher smoking prevalence among females than males with drug or alcohol abuse or dependence (Husky, Paliwal, Mazure, and McKee, 2007), (b) the absence of gender differences between males and females among different Hispanic ethnicities (Lariscy et al., 2013), and (c) the absence of clear gender differences in older smokers (Drum, Shiovitz-Ezra, Gaumer, and Lindau, 2009). The smaller differences between genders seen in older age brackets are a pattern that shows up with some frequency when examining intersections with gender and age. We did not see any such patterns with the two other exceptions.

Youth

To illustrate smoking prevalence among U.S. youth, Table 2 also shows results on smoking prevalence from two years of a national survey among high school and middle school students (National Youth Tobacco Survey, NYTS; Arrazola, Neff, Kennedy, Holder-Hayes, and Jones, 2014; CDC, 2012b). Prevalence rates among high school students were 4.8 and 2.9 percentage points higher in males than females consistent with patterns seen in adults. The male to female ratios of approximately 1.3:1 seen among high school students also align closely with those seen in adults as do the stability of the male to female ratios across survey years. The only discernible difference from the patterns seen in adults is the overlapping confidence intervals (CIs) seen in the high school male and female rates for 2013. Prevalence rates among middle school students also trended towards being slightly higher in males than females, although by less than a percentage point and with overlapping CIs in both years. Male to female ratios among middle school students are also lower than those seen among adults or high school students at approximately 1.2:1 and 1.1:1 across the two survey years.

Including the studies characterized in Table 2, we reviewed 22 reports on cigarette smoking prevalence in youth (Arrazola et al., 2014; Caraballo, Yee, Pechacek, Henson, and Gfroerer, 2006; CDC, 2004b, 2004c, 2006a, 2006b, 2008b, 2010a, 2010b, 2012b, 2013a; Chung and Joung, 2014; Corliss et al., 2014; Daw, Nowotny, and Boardman, 2013; Delnevo and Hrywna, 2006; Duncan and Rees, 2005; Dunn, 2014; Eaton et al., 2012; Eaton et al., 2010; Garrett, Dube, Winder, and Caraballo, 2013; Marshall et al., 2006; Reddy, Resnicow, Omardien,

Table 2Percentage of adults (aged ≥ 18 years) and youth (high school/middle school) who were current cigarette smokers^a – National Adult Tobacco Survey, United States, 2009–2010 and 2012–2013 and National Youth Tobacco Survey, 2009 and 2013.

	Males		Females		Male:Female Ratio	
	2009–2010	2012–2013	2009–2010	2012–2013	2009–2010	2012–2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
Adults	22.2 (21.5–23.2)	20.0 (19.8–21.4)	16.9 (16.3–17.5)	14.5 (13.9–15.1)	1.31	1.38
	Males		Females		Male:Female Ratio	
	2009	2013	2009	2013	2009	2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
High school	19.6 (16.9–22.6)	14.1 (12.3–16.1)	14.8 (13.0–16.8)	11.2 (9.8–12.9)	1.32	1.26
Middle school	5.6 (4.4–7.0)	3.0 (2.3–3.8)	4.7 (4.0–5.6)	2.8 (2.1–3.8)	1.19	1.07

Notes. Adult data adapted from King et al. (2012 [2009–2010 survey]) and Agaku et al. (2014 [2012–2013 survey]). Youth data adapted from CDC (2012b [2009 survey]) and Arrazola et al. (2014 [2013 survey]). CI = confidence interval.

^a Adults: Reported smoking at least 100 cigarettes during their lifetime and now smoked “every day” or “some days.” Youth: reported smoking ≥ once in the past 30 days.

Table 3

Percentage of adults (aged ≥ 18 years) who were current tobacco users — National Adult Tobacco Survey, United States, 2009–2010 and 2012–2013.

Product	Males		Females		Male: Female Ratio	
	2009–2010	2012–2013	2009–2010	2012–2013	2009–2010	2012–2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
Any tobacco (includes cigarettes) ^a	32.2 (31.3–33.2)	26.2 (25.4–27.0)	18.5 (17.9–19.1)	15.4 (14.8–16.0)	1.74	1.70
Cigars/cigarillos/little cigars ^b	10.4 (9.7–11.0)	3.2 (2.8–3.5)	3.1 (2.8–3.4)	0.7 (0.6–0.9)	3.35	4.57
Waterpipe/hookah ^c	2.3 (1.9–2.6)	0.6 (0.5–0.8)	0.9 (0.7–1.0)	0.4 (0.2–0.5)	2.56	1.50
Regular pipe ^d	1.8 (1.6–2.1)	0.5 (0.4–0.6)	0.4 (0.3–0.5)	–	4.50	–
Smokeless ^e	6.5 (6.1–7.0)	4.8 (4.4–5.2)	0.4 (0.3–0.5)	0.3 (0.2–0.3)	16.25	16.00
Snus ^f	2.5 (2.2–2.8)	–	0.4 (0.2–0.5)	–	6.25	–
Electronic cigarettes ^g	–	2.2 (1.9–2.5)	–	1.6 (1.4–1.8)	–	1.38

Notes. Adapted from King et al. (2012 [2009–2010 survey]) and Agaku et al. (2014 [2012–2013 survey]). Regular pipe data for 2012–2013 not presented because relative standard error ≥ 30%. Snus was included in the definition of *smokeless* in 2012–2013. Electronic cigarettes were not included in 2009–2010. CI = confidence interval.

^a Defined as currently using ≥ 1 of the above products (2009–2010) or “every day” or “some day” use of the above products (2012–2013).

^b Reported using at least once during their lifetime and at least once in the past 30 days (2009–2010); Reported using ≥ 50 times during their lifetime and currently using every day/some days (2012–2013).

^c 2009–2010: ≥ 1 lifetime use and used at least once in the past 30 days; 2012–2013: ≥ 1 lifetime use and currently using every day/some days.

^d 2009–2010: ≥ 1 lifetime use and used at least once in the past 30 days; 2012–2013: ≥ 50 lifetime uses and currently using every day/some days.

^e Defined as chew/snuff/dip (2009–2010) and chew/snuff/dip/snus/dissolvable tobacco products (2012–2013); 2009–2010: ≥ 1 lifetime use and used at least once in the past 30 days; 2012–2013: ≥ 20 lifetime uses and currently using every day/some days.

^f ≥ 1 lifetime use and used at least once in the past 30 days.

^g ≥ 1 lifetime use and currently using every day/some days.

and Kambaran, 2007). While the majority of reports noted higher prevalence rates among males than females (Arrazola et al., 2014; CDC, 2004b, 2008b, 2010a, 2012b; Chung and Joung, 2014; Daw et al., 2013; Dunn, 2014; Eaton et al., 2012; Eaton et al., 2010; Marshall et al., 2006), differences were often small (e.g., Dunn, 2014; Reddy et al., 2007), females exceeded males in several reports (Caraballo et al., 2006; CDC, 2006a, 2006b; CDC, 2004c; Delnevo and Hrywna, 2006; Duncan and Rees, 2005), and there were numerous instances of overlapping CIs in studies involving younger youth (e.g., middle school students) (e.g., Arrazola et al., 2014; CDC, 2012b; Marshall et al., 2006). Gender differences were clearly more discernible among older youth. For example, a report examining gender differences in cigarette smoking in 12th graders noted consistently higher prevalence rates in

males than females across consecutive years of the Monitoring The Future (MTF) survey starting in the early 1990s and continuing through the end of the study period in 2010 (Daw et al., 2013).

Prevalence of current use of other tobacco products

Adults

To illustrate prevalence of current use of other tobacco products among U.S. adults, Table 3 shows results from two survey years (2009–10 & 2012–13) of the NATS (King et al., 2012; Agaku et al., 2014). Prevalence rates were higher among males than females in 10 of the 11 (91%) possible comparisons. The only exception was the comparison of hookah use in the 2012–13 survey year where the trend was

Table 4Percentage of youth (high school/middle school) who were current tobacco users^a — National Youth Tobacco Survey, United States, 2009 and 2013.

Product	Males		Females		Male:Female Ratio	
	2009	2013	2009	2013	2009	2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
High school						
Any tobacco (includes cigarettes)	29.4 (25.3–33.8)	27.2 (24.6–30.0)	18.2 (16.1–20.5)	18.5 (16.8–20.2)	1.62	1.47
Cigars/cigarillos/little cigars	15.0 (12.4–18.1)	15.4 (13.9–17.0)	6.7 (5.2–8.2)	8.3 (6.9–9.8)	2.24	1.86
Waterpipe/hookah	–	5.6 (4.7–6.7)	–	4.8 (4.1–5.7)	–	1.17
Regular pipe	5.3 (4.5–6.3)	5.0 (4.1–6.0)	2.5 (1.9–3.3)	3.3 (2.7–4.0)	2.12	1.52
Bidis	2.7 (2.1–3.5)	0.8 (0.6–1.2)	2.1 (1.6–2.6)	0.5 (0.3–0.8)	1.29	1.60
Kreteks	2.9 (2.3–3.7)	1.2 (0.8–1.6)	1.9 (1.3–2.8)	0.5 (0.3–0.8)	1.53	2.40
Smokeless tobacco ^b	11.6 (8.3–15.9)	9.6 (7.6–12.0)	1.8 (1.3–2.4)	1.7 (1.2–2.3)	6.44	5.65
Snus	–	2.7 (2.1–3.5)	–	0.9 (0.6–1.4)	–	3.00
Electronic cigarettes	–	5.5 (4.5–6.8)	–	3.5 (2.8–4.3)	–	1.57
Middle school						
Any tobacco (includes cigarettes)	9.6 (8.2–11.2)	6.5 (5.3–8.0)	6.7 (5.8–7.6)	6.5 (5.3–7.9)	1.43	1.00
Cigars/cigarillos/little cigars	4.6 (3.9–5.5)	3.3 (2.6–4.2)	3.2 (2.6–4.0)	2.9 (2.1–4.0)	1.44	1.14
Waterpipe/hookah	–	0.9 (0.6–1.4)	–	1.3 (0.8–1.9)	–	0.69
Regular pipe	2.7 (2.1–3.6)	1.6 (1.1–2.2)	1.7 (1.2–2.5)	2.2 (1.5–3.2)	1.59	0.73
Bidis	2.0 (1.5–2.6)	0.5 (0.3–0.8)	1.2 (0.8–1.8)	0.4 (0.2–0.6)	1.67	1.25
Kreteks	1.6 (1.2–2.1)	0.5 (0.3–0.8)	0.7 (0.4–1.1)	–	2.29	–
Smokeless tobacco ^b	3.7 (2.8–4.9)	1.9 (1.2–2.8)	1.4 (1.0–1.9)	0.8 (0.6–1.2)	2.64	2.38
Snus	–	0.7 (0.4–1.0)	–	–	–	–
Electronic cigarettes	–	1.4 (1.0–1.9)	–	0.9 (0.6–1.4)	–	1.56

Notes. Adapted from CDC (2012b [2009 survey]) and Arrazola et al. (2014 [2013 survey]). Waterpipe/hookah, snus, and electronic cigarettes not included in 2009. Kretek and Snus data for females in 2013 were not presented because sample size < 50 or relative standard error ≥ 0.3. CI = confidence interval.

^a Current use for all forms of tobacco was defined as reporting using a product at least once in the past 30 days.

^b Smokeless tobacco defined as chew/snuff/dip both years.

in the direction of higher prevalence in males but with overlapping CIs. Male to female prevalence ratios ranged from 1.4:1 for e-cigarettes to 16.3:1 for smokeless tobacco use. Gender differences in use of any tobacco product appear to be stable at approximately a 1.7:1 male to female difference, somewhat above the ratio seen with cigarettes. Gender differences in the use of other combustibles are substantially larger than with cigarettes, and use of smokeless larger still. There is only a single estimate for e-cigarettes, but it is approximately 1.4 suggestive of a close alignment with cigarette smoking.

Including the report characterized in Table 3, we reviewed nine reports on this topic. Six reports (67%) noted higher prevalence rates in males than females across every comparison, which included any tobacco use, cigars, waterpipe/hookah, regular pipe, smokeless, snus, and kreteks (Bhattacharyya, 2012; Cullen et al., 2011; King et al., 2012; King, Dube, and Tynan, 2013; Mumford, Levy, Gitchell, and Blackman, 2006; Nelson et al., 2006). One of the three exceptions was the report by Agaku et al. (2014) shown in Table 3 where prevalence rates of hookah use did not differ between males and females. Another study (Vander Weg et al., 2008) in young military recruits noted gender differences in five comparisons (any tobacco use, pipes, cigars, bidis, smokeless) but CIs overlapped in the comparison of kreteks. The third exception was a report (Lariscy et al., 2013) wherein prevalence rates were higher in males than females for any tobacco use, but CIs overlapped across the other comparisons including cigars, waterpipe/hookah, regular pipes, smokeless, snus, and e-cigarettes. The uncharacteristic patterns of overlapping CIs in this one report was likely because gender comparisons were made within multiple race/ethnicity subgroups, which resulted in relatively small sample sizes and large CIs in many cells. Overall, male-to-female ratios observed in the literature review matched closely those outlined in Table 3, although in some cases, such as military recruits, ratios were larger (Vander Weg et al., 2008).

Youth

To illustrate prevalence of use of other tobacco products in youth, Table 4 shows results from two survey years (2009 & 2013) of the NYTS (Arrazola et al., 2014; CDC, 2012b). Among high school students (upper panel), prevalence rates trended towards being higher in males than females in each of the 17 comparisons, but with 6 (35%) instances of overlapping CIs. The male to female ratios ranged from approximately 1.2:1 to 6.4:1 across different products, a pattern that aligned well with that seen in adults but generally with smaller ratios. An exception may be e-cigarette use where the ratio (1.6:1) is slightly higher than what is seen in adults and is also higher than what is seen for cigarette smoking in high school students. Among middle school students (Table 4, lower panel), prevalence rates again trended towards being higher in males than females in 12 of the 15 (80%) comparisons for which data were available; rates were higher in females in 2 (13%) instances, equal in another (7%), and CIs overlapped in the majority (11/15, 73%) of comparisons. This developmental pattern in the emergence of gender differences in the use of these different tobacco products is consistent with the pattern characterized above for cigarette smoking. Male to female ratios ranged from 0.69 – 2.64:1, following the same general pattern seen in high school students and adults. As with high school students, the male to female ratio for e-cigarette use (1.6:1) is higher than expected from the pattern seen in adults or based on gender ratios for cigarette smoking in youth.

Including the report characterized in Table 4, we reviewed 14 reports on current use of tobacco products among youth. Six reports addressed any tobacco use in youth (Arrazola et al., 2014; CDC, 2010b, 2012b; Eaton et al., 2012; Haynie et al., 2013; Palamar et al., 2014); each trended towards higher prevalence among males with just a couple of instances of overlapping CIs among middle school students (CDC, 2010b, 2013a). Prevalence of current cigar use was examined in nine reports (Arrazola et al., 2014; CDC, 2010b, 2012b, 2013a; Delnevo and Hrywna, 2006; Eaton et al., 2012; Eaton et al., 2010; King et al., 2014; Marshall et al., 2006); each noted higher prevalence rates in

males than females, although with two instances of overlapping CIs in middle school students (CDC, 2010b, 2013a). Hookah use was examined in 4 reports (Amrock et al., 2014; Arrazola et al., 2014; CDC, 2013a; Palamar et al., 2014); all but one (Palamar et al., 2014) showed considerable overlap in CIs. Pipe use was compared across males and females in five reports (Arrazola et al., 2014; CDC, 2010b, 2012b, 2013a; Marshall et al., 2006); all noted higher prevalence in high school students, and trends in the same direction for middle school students but with overlapping CIs. Bidis and Kreteks were each examined in five reports (Arrazola et al., 2014; CDC, 2010b, 2012b, 2013a; Marshall et al., 2006); use of both products trended towards higher prevalence in males than females but with overlapping of CIs. Prevalence of smokeless tobacco use was examined in 6 reports (Arrazola et al., 2014; CDC, 2012b, 2013a; Eaton et al., 2012; Marshall et al., 2006; Nelson et al., 2006); prevalence was generally higher among males, but with overlapping CIs in middle school (CDC, 2013a) and in a single study in Asian high school students (CDC, 2012b). Male to female ratios largely aligned with patterns shown in Table 4. E-cigarette use was examined in 2 reports (Arrazola et al., 2014; CDC, 2013a), with use among high school males exceeding females in both reports. Middle school students in those same two reports show the same trend towards higher e-cigarette use in males than females but with overlapping CIs. Male to female ratios for e-cigarette use in high school and middle school were larger than those seen for cigarette smoking in youth and larger than the male to female ratios seen for e-cigarette use among adults. Only one report specifically examined the use of dissolvable tobacco products but a valid estimate of prevalence among females could not be obtained precluding a gender comparison (Arrazola et al., 2014).

Intersections of gender with other risk factors for cigarette smoking

This section examines intersections between gender and other vulnerabilities including chronological age. To illustrate these intersections, Table 5 shows the prevalence rates of current smoking in Table 1 broken down by seven other vulnerabilities (Jamal et al., 2014). Table 6 does the same for military status (Bray et al., 2006; Barlas et al., 2013). Finally the top row of Table 7 illustrates a two-way intersection between mental illness and gender while the remainder of that table illustrates three-way intersections of mental illness, gender, and five vulnerabilities (CDC, 2013b). The aim of this section is to examine whether gender differences remain discernible in the presence of these other well-known markers of vulnerability to cigarette smoking (i.e., independent associations).

Two-way intersections

Age and gender. Including the report shown in Table 5, we reviewed 17 studies containing data on the intersection of gender and age (Agaku King, Dube, et al., 2014; CDC, 2003; CDC, 2004a, 2005a, 2005b, 2006c, 2007, 2008a, 2010c; CDC, 2011; CDC, 2012a; CDC, 2013b; Drum et al., 2009; Flegal, 2007; French, Jang, Tait, and Anstey, 2013; Jamal et al., 2014; Syamlal et al., 2014). Fifteen (88%) of them showed gender differences (males > females) within the different age brackets consistent with the patterns shown in Table 5. Also consistent with the results shown in Table 5 is that the two reports that did not show gender differences were conducted in older populations (Health and Retirement study—French et al., 2013; National Social Life, Health, and Aging Project—Drum et al., 2009).

Race/ethnicity and gender. Including the report reviewed in Table 5, we reviewed 26 studies containing data on the intersection of race/ethnicity and gender (Agaku, King, Dube, et al., 2014; Barbeau, Krieger, and Soobader, 2004; Blanco et al., 2014; Bosdriesz et al., 2013; CDC, 2003, 2004a, 2004c, 2005a, 2005b, 2006c, 2007, 2008a, 2009, 2010c; CDC, 2011; CDC, 2012a; CDC, 2013b; Chae, Gavin, and Takeuchi, 2006; Garrett et al., 2011; Gorman, Lariscy, and Kaushik, 2014; Jamal et al., 2014; Lariscy et al., 2013; Schoenborn and Adams, 2010; Schoenborn,

Table 5Percentage of adults (aged ≥ 18 years) who were current cigarette smokers^a by selected characteristics – National Health Interview Survey, United States, 2005 and 2013.

	Males		Females		Total		Male: Female Ratio	
	2005 (n = 13,762)	2013 (n = 15,440)	2005 (n = 17,666)	2013 (n = 19,117)	2005 (n = 31,428)	2013 (n = 34,557)	2005	2013
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)		
<i>Age group (years)</i>								
18–24	28.0 (25.0–31.1)	21.9 (19.0–24.8)	20.7 (18.3–23.1)	15.4 (12.9–17.9)	24.4 (22.4–26.4)	18.7 (16.9–20.5)	1.35	1.42
25–44	26.8 (25.4–28.2)	23.3 (21.7–24.9)	21.4 (20.2–22.6)	17.1 (16.0–18.2)	24.1 (23.1–25.1)	20.1 (19.1–21.1)	1.25	1.36
45–64	25.2 (23.7–26.7)	21.9 (20.5–23.4)	18.8 (17.7–20.0)	18.1 (16.8–19.3)	21.9 (21.0–22.9)	19.9 (19.0–20.9)	1.34	1.21
≥65	8.9 (7.6–10.2)	10.6 (9.2–11.9)	8.3 (7.3–9.3)	7.5 (6.5–8.4)	8.6 (7.8–9.3)	8.8 (8.0–9.7)	1.07	1.41
<i>Race/ethnicity^b</i>								
White	24.0 (22.8–25.2)	21.2 (19.9–22.4)	20.0 (19.1–20.9)	17.8 (16.8–18.8)	21.9 (21.1–22.7)	18.6 (18.6–20.2)	1.20	1.19
Black	26.7 (23.9–29.4)	21.8 (19.2–24.3)	17.3 (15.5–19.0)	15.4 (13.7–17.0)	21.5 (19.8–23.1)	18.3 (16.8–19.7)	1.54	1.42
Hispanic	21.1 (19.3–23.0)	17.3 (15.3–19.2)	11.1 (9.8–12.4)	7.0 (6.0–7.9)	16.2 (15.1–17.4)	12.1 (11.0–13.2)	1.90	2.47
American Indian/Alaska Native	37.5 (20.7–54.3)	32.1 (20.9–43.3)	26.8 (15.6–38.1)	22.0 (12.2–31.8)	24.8 (17.7–31.8)	26.1 (18.5–33.7)	1.40	1.46
Asian ^c	20.6 (15.7–25.5)	15.1 (12.1–18.1)	6.1 (3.7–8.5)	4.8 (3.2–6.5)	13.3 (10.4–16.3)	9.6 (7.9–11.4)	3.38	3.15
Multiple races	26.1 (16.3–36.0)	29.1 (22.0–36.2)	23.5 (14.8–32.2)	24.8 (18.0–31.5)	24.8 (17.7–31.8)	26.8 (21.9–31.8)	1.11	1.17
<i>Education level^d</i>								
0–12 years (no diploma)	29.5 (27.2–31.8)	30.6 (27.7–33.5)	21.9 (20.0–23.7)	18.0 (16.1–20.0)	25.5 (24.0–27.1)	24.2 (22.5–25.9)	1.35	1.70
GED	47.5 (41.5–53.6)	42.9 (36.4–49.3)	38.8 (33.6–44.0)	39.7 (33.5–45.9)	43.2 (39.1–47.4)	41.4 (36.8–45.9)	1.22	1.08
High school diploma	28.8 (27.0–30.7)	26.7 (24.6–28.8)	20.7 (19.3–22.2)	17.6 (16.1–19.2)	24.6 (23.4–25.7)	22.0 (20.7–23.3)	1.39	1.52
Some college, no diploma	26.2 (24.0–28.4)	22.4 (20.4–24.4)	21.1 (19.2–22.9)	19.5 (17.8–21.3)	23.5 (22.1–24.9)	20.9 (19.4–22.3)	1.24	1.15
Associate degree	26.1 (23.2–28.9)	17.8 (15.5–20.2)	17.1 (15.0–19.3)	17.7 (15.5–20.0)	20.9 (19.2–22.6)	16.2 (15.6–16.8)	1.53	1.01
Undergraduate degree	11.9 (10.5–13.3)	10.4 (9.0–11.9)	9.6 (8.3–10.8)	7.9 (6.9–9.0)	10.7 (9.8–11.6)	29.2 (27.5–31.0)	1.24	1.32
Graduate degree	6.9 (5.3–8.5)	5.7 (4.5–7.0)	7.4 (5.9–8.8)	5.5 (4.1–6.8)	7.1 (6.0–8.3)	16.0 (14.3–17.7)	0.93	1.04
<i>Poverty status^e</i>								
At or above poverty level	23.7 (22.6–24.7)	18.7 (17.7–19.7)	17.6 (16.8–18.5)	13.8 (13.0–14.6)	20.6 (19.9–21.3)	16.2 (15.6–16.8)	1.35	1.36
Below poverty level	34.3 (31.0–37.5)	33.8 (30.7–36.8)	23.9 (24.5–29.3)	25.8 (23.8–27.8)	29.9 (27.9–31.9)	29.2 (27.5–31.0)	1.44	1.31
<i>Disability/limitation^f</i>								
Yes	– ⁱ – ⁱ	26.1 (23.6–28.7)	– ⁱ – ⁱ	20.4 (18.5–22.3)	– ⁱ	23.0 (21.4–24.5)	– ⁱ	1.28
No	– ⁱ – ⁱ	19.9 (18.6–21.2)	– ⁱ – ⁱ	14.5 (13.5–15.5)	– ⁱ	17.0 (16.2–17.7)	– ⁱ	1.37
<i>U.S. census region^g</i>								
Northeast	20.7 (18.6–22.9)	18.0 (15.8–20.2)	17.9 (16.4–19.5)	15.8 (14.0–17.7)	19.2 (17.8–20.6)	16.9 (15.6–18.1)	1.16	1.14
Midwest	27.3 (25.3–29.3)	23.6 (21.6–25.6)	21.3 (19.8–22.8)	17.4 (15.5–19.3)	24.2 (23.0–25.3)	20.5 (19.1–21.9)	1.28	1.36
South	25.3 (23.6–27.0)	22.7 (21.1–24.4)	18.5 (17.3–19.7)	16.2 (15.1–17.3)	21.8 (20.6–23.0)	19.2 (18.2–20.3)	1.37	1.40
West	20.1 (18.3–21.9)	15.8 (14.0–17.5)	13.9 (12.6–15.2)	11.5 (10.3–12.7)	17.0 (16.0–18.0)	13.6 (12.5–14.7)	1.45	1.37
<i>Sexual orientation^h</i>								
Straight	– ⁱ – ⁱ	20.3 (19.3–21.2)	– ⁱ – ⁱ	15.0 (14.3–15.8)	– ⁱ	17.6 (16.9–18.2)	– ⁱ	1.35
Lesbian/gay/bisexual	– ⁱ – ⁱ	26.4 (19.9–32.9)	– ⁱ – ⁱ	26.7 (20.1–33.4)	– ⁱ	26.6 (22.4–30.8)	– ⁱ	0.99
Overall	23.9 (22.9–24.8)	20.5 (19.5–21.4)	18.1 (17.4–18.9)	15.3 (14.6–16.1)	20.9 (20.3–21.5)	17.8 (17.2–18.4)	1.32	1.34

Notes. Adapted from Jamal et al. (2014). CI = confidence interval. GED = General Educational Development certificate.

^a Persons who reported smoking ≥ 100 cigarettes during their lifetime and who, at the time of interview, reported smoking every day or some days. Excludes 296 (2005) and 121 (2013) respondents whose smoking status was unknown.^b Excludes 45 (2005) and 73 (2013) respondents of unknown race.^c Does not include Native Hawaiians or Other Pacific Islanders.^d Among persons aged ≥ 25 years. Excludes 339 (2005) and 155 (2013) persons whose educational level was unknown.^e 2005 and 2013 estimates based on reported family income and 2004/2013 poverty thresholds (respectively) published by the U.S. Census Bureau.^f Defined based on self-reported presence of selected impairments, including vision, hearing, cognition, and movement (see CDC, 2014).^g See CDC (2014) for states in each census region.^h Response options were “straight, that is, not gay” for men, “straight, that is not gay or lesbian” for women, “gay” for men, “gay or lesbian” for women, and “bisexual” for either men or women.ⁱ Questions pertaining to disabilities/limitations and sexual orientation not included in the 2005 National Health Interview Survey.**Table 6**Percentage of adults (aged ≥ 18 years) who were current cigarette smokers^a by Service Branch—Department of Defense Survey of Health-Related Behaviors, 2005 and 2011.

	Males		Females		Male:Female Ratio	
	2005	2011	2005	2011	2005	2011
	% (SE)	% (SE)	% (SE)	% (SE)		
Active military/civilians						
Marines	36.3 (2.8)	31.4 (0.8)	26.6 (1.9)	22.9 (2.4)	1.36	1.37
Army	39.4 (1.9)	28.1 (0.8)	26.0 (3.1)	19.0 (1.7)	1.52	1.48
Navy	29.8 (3.3)	25.6 (0.8)	22.2 (3.0)	18.4 (1.5)	1.34	1.39
Air Force	23.3 (2.0)	17.2 (0.4)	22.8 (1.5)	15.0 (0.8)	1.02	1.15
Coast Guard	–	20.4 (0.7)	–	17.1 (1.6)	–	1.19
Civilian	30.0 (0.6)	23.8 (0.5)	22.7 (0.5)	18.6 (0.4)	1.32	1.28

Notes. Active military/civilian data adapted from Bray et al. (2006 [2005 survey]) and Barlas et al. (2013 [2011 survey]). Coast Guard data not collected in DoD 2005 survey. SE = standard error.

^a Defined as any smoking in the past 30 days (DoD, 2005) and smoking ≥ 100 cigarettes in one's lifetime and currently smoking every day or some days (DoD, 2011).

Table 7

Percentage of adults (aged ≥ 18 years) who smoke cigarettes^a by mental illness status, sex, and selected characteristics — National Survey on Drug Use and Health, United States, 2009–2011.

	% of persons with any mental illness ^b who smoke cigarettes							% of persons with no mental illness who smoke cigarettes						
	Males (n = 11,100)		Females (n = 18,300)		Total (n = 29,400)		Male:Female Ratio	Males (n = 42,700)		Females (n = 42,000)		Total (n = 84,700)		Male:female ratio
	%	(95% CI)	%	(95% CI)	%	(95% CI)		%	(95% CI)	%	(95% CI)	%	(95% CI)	
Overall	39.6	(38.2–41.1)	33.8	(32.7–34.8)	36.1	(35.2–36.9)	1.17	24.4	(23.8–25.0)	18.4	(17.8–18.9)	21.4	(21.0–21.9)	1.33
Age group (years)														
18–24	45.2	(43.6–46.9)	39.1	(37.9–40.3)	41.6	(40.6–42.6)	1.16	36.7	(35.7–37.6)	24.9	(24.1–25.7)	31.3	(30.6–32.0)	1.47
25–44	44.7	(42.5–46.9)	37.8	(36.2–39.5)	40.5	(39.3–41.8)	1.18	29.8	(28.8–30.8)	21.7	(20.9–22.6)	25.9	(25.2–26.6)	1.37
45–64	34.7	(31.6–37.9)	32.8	(30.5–35.1)	33.5	(31.7–35.4)	1.06	22.1	(21.0–23.3)	19.2	(18.2–20.3)	20.7	(19.9–21.5)	1.15
≥65	18.3	(13.0–25.3)	10.1	(7.5–13.5)	13.0	(10.3–16.1)	1.81	9.1	(7.8–10.5)	8.6	(7.6–9.7)	8.8	(8.0–9.7)	1.06
Race/ethnicity ^c														
White	40.4	(38.7–42.1)	36.0	(34.8–37.2)	37.7	(36.7–38.7)	1.12	24.4	(23.7–25.1)	20.1	(19.4–20.7)	22.3	(21.7–22.8)	1.21
Black	41.5	(37.1–46.1)	29.5	(26.5–32.6)	34.0	(31.5–36.5)	1.41	25.9	(24.1–27.9)	19.2	(17.5–20.9)	22.3	(21.0–23.7)	1.35
Hispanic	38.2	(34.0–42.6)	26.8	(24.1–29.8)	31.6	(29.1–34.2)	1.43	25.5	(23.9–27.2)	13.4	(12.1–14.7)	19.8	(18.7–20.9)	1.90
American Indian/ Alaska Native	– ^g	– ^g	56.0	(44.9–66.5)	54.7	(45.3–63.7)		35.0	(27.9–42.9)	26.3	(20.7–32.9)	30.5	(25.7–35.7)	1.33
Asian	26.6	(20.3–34.1)	16.0	(12.4–20.4)	20.6	(17.2–24.6)	1.66	15.9	(13.6–18.5)	5.5	(4.2–7.3)	10.4	(9.0–11.9)	2.89
Other	35.8	(27.3–45.3)	43.1	(36.4–50.0)	40.0	(34.5–45.7)	0.83	26.3	(22.4–30.7)	26.3	(21.8–31.4)	26.3	(23.2–29.6)	1.00
Education level ^d														
<High school graduate	53.0	(48.5–57.4)	41.5	(37.8–45.3)	46.6	(43.6–49.6)	1.28	34.8	(32.8–36.9)	22.7	(20.9–24.7)	28.9	(27.6–30.3)	1.53
High school graduate	42.8	(39.5–46.3)	38.6	(36.1–41.2)	40.2	(38.2–42.3)	1.11	28.4	(27.2–29.7)	21.9	(20.8–23.0)	25.2	(24.3–26.0)	1.30
Some college	39.3	(35.9–42.9)	37.5	(35.2–39.8)	38.1	(36.2–40.2)	1.05	23.5	(22.2–24.9)	19.9	(18.7–21.1)	21.6	(20.7–22.5)	1.18
College graduate	22.0	(19.4–24.9)	16.7	(14.9–18.6)	18.7	(17.2–20.3)	1.32	11.7	(10.8–12.6)	9.5	(8.7–10.4)	10.6	(10.0–11.3)	1.23
Poverty status ^e														
At or above poverty level	36.8	(35.2–38.5)	30.9	(29.8–32.0)	33.3	(32.3–34.2)	1.19	22.9	(22.3–23.5)	16.8	(16.3–17.4)	20.0	(19.5–20.4)	1.36
Below poverty level	52.8	(49.4–56.2)	45.1	(42.8–47.4)	47.9	(45.9–49.8)	1.17	38.3	(36.3–40.4)	28.6	(26.9–30.3)	32.8	(31.5–34.1)	1.34
Unknown	24.9	(19.2–31.6)	23.8	(18.8–29.6)	24.2	(20.6–28.2)	1.05	21.4	(16.3–27.5)	17.4	(14.0–21.4)	19.5	(16.2–23.3)	1.23
U.S. census region ^f														
Northeast	37.6	(34.4–40.8)	32.9	(30.6–35.4)	34.7	(32.8–36.7)	1.14	22.9	(21.6–24.3)	18.8	(17.7–20.1)	20.9	(20.0–21.8)	1.22
Midwest	42.9	(40.4–45.4)	36.7	(34.7–38.7)	39.1	(37.5–40.7)	1.17	25.8	(24.7–26.9)	20.8	(19.8–21.9)	23.4	(22.6–24.2)	1.24
South	41.9	(39.3–44.5)	35.3	(33.5–37.1)	37.8	(36.3–39.3)	1.19	26.1	(25.0–27.2)	19.2	(18.2–20.2)	22.7	(21.9–23.5)	1.36
West	35.1	(32.1–38.2)	29.0	(27.0–31.0)	31.5	(29.7–33.3)	1.21	21.6	(20.3–23.0)	14.4	(13.3–15.5)	18.1	(17.2–19.0)	1.50

Notes. Adapted from CDC (2013b). CI = confidence interval.

^a Persons who reported ever smoking all or part of a cigarette in the 30 days preceding the interview.

^b Any mental illness is defined as a diagnosable mental, behavioral, or emotional disorder, other than a developmental or substance use disorder, that met the criteria found in the 4th edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV). For details on the methodology, see Section B.4.3 in Appendix B of the Results from the 2011 National Survey on Drug Use and Health: Mental Health Findings.

^c Persons identified as Hispanic might be of any race. Persons identified as White, Black, Asian, American Indian/Alaska Native, or Other are all non-Hispanic. The five racial/ethnic categories are mutually exclusive. "Other" includes Native Hawaiians or Other Pacific Islanders and persons of two or more races.

^d Among persons aged ≥ 25 years.

^e Based on reported family income and poverty thresholds published by the U.S. Census Bureau.

^f See CDC (2014) for states in each census region.

^g No estimate reported because of low precision.

Adams, Barnes, Vickerie, and Schiller, 2004; Shavers, Lawrence, Fagan, and Gibson, 2005; Syamlal et al., 2014). Twenty-one (81%) of these reports showed racial/ethnic and gender differences within the subgroups consistent with the patterns in Table 5 suggesting that the associations of gender and race/ethnicity with prevalence are largely independent. The other five (19%) reports noted overlapping male and female CIs within specific subgroups: three among Native Americans/Alaska Natives but not other racial/ethnic groups (Barbeau et al., 2004; CDC, 2004a; Schoenborn et al., 2004), one among Puerto Rican smokers but not other Hispanic subgroups (Blanco et al., 2014), and one among those identifying as "Other" race but not within other racial/ethnic groups (CDC, 2013b).

We reviewed one report in youth wherein gender differences in smoking prevalence were reported by race/ethnicity (Whites, Blacks, Hispanics) (Eaton et al., 2012). Smoking prevalence trended towards being higher in males than females across each of the race/ethnicity groups although male and female CIs overlapped within the White and Hispanic groups.

Educational attainment, poverty level, disability status, and gender. Table 5 shows results illustrating separate intersections of gender with educational attainment, poverty level, and disability status. Smoking

prevalence rate was inversely associated with educational attainment, with robust gender differences being discernible within educational levels except those associated with the highest (GED degree) and lowest (graduate degrees) prevalence rates. Regarding poverty status, smoking prevalence rates were higher among those with incomes below versus at or above the federal poverty levels, with gender differences being quite discernible across poverty levels. Similarly, smoking prevalence was greater among those with versus without a disability, with gender differences remaining discernible within each group. As with the other vulnerabilities discussed above, gender and these three socioeconomic markers appear to act independently in their association with smoking prevalence. That is clearly the case for poverty and disability whereas with education there is greater variance around the estimates at the highest and lowest levels perhaps related to smaller sample sizes.

Including the report illustrated in Table 5, we reviewed 19 studies with data on gender and SES (Agaku, King, Dube, et al., 2014; CDC, 2003, 2004a, 2004b, 2005b, 2006c, 2007, 2008a, 2010c; CDC, 2011; CDC, 2012a; CDC, 2013b; Chae et al., 2006; de Castro et al., 2010; Jamal et al., 2014; Lee, LeBlanc, Fleming, Gómez-Marín, and Pitman, 2004; Schoenborn and Adams, 2010; Schoenborn et al., 2004; Syamlal et al., 2014). Eighteen reports showed prevalence differences by

education and gender (all reports except Lee et al., 2004), 16 by poverty status and gender (Agaku, King, Dube, et al., 2014; CDC, 2003, 2004a, 2004b, 2005b, 2006c, 2007, 2008a, 2010c; CDC, 2011; CDC, 2012a; CDC, 2013b; Chae et al., 2006; Jamal et al., 2014; Schoenborn and Adams, 2010; Schoenborn et al., 2004), one by occupation and gender (Lee et al., 2004), three by disability and gender (Agaku, King, Dube, et al., 2014; CDC, 2012a; Jamal et al., 2014), and two by annual income and gender (de Castro et al., 2010; Syamlal et al., 2014). All of these studies noted differences in smoking prevalence by levels of education, poverty, or disability status and gender differences within the different levels of SES. The pattern of overlapping CIs at the highest and lowest levels of education was common, with the estimates consistently trending in the direction of rates among males exceeding females. There were overlapping CIs at the lower education levels (e.g., GED), and while the direction sometimes reversed with females exceeding males at the highest educational level (graduate degrees) there were again overlapping CIs (e.g., see Agaku, King, Dube, et al., 2014; CDC, 2012a; Jamal et al., 2014).

U.S. census region and gender. Table 5 illustrates a graded relationship between smoking prevalence and census region, with prevalence rates being highest among those residing in the Midwest, followed by the South, Northeast, and West. Rates among males were higher than females within each region across survey years with the only overlap in CIs being seen in the Northeast. Male to female ratios generally were consistent with those shown for the general adult population except for the Northeast where they were smaller.

Including the study illustrated in Table 5, we reviewed 8 reports on this topic (Agaku, King, Dube, et al., 2014; CDC, 2010c; CDC, 2011; CDC, 2012a; CDC, 2013b; Chae et al., 2006; Jamal et al., 2014; Syamlal et al., 2014). All reported higher rates among males than females suggesting independent associations of region and gender with smoking prevalence. There was only a single instance of overlapping CIs in one region (South) in a comparison of Asian smokers by region (Chae et al., 2006).

Sexual orientation and gender. The one vulnerability for cigarette smoking illustrated in Table 5 that appeared to interact with gender is sexual orientation (only reported for 2013, see Jamal et al., 2014). Smoking prevalence was higher among lesbian/gay/bisexuals than heterosexuals but the typical pattern of males smoking at higher rates than females was only seen among heterosexuals. Rates were approximately equal in males and females among lesbian/gay/bisexuals. In the one other report we reviewed on this topic, smoking rates differed by sexual orientation consistent with Table 5; however, gender differences (males > females) were also discernible within heterosexual and lesbian/gay groups, suggesting that the interaction evident in Table 5 is not reliable across studies (Fallin et al., 2014).

Active military, veterans and gender. Shown in Table 6 are prevalence rates of current smoking among civilians and different branches of the U.S. military from the two studies reviewed on this topic (Barlas, Higgins, Pflieger, and Diecker, 2013; Bray et al., 2006). Differences in smoking prevalence were discernible across both survey years whether comparing rates between different military branches (2005) or between the various branches and civilians (2011). Despite sizeable differences in prevalence, there are consistent gender difference (males > females) within and across each group and year, with the only exception being overlapping SEMs among Air Force males and females in 2005. This strongly suggests that the relationships of military status and gender with smoking prevalence are independent.

We failed to identify any reports on military veterans that met study inclusion criteria.

Psychiatric disorders, other medical co-morbidities, and gender. Illustrated in the top row of Table 7 are prevalence rates of current smoking by presence or absence of any mental illness (CDC, 2013b). Differences in

smoking prevalence by mental illness status and gender are clearly discernible with no evidence of an interaction.

Including the report shown in Table 7, we reviewed three reports on this topic (CDC, 2013b; Garrett et al., 2011; Smith, Mazure, and McKee, 2014). Two showed independent associations of psychiatric status and gender with smoking prevalence consistent with Table 7 (CDC, 2013b; Smith et al., 2014). The third study showed the usual association of gender with smoking prevalence (male > female) among those with mental illness but did not include a sample without mental illness (Hickman, Delucchi, and Prochaska, 2010).

A single report was identified on gender differences in current smoking prevalence among those with another substance use disorder (Husky et al., 2007). Females had a higher smoking prevalence than males among those with an alcohol or drug use disorder. This sample was selected from the general population of US adults surveyed in the first wave of the NESARC (2001–02).

We failed to identify any reports on other medical co-morbidities that met study inclusion criteria.

Three-way intersections

Table 7 provides the opportunity to examine intersections of psychiatric status, gender, and each of five other vulnerabilities (CDC, 2013b). The most consistent pattern across each of these three-way intersections is independence of the respective risk factors. With age, for example, (a) smoking rates are higher among those with versus without mental illness across each age bracket, (b) smoking rates generally vary inversely with age independent of mental illness, and (c) gender differences remain discernible within each age bracket independent of mental illness although with some overlapping of CIs in the older age brackets. Poverty status serves as an even stronger example of independent associations: (a) smoking prevalence is higher among those with compared to those without mental illness independent of poverty level; (b) smoking prevalence is greater among those with incomes below compared to those with incomes at or above the federal poverty level independent of mental illness; (c) smoking prevalence is greater among males than females within groups with and without mental illness and among those with incomes below or at or above the federal poverty level. Of the 42 gender comparisons related to the three-way intersections shown in Table 7, 40 (95%) were above 1.0. Both exceptions were among those identifying as “Other” for race/ethnicity (i.e., the group with the overall highest smoking prevalence and greater variance around the estimates).

In addition to the report characterized in Table 7 (CDC, 2013b), one additional report on three-way intersections was reviewed (age, gender, and civilian/military status) (Bray et al., 2006). Smoking rates varied by military/civilian status, smoking prevalence rates were lowest among older smokers within all groups, and rates among males were higher than females within all groups despite considerable variations across groups in smoking prevalence.

Observed and predicted cumulative increases in smoking prevalence

In this section we further examine whether the vulnerabilities discussed above in the form of two-way (Table 5) and three-way (Table 7) intersections represent additive increases in risk. We examined the highest and lowest prevalence rates associated with each intersection of interest. For example, for the two-way intersection of gender and age in the 2005 survey results shown in Table 5, we used the 28.0% prevalence rate for males in the 18–24 years age group and the 8.3% rate for females in the >65 years age group. The difference between those two prevalence rates (28.0%–8.3% = 19.7%) was taken to represent the observed influence of the gender and age intersection. We then calculated a predicted influence based on additive increases in prevalence associated with being male and younger in that survey year. The influence of being male was estimated by calculating the difference between the overall smoking prevalence rate among males minus the rate among

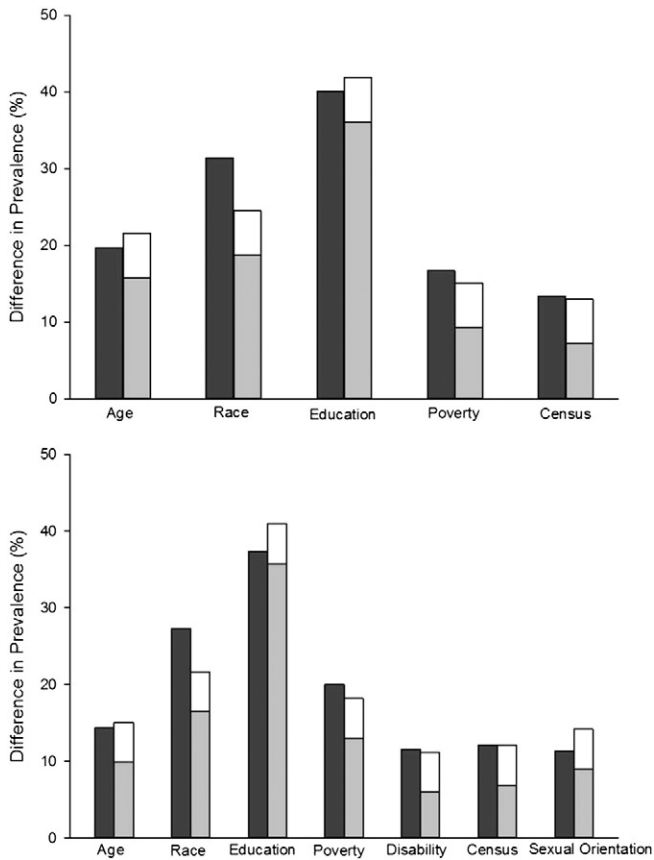


Fig. 1. All differences in smoking prevalence are based on data reported in Table 5, with those based on the 2005 survey results shown in the upper panel and those from the 2013 survey in the lower panel. Values listed as Observed represent the difference between the highest and lowest rates of current smoking associated with the intersection of gender and the respective vulnerability of interest shown on the X axis. Values shown as Predicted represent the sum of the total increase in risk associated with being male added to the total increase in risk associated with the respective vulnerability of interest shown on the X axis. Observed differences in smoking prevalence are shown as black bars. Predicted differences are shown as two-tone bars, with the contribution of gender in white and of the other vulnerability listed on the X axis in gray.

females (23.9%–18.1% = 5.8%). The influence of young age was estimated by calculating prevalence among individuals aged 18–24 years minus prevalence among those aged >65 years (24.4%–8.6% = 15.8%).

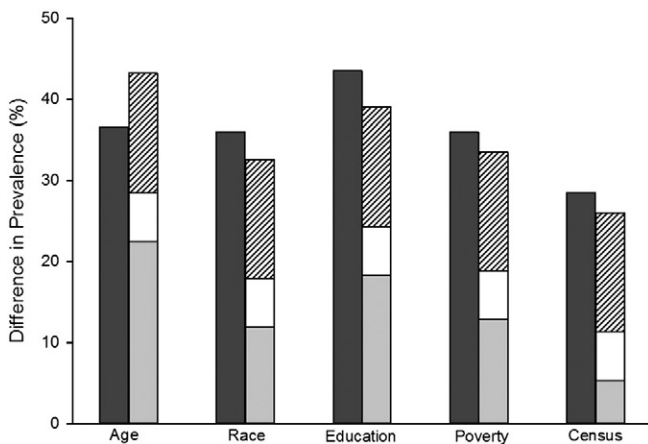


Fig. 2. Observed and predicted differences in smoking prevalence are defined as in Fig. 1 except showing three-way intersections based on data reported in Table 7. Observed differences are shown as black bars. Predicted differences are shown as three-tone bars, with the contribution of gender in white, psychiatric disorder in striped, and of the other vulnerability listed on the X axis in gray.

To calculate the predicted influence of the gender and age intersection, we summed the predicted increases associated with being male (5.8%) and in the youngest age bracket (15.8%). The resultant value of 21.6% is 1.9% higher than the observed difference in smoking prevalence between the youngest males and the oldest females, falling slightly below perfect additivity.

This same algorithm was applied to each of the two-way intersections in the 2005 (Fig. 1, upper panel) and 2013 (Fig. 1, lower panel) survey years shown in Table 5. The average observed difference in prevalence across the 12 two-way intersections was 0.5% above perfect additivity (range = −3.6% to +6.9%) (Fig. 1; upper panel for 2005 results; lower panel for 2013 results). This same general algorithm was also applied in examining observed and predicted differences in prevalence in the five three-way intersections shown in Table 7. The average observed difference in prevalence was 1.3% above perfect additivity (range = −6.6% to +4.5%) (Fig. 2).

Discussion

The results from the present study demonstrate a pervasive gender difference in current use of cigarettes and other tobacco and nicotine delivery products in the U.S. The pattern of male prevalence rates exceeding those in females is already discernible in middle school, becomes more defined in high school, and is well established by young adulthood where, at least with cigarette smoking, the pattern remains relatively stable through much of adulthood before dissipating at older ages. The 1.3:1 to 1.4:1 ratios of adult male to female cigarette smokers is a notable reduction from the approximately 2.2:1 ratio seen in the mid 1950s when U.S. smoking prevalence rates in males and females were quite high (~55% & 25%, respectively). This change corresponds to greater reductions in smoking prevalence over time in males than females, especially among women with lower educational attainment in whom smoking rates have decreased relatively little (Chilcoat, 2009). The present results also demonstrate that gender differences in smoking prevalence have remained relatively stable despite changes in absolute prevalence rates in males and females across the approximately 10-year period examined in this review. They also largely remain stable within the context of many other characteristics associated with increases or decreases in absolute prevalence rates. By and large, where decreases in gender differences were seen was at the margins where prevalence rates were highest or lowest (e.g., highest and lowest levels of educational attainment or age), samples sizes tend to be smaller, and variance around the estimates greater.

In terms of gender differences seen among cigarette smokers extending to use of other tobacco products, male to female ratios were often larger across the latter. The largest differences are seen for smokeless products, which continue to be used at quite low rates among females. Little data were available regarding use of newer smokeless products that have design features expected to have greater appeal to females (dissolvable products), which is a gap that merits monitoring going forward. Gender differences in use of e-cigarettes among adults generally align with those seen for cigarette smoking, which is consistent with use of e-cigarettes mostly being restricted to cigarette smokers. The same patterns of male to female ratios seen with other tobacco products among adults generally are observed among youth, although with male to female ratios typically being smaller. A notable exception is in e-cigarette use where male to female ratios trended towards being larger in youth than those among adults. This pattern may suggest that e-cigarette use starts at a later age in females or perhaps is less likely to be used by non-smokers among females than males. There is still relatively little data on prevalence of e-cigarette use, or use of electronic delivery devices more generally, in adults and youth, which is an important gap to address going forward. As was discussed

above, lower rates of use of non-combusted products among females could represent an obstacle to substituting such products for cigarettes among women who are unable to quit smoking. Another observation that also merits close monitoring going forward is the relatively higher rates of current use of cigars/cigarillos/little cigars among high school students of both genders, and lower male to female ratios, compared to adults (King et al., 2014; Messer et al., 2014).

The present results provide strong evidence that changes in risk associated with gender are largely independent of other vulnerabilities and that they intersect in an approximately additive manner with these other risk factors. This is an important matter to consider with regard to understanding risk. Take as an example the 5.6-fold difference in prevalence rates (53% vs. 9.5%) seen in Table 7 among males with less than 12 years of education and a psychiatric disorder compared to females who are college graduates and without a psychiatric disorder. Consider what those differences in prevalence rates might be if the lowest educated males with a psychiatric condition also resided in the Midwest census region, had annual incomes below the federal poverty level, were of mixed racial/ethnic origin, and had another substance use disorder. Consider further what the differences might be if the most educated females with a college education resided in the West, had incomes above the poverty level, did not have another substance use disorder, and were of Asian racial/ethnic origin. Both sets of characteristics seem quite plausible, and one can readily see how their respective cumulative risks might begin to approach 1.0 and zero. This is a topic that merits further examination beyond a literature review where the independence of the respective markers of vulnerability and associated changes in cumulative risk can be quantified, tested statistically, and compared in terms of the degree of risk associated with the different vulnerabilities. This is also an observation that raises concerns about characterizations of cigarette smoking as a matter of personal choice as is sometimes put forward by representatives of the tobacco industry and others who object to governmental efforts to curtail marketing and availability of cigarettes to vulnerable subgroups.

Another point that merits mention is that not all vulnerabilities are associated with equal increases in risk. While the overarching focus of the present study was gender, the risk associated with it is of smaller magnitude than risk associated with low educational attainment or young age (Figs. 1 & 2). Of course, where the really sizeable changes in risk are seen is in combinations of particular risk factors (e.g., young males in the military, young minority males or females, less educated/blue collar males or females). These are the multiple risk groups around which tobacco manufacturers develop marketing campaigns and will need to be the focus of antismoking campaigns as well (Davis et al., 2008).

Another gap in the results of this review that merits mention is we were unable to identify any studies of tobacco use among a nationally representative sample of military veterans. Of course, there is a good reason to believe that the vulnerability to tobacco use seen among active military continues beyond discharge. Military veteran status was included as a demographic characteristic starting in the 2013 NSDUH, which should help to address this knowledge gap (SAMHSA, 2014).

This report has several limitations that should be acknowledged. Data on the use of tobacco products in this report is almost exclusively dependent on user self-report and associated limitations, especially where potential stigma is involved. The data are exclusively observational thereby precluding causal inferences, and also largely cross sectional, which is associated with greater risk of confounding by cohort effects, etc. The present study focuses on only a single country thereby potentially limiting generalizability beyond the U.S. Finally, some of the vulnerabilities examined in this review (e.g., any mental illness) include subgroups across which prevalence rates may vary. As such generalizations of findings to those subgroups should be made cautiously. These limitations notwithstanding, the present study provides a detailed overview of the place of

gender differences in the current landscape of tobacco use among U.S. adults and youth. The careful examination of the magnitude and nature of the intersections of gender with a broad range of other vulnerabilities to tobacco use adds an important dimension to this report with potential implications for improving policy development in the areas of tobacco control and regulation.

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Competing interests

In the past three years, through Pinney Associates Dr. Henningfield has consulted with GlaxoSmithKline Consumer Healthcare on smoking cessation, NJOY on electronic cigarettes, and testified in litigation against the tobacco industry. He advises pharmaceutical developers on the evaluation and regulation of medications with respect to their potential for abuse and addiction. He shares ownership in a novel nicotine medication, an option for which has been sold to Nicovum USA, and consults on tobacco harm minimization (including nicotine replacement therapy and digital vapor products) with Nicovum USA, RJ Reynolds Vapor Company, and RAI Services Company, which are all subsidiaries of Reynolds American Inc. Other authors have no disclosures to report.

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