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IMPACT OF NON-MENTHOL FLAVORS IN TOBACCO PRODUCTS ON PERCEPTIONS AND USE AMONG YOUTH, YOUNG ADULTS AND ADULTS: A SYSTEMATIC REVIEW

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Abstract

Objective—This systematic review examines the impact of non-menthol flavors in tobacco products on tobacco use perceptions and behaviors among youth, young adults and adults.

Data sources—English-language peer-reviewed publications indexed in four databases were searched through April, 2016.

Study selection—A search strategy was developed related to tobacco products and flavors. Of 1,688 articles identified, we excluded articles that were not English-language, were not peer-reviewed, were qualitative, assessed menthol-flavored tobacco products only and did not contain original data on outcomes that assessed the impact of flavors in tobacco products on perceptions and use behavior.

Data extraction—Outcome measures were identified and tabulated. Two researchers extracted the data independently and used a validated quality assessment tool to assess study quality.

Data synthesis—Forty studies met the inclusion criteria. Data showed that tobacco product packaging with flavor descriptors tended to be rated as more appealing and as less harmful by both tobacco users and nonusers. Many tobacco product users, especially adolescents, reported experimenting, initiating, and continuing to use flavored products because of the taste and variety of the flavors. Users of many flavored tobacco products also showed decreased likelihood of intentions to quit compared to non-flavored tobacco product users.

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Contributors

LH and AG conceptualized and designed the study. LH, CM, HB and LR conducted the data screening, extraction, and analyses. LH led and oversaw the writing of the manuscript, with contributions from CM, HB, LR and AR. AG contributed to the manuscript by providing key information on the study context, suggestions about the analysis approach, and interpretation of results. All authors read, provided comments, and approved the final manuscript.

Competing interests

None declared.

Conclusions—Flavors in most tobacco products appear to play a key role in how users and nonusers, especially youth, perceive, initiate, progress and continue using tobacco products. Banning non-menthol flavors from tobacco products may ultimately protect public health by reducing tobacco use, particularly among youth.

INTRODUCTION

In 2010, World Health Organization Framework Convention on Tobacco Control guidelines recommended restrictions or bans on flavors in tobacco products and recognized that “masking tobacco smoke harshness with flavours contributes to promoting and sustaining tobacco use” and that “there is no justification for permitting the use of ingredients, such as flavouring agents, which help make tobacco products attractive.”[1] Jurisdictions (including cities, states/provinces and countries) around the world have taken legislative measures to regulate flavors in tobacco products with different levels of restrictions to reduce tobacco product attractiveness, especially among youth. The 2009 U.S. Family Smoking Prevention and Tobacco Control Act (FSPTCA) banned cigarettes containing non-menthol flavorings, [2] a step that other global entities, including the European Union (EU), Australia, and France have also taken. Other countries, such as Canada and Brazil, have extended, or are in the process of extending, flavor bans to include other tobacco products and even menthol flavor.[3]

The passage of the FSPTCA was influenced by data showing that candy- and fruit-flavored cigarettes may be marketed to selectively appeal to and attract younger consumers.[4–6] An examination of tobacco industry documents outlines perceived benefits of flavored products to consumers, including pleasing aromas and aftertaste, increased excitement about the flavors and smoking enjoyment, and a “high curiosity to try factor”. [4] Flavoring was determined as one of the key factors underlying the growth in smokeless tobacco sales from 2005 to 2011, accounting for 59.4% of the total growth in moist snuff sales alone.[7] Due to the reported rapid rise of novel tobacco products and the concern over their effects on public health, the U.S. Food and Drug Administration (FDA) finalized a rule in May 2016 to extend its authority over all tobacco products (also known as the “deeming rule”).[8] FDA cited the high prevalence of flavored tobacco use among youth and young adults as a reason for extending their authority over other tobacco products.[8] However, FDA has not banned flavors in non-cigarette tobacco products in the final deeming rule but intends to issue a proposed product standard for prohibiting flavored cigars, including cigarillos and little cigars.[9]

Despite recent bans on flavored cigarettes in some countries, the marketing and sale of flavored cigarettes still occurs in many countries. Further, the marketing and sale of exempted flavored non-cigarette tobacco products is still broadly allowed, and the tobacco industry continues to introduce new flavors in non-cigarette products into the market.[10] Use of flavored non-cigarette tobacco products remains high. For example, in 2014, approximately 12% of U.S. middle- and high-school students used flavored tobacco products in the past 30 days,[11] and a 2012 study found that 19% of U.S. young adults reported past 30-day use of flavored tobacco products.[12] Prevalence of flavored tobacco

product use in the last 30 days among Canadian students in grades 9 through 12 is also high, at 10% in 2013.[13]

Understanding the impact of flavoring on tobacco use is a research priority outlined by FDA Center for Tobacco Products,[14] and it is an area of interest for tobacco researchers and government bodies worldwide.[15] While FDA and its affiliated Tobacco Products Scientific Advisory Committee have investigated the effect of menthol flavoring on public health[16, 17], more limited work has investigated the impact of non-menthol flavoring on youth and adult perceptions, initiation, use, and cessation of diverse tobacco products.

A recent systematic review examined the use of and attitudes toward non-menthol flavored tobacco products[18] but its scope was limited to U.S. studies only, and only studies prior to September 2013 were included.[18] While this review did examine the prevalence of flavored tobacco use and the relationships between flavored tobacco use and age, it did not critically examine the role that non-menthol flavoring plays in tobacco use behaviors, such as initiation and cessation, and whether the flavoring in tobacco products specifically affects these relationships. Given the rapid pace at which the marketplace and research on flavored tobacco products are evolving, and the interest of the topic and robust evidence to domestic and international policy-makers, we conducted a systematic review of articles published through April 2016 to investigate the role of non-menthol flavored tobacco products in attitudes, perceptions, intentions, use, and cessation of tobacco products in the U.S. and globally.

METHODS

Eligibility Criteria

Eligibility criteria of participants included populations of any age, race, sex, ethnicity, or country. We excluded the following types of articles: those that were not English-language; were not peer-reviewed; did not contain original data about flavored tobacco products; did not address the impact of flavors on tobacco product perceptions and use behaviors; were related to smoking marijuana; and limited findings to menthol flavored tobacco products only. For this paper, we excluded articles that used qualitative study designs.

Type of Outcome Measures and Intervention

Our outcome measures included reasons for using flavored tobacco products; perceptions about product taste, appeal, and health risks; expectancies and beliefs; intention to try; intention to quit; use behaviors including experimentation, initiation, preference, and progression to regular use, dual or poly tobacco use; and cessation.

Data sources and study selection

One author (HMB) conducted searches of PubMed, Embase, PsycINFO, and CINAHL during March 2015. A general search strategy was developed using Boolean language to connect variants of words related to tobacco products and use and flavor for PubMed¹, which was translated to match the search string requirements for other databases. To supplement the database search, two authors (CM and HMB) conducted a manual search of

the reference lists in each of the included articles. In September 2015, authors conducted a second search using the same search strings and databases to include articles published and indexed after the initial search. A total of 2,013 articles resulted from searching the four databases during the initial search (March 2015) (Figure 1). After authors removed duplicates, 1,404 articles remained for title and abstract review. The second search (September 2015), identified 88 additional articles for title/abstract review after de-duplication. Due to the rapid pace of research on flavored tobacco products, a third search was conducted in April 2016. This search identified 196 articles for title/abstract review after removing duplicates. Two authors (CM and HMB) reviewed the full text of articles eligible for full text screening. A third author (LH) resolved any discrepancies on inclusion decisions. In total, 122 full-text articles from the databases were assessed for eligibility, along with an additional 16 articles using the same eligibility criteria through the manual search of references. Eighty articles were excluded because they did not include original data (n=17), did not have data on the specified outcomes (n=58), were only on menthol (n=1), or were duplicates to the previous searches (n=4). 18 articles with a qualitative study design were further excluded from analysis. A total of 40 articles were included in the final analysis. The study selection processes, including reasons for exclusion at the full-text review phase, are illustrated in Figure 1.

Data extraction and synthesis

Two authors (CM and LH) independently extracted data using a pilot-tested data extraction sheet, which assessed study aim, type of flavored tobacco product, characteristics of study populations and study design, and main results and findings related to the impact of flavors in tobacco products. We used a validated quality assessment tool (QATSDD) to examine the quality of quantitative studies with a diverse range of research designs.[19] Studies were scored on a 4-point scale from 0 (did not address criteria at all) to 4 (completely addressed criteria), with specified guidance to inform scorers based on the level of detail provided by study authors.[19] Specific scores were not used for inclusion/exclusion or used in any analysis. Rather, the tool was used to provide a valuable overall assessment of the general quality of included studies from which our conclusions our based. To ensure agreement in data extraction and quality assessment, two authors (CM and LH) reviewed and extracted a sample of the same five articles and resolved discrepancies through an iterative approach of discussion. We created evidence tables using pertinent information extracted from each study, and we grouped the results by outcome measures. Due to the heterogeneity in outcomes across studies, a meta-analysis was not conducted.

¹Final PubMed search string: (electronic cigarettes[mesh] OR tobacco products[mesh] OR smoking[mesh]) AND flavoring agents[mesh] OR (((smoke OR smoker OR smokers OR smokes OR smokings OR smoking OR cigarette OR cigarettes OR cigar OR cigars OR cigarillos OR cigarillo OR hookahs OR hookah OR waterpipe OR waterpipes OR narghile OR narghiles OR argila OR argiles OR tobacco OR tobaccos OR cigar* OR smoke* OR tobacco* OR ends OR "electronic nicotine delivery system*" OR vape OR vapor OR vapour OR vapours OR vapors OR vapor OR vapors OR vaping OR snus OR pipe OR pipes OR "e-cigarette" OR "e-cigarettes" OR bidi OR bidis OR kretek OR kreteks OR chewing tobacco OR snuff OR shisha OR "water pipe" OR "water pipes" OR goza OR narkeela OR "hubble bubble" OR hukkah OR hukkas OR hukka OR argileh) AND (flavor OR flavor* OR flavour OR flavour* OR flavors OR flavours. OR flavoring OR flavouring OR flavorings OR flavourings OR flavoured OR flavoured OR flavoring OR flavorings OR flavouring OR flavourings OR flavoring OR flavourants OR flavorants)) OR (kretek OR kreteks OR bidi OR bidis))

RESULTS

Over half of the 40 included studies were conducted in the U.S (Table 1), and most studies (90%) were published between 2010 and 2015. The majority of the studies used cross-sectional data, with two studies using a longitudinal design.[25] Table 1 lists product types examined and relevant outcomes for included studies. Descriptions of study design and main findings are provided in Table 2 (more detailed results of included studies in the Supplementary Table).

Taste, Appeal, Risk Perceptions

Eleven studies examined taste, appeal, and perceived risk for flavored tobacco products. Four studies with similar study designs assessed the impact of cigarette packaging descriptors with and without flavors among girls and young women in Brazil,[20] Canada, [21] the United Kingdom (UK),[22] and the U.S.[23] Results indicated that removing flavor descriptors from packs significantly reduced measures of taste[20–23] and appeal.[20–22] Further, two of the studies found that packs with flavor descriptors were more likely to be rated as lower health risk than packs without descriptors[22], and young girls were significantly more likely to rate packs with flavor descriptors as less harmful than young women.[20] Similarly, a smokeless tobacco packaging study of 1000 participants in the U.S. found that among those who reported a difference between packaging elements on their product opinions, more youth and young adults perceived the pack with flavor descriptors as having better taste and as more appealing compared to the pack without flavor descriptors. [24] Young adults were also more likely than older adults to report that packs without flavor descriptors would deliver more dangerous chemicals than those with flavor descriptors.[24] A longitudinal study with large numbers of participants from the U.S., Mexico, and Australia examined cigarette brands with flavor capsules and found that, compared to adult smokers of regular non-flavored cigarettes, adults who preferred brands with flavor capsules viewed their variety of cigarettes as having better taste, as more appealing and less harmful (except Australian smokers) than other brand varieties.[25] A UK study of 1205 adolescents assessed the impact of electronic cigarette (e-cigarette) flavor descriptors on perceptions of product harm and also found perceptions of harm differed depending on the flavors.[26] Tobacco flavored e-cigarettes were perceived as being more harmful while cherry and candy floss flavors were perceived as less harmful.[26] An online study conducted among 915 Canadians aged 16 years and older found that flavors accounted for 36% of consumers' overall perceptions of reduced harm about e-cigarettes, as equally influential as health warnings (35%), while other product attributes such as nicotine content and price were less influential in perceived reduced harm.[27] Younger smokers and nonsmokers particularly perceived cherry or coffee flavored e-cigarettes as less harmful, while older smokers indicated tobacco flavor with less harm.[27] In a UK study of 471 e-cigarette and cigarette nonusers, aged 11–16 years, flavored e-cigarette advertisements were more appealing than non-flavored e-cigarette advertisements.[28] A study of 689 U.S. adolescents cited flavors as one of the reasons why they perceived hookah to be safer or less addictive than cigarettes. [29] However, a small U.S. study of 20 college smokers did not detect an appreciable difference in harshness or irritation between flavored and non-flavored cigarettes.[30]

Preference

Ten studies examined preference for flavored tobacco products. One U.S. study of 4780 middle and high school students found that preference for sweet e-cigarette flavors was high, with most lifetime and current e-cigarette users reporting they preferred sweet flavors compared to menthol and tobacco flavors when they smoked e-cigarettes.[31] A UK study of 1205 adolescents also found that fruit, sweet and coffee flavors in e-cigarettes were perceived as more likely to be tried by young never smokers compared to tobacco flavor, and these flavors were perceived as more likely to be used or tried by young never smokers than adult smokers trying to quit smoking.[26] Three studies among adult e-cigarette users reported that the variety of flavor choices was rated as important by the majority of users (85.4%) and influenced device choice;[32] most users (72%) preferred vaping non-traditional flavors such as fruity and candy/nuts to traditional flavors (i.e., menthol or tobacco);[33] and former cigarette smokers were more likely to use fruit and sweet flavors.[34] Similarly, a U.S. study of 6678 participants reported a clear preference among youth, young adults, female and black cigar smokers for cigar brands that produce flavored varieties.[35] Many current adult cigarette smokers (33%) in 27 EU countries, particularly female smokers, reported specific sweet, menthol or fruity flavors as important in their cigarette brand preference.[36] Preference for flavor capsule cigarette brands has significantly risen in recent years in Mexico and Australia, particularly among young adults (though the majority of the flavor capsule varieties reported refer to menthol).[25] But a U.S. study of 20 college smokers did not find a relationship between preference and whether the brand of cigarette was flavored or non-flavored.[30] An online study of 367 U.S. college hookah users found that participants preferred fruit-flavored varieties to tobacco flavor.[37] Further, flavor accounted for almost two-thirds of the hookah use decision, compared to price (22%) and nicotine content (13%).[37]

Expectancies and Beliefs

Six studies examined expectancies and beliefs of flavored tobacco products that influence consumers' decisions. An online study conducted among 915 Canadians found that flavors in e-cigarettes had a moderate influence (25%) on judgments of product efficacy in quitting smoking compared to other product attributes such as nicotine content (10%), price (26%) and health warnings (39%).[27] Another online U.S. study of 765 adult smokers that estimated the value smokers placed on attributes of e-cigarettes found that removing the attribute "coming in flavors" significantly reduced the price smokers were willing to pay among e-cigarette-only users.[38] Among 424 U.S. college students, Camel Exotics (flavored cigarettes) produced greater positive expectancies than did Camel Lights (non-flavored cigarettes), with the strongest difference among susceptible/experimenters.[39] In addition, participants rated Camel Lights more negatively than Camel Exotics; this relationship held true across nonsmokers, susceptible/experimenters and regular smokers. A cigarette packaging study among 253 high school students in the U.S. found that flavor descriptors led to more positive beliefs about the hedonic qualities (e.g., enjoyable, relaxing, good tasting) of brands than the traditional descriptors, although this interaction was only significant among high sensation seekers.[40] A study of 81 adult e-cigarette users in four countries found that the most frequently cited positive feature of e-cigarettes was their taste and variety of flavors (18% of total open-ended comments).[41] In one study of 447 young

adults in India that assessed perception of hookah use, 36.8% of hookah users indicated that hookah “contains pleasant flavors”, significantly higher than non-users (24.6%).[42]

Reasons for Use

Seven studies addressed reasons for using flavored tobacco products. In a U.S. study of 13,651 adolescents, product flavoring was consistently reported as the most common reason for use across all product types, including e-cigarettes (81.5%), hookah (78%), cigars (73.8%), smokeless tobacco (69.%) and snus pouches (67.2%).[43] An online study of 1567 adults found that a majority of e-cigarette users (60%) and one-third of nonusers reported reasons or interest for using e-cigarettes because “they come in appealing flavors” and “I like experimenting with various flavors”.[44] This study also found that flavors were a common reason for discontinued use of e-cigarettes among former e-cigarette users because they “don’t like the flavor(s)”.[44] In an online study of 1095 Canadians, “they taste good” was a more common reason for using e-cigarettes cited by younger non-smokers (32.3%) and smokers (18.4%) than by older smokers (6.5%).[45] In a U.S. study of 9301 adults, 55.5% of daily e-cigarette users, 50.4% of infrequent e-cigarette users (1–5 days in past 30 days) and 41.9% of intermediate e-cigarette users (6–29 days in past 30 days) reported the availability of flavors (not including menthol) as a reason to use e-cigarettes while cutting down on other tobacco products was the most common reason cited for e-cigarette use among daily (91%) and intermediate (84.6%) users.[46] In an online U.S. study of 3878 adults, 8% of e-cigarette users reported flavors as a reason for first trying e-cigarettes compared to 53% of respondents reporting first using e-cigarettes out of curiosity, and 30% reporting first using them because they wanted to quit or reduce smoking.[47] In an urban sample of 133 Canadian young adults, the primary reason reported for smoking cigarillos was because of the flavor (56%).[48] Among a convenience sample of 642 youth in Massachusetts, only 1% reported using bidis instead of cigarettes because of the flavor, but 23% said bidis tasted better than cigarettes.[49]

Intention to Try/Initiation

Twelve studies assessed intention to try or initiation of flavored tobacco products. In a U.S. study of 13,651 adolescents, the majority of ever users (80.8%) reported that the first product they had used was flavored, including hookah (88.7%), e-cigarettes (81.0%), snus pouches (81.2%), smokeless tobacco excluding snus (68.9%), any cigar type (65.4%) and cigarettes (50.1%).[43] The majority of past 30-day users (79.8%) also reported that the products used were flavored.[43] One U.S. study of 468 adult users reported a majority (60%) of participants’ first smokeless tobacco product used was mint flavored.[50] A cross-sectional study in the EU found that though few ever adult cigarette smokers (1.4%) reported specific flavors as being important in their initial smoking, flavors were significantly associated with initial smoking in younger smokers ages 15–24.[36] Among U.S. adolescents and young adults, flavored cigarette brands led to higher trial intentions compared to non-flavored cigarette brands in two different studies.[39, 40] In an online study of 915 Canadians aged 16 years and older, flavor accounted for 24% of consumers’ intentions to try e-cigarettes, showing a moderate influence compared to other product attributes.[27] Younger smokers and nonsmokers were particularly interested in trying cherry flavored e-cigarettes while older smokers indicated greater interested in trying

tobacco flavor.[27] A U.S. study of 1157 adolescent and young adult ever e-cigarette users found that the availability of flavors was a primary reason for experimentation with the product, particularly among high school students compared to college students.[51, 52] An online study of 1095 Canadians showed that younger non-smokers were less likely to try a flavored e-cigarette than younger smokers and older smokers.[45] In a UK study of 471 e-cigarette and cigarette nonusers aged 11–16 years, flavored e-cigarette advertisements elicited greater interest in buying and trying e-cigarettes than non-flavored e-cigarette advertisements, but the appeal of using e-cigarettes was low for both sets of advertisements. [28] A U.S. study of 228 male adolescents found that their willingness to try e-cigarettes compared to plain varieties did not differ based on flavor status, although virtually none of the males (<1%) had tried e-cigarettes previously. An online European study, financially underwritten by an e-cigarette users advocacy group, reported that initiating e-cigarette use to enjoy the variability of flavors was ranked as a 3 on a 5-point scale from 1 (not important) to 5 (most important).[53] A U.S. online study, financially supported by a company that markets e-cigarettes, reported that non-smoking teens interest in trying e-cigarettes did not vary by flavor, but adult smoker interest did.[54]

Progression to Regular Use

Two studies examined the impact of flavored tobacco on the progression from tobacco initiation to regular use of flavored products.[50, 55] A U.S. study that used data from five separate studies of adult smokeless tobacco users at various stages of reducing or quitting tobacco found that among smokeless tobacco users who started using mint-flavored products, 64.4% reported current use of flavored products, whereas 48.7% of those who started using non-flavored products continued to use non mint-flavored products.[50] A nationally representative sample of 29,296 high school students from the Canadian Youth Smoking Survey reported a strong association between flavored tobacco use and being a current cigar, cigarillo, or little cigar smoker.[55] Respondents who reported ever using flavored tobacco were more likely to currently use cigars, cigarillos or little cigars compared to respondents who had never used flavored tobacco products.[55] It should be noted that the two studies used cross sectional data to examine progression to regular use.

Dual/Poly Use

Three studies assessed the role of flavors in dual or poly use of tobacco products. One survey among 24,658 middle and high school students in the U.S. assessed the association between types of use (singular tobacco product vs. multiple tobacco products) and found that among current cigarette smokers, use of flavored products was significantly associated with dual and poly tobacco use.[56] Another study found that cigar brands offering flavored varieties were preferred more by cigar smokers who were also current cigarette smokers.[35] A Canadian study of 17,396 young never smokers found that those who had ever tried or tried a flavored tobacco product in the past 30 days had significantly higher odds of being susceptible to cigarette smoking.[57]

Quit Intention and Quitting Behavior

Four studies assessed flavored tobacco use and intention to quit. A study of 18,866 U.S. middle and high school students found that flavored cigar (59.7%) and cigarette (49.3%)

users had a higher prevalence of not thinking about quitting than non-flavored cigar (18.4%) and cigarette (9.8%) users.[58] Similarly, a study in Poland of 2254 adult users reported that females who smoked flavored cigarettes were less likely to intend to quit than females who smoked non-flavored cigarettes.[59] U.S. adult e-cigarette users who reported vaping non-tobacco and non-menthol flavors were more likely to have quit smoking than e-cigarette users who vaped traditional flavors.[33] One study of adult e-cigarette users, financially underwritten by an e-cigarette user advocacy group, reported that the variability of e-cigarette flavors was an important factor in reducing or quitting smoking and a greater number of flavors regularly used was associated with smoking abstinence among dedicated long-term e-cigarette users.[34]

Risk of Bias Assessment

Most studies were rated highly in terms of having explicit aims and objectives, description of research setting and fit between stated research question and method of data collection (see QATSDD scores in Table 3). However, a majority of studies did not report an explicit theoretical framework, evidence of sample size consideration, and statistical assessment of reliability and validity of measurement tools. Several studies failed to adequately address fit between stated research question and method of data collection (scored at 1 or below).[34, 50, 54] It is important to note that studies may have received a low score simply because a certain criteria was not described in detail in the manuscript, even though the study authors may have considered it (e.g., power calculations for sample size consideration often not reported due to word constraints). Three studies were financially supported by e-cigarette companies or advocacy groups of e-cigarette users.[34, 53, 54]

DISCUSSION

This systematic review highlights and extends in important ways what policy-makers and public health practitioners strongly suspect: flavors play a key role in influencing perceptions and multiple tobacco use patterns about most tobacco products, particularly for adolescents. Flavors in tobacco products seem to have a universal and rather strong appeal to youth and young adults interested in initiating tobacco use or experimenting with different products due to the variety and availability of flavors[20, 24, 27, 28, 35, 43, 51], are reported as a reason for using most tobacco products[37, 43, 44, 46–49], and appear to play a more important role in use of e-cigarettes, hookah, little cigars and cigarillos among younger people.[43, 48] The availability of non-menthol flavored tobacco products and their appeal to adolescents have the potential to undermine progress gained on reducing tobacco use.[8] Flavored tobacco products were perceived as having better taste and were more appealing by users and nonusers, especially among younger age groups.[20–25] Flavored tobacco products were also perceived as less risky or harmful, and these perceptions potentially interact with age, with younger participants appearing more likely to believe that flavored products were less harmful compared to non-flavored products.[22, 24–27] Tobacco product users and nonusers showed a clear preference for sweet, fruit-flavored varieties over traditional tobacco flavors.[25, 31–33, 35–37], and flavors give tobacco products higher positive expectancies and beliefs about hedonic qualities, product features and values that may influence consumers' decisions more than non-flavored tobacco products.[27, 38–42]

Not surprisingly, given the strong impact of flavors in perceptions of tobacco products, flavors were associated with progression to regular use and dual and poly use of tobacco products. Tobacco users tended to switch to flavored products and maintain multiple flavored products.[35, 50, 55–57] Finally, results from this review showed that use of flavored tobacco products, such as cigarettes and cigars, may be associated with lower quit intentions.[58, 59] However, two e-cigarette studies, one funded by a user advocacy group, found that flavors in e-cigarettes may help adult e-cigarette users in quitting cigarette smoking.[33, 34]

Our systematic review significantly expands on a recent systematic review by Feirman, et al. of U.S. studies published through 2013.[18] Our review includes articles that critically summarized data for the first time on the role of flavors in tobacco use perceptions as well as tobacco use behaviors. We specifically examined flavors as being related to taste, appeal, risk perceptions, preference, reasons for use, intention to try, initiation, progression to regular use, dual/poly use, quit intention and quitting behavior. Our review also includes 17 non-U.S. studies and 26 new studies published between 2014 and 2016 alone. While there did not appear to be any appreciable difference between the results of U.S. versus non-U.S. studies, it is important to note that most of the non-U.S. studies were conducted in highly developed countries with moderate to strong tobacco regulatory frameworks, such as Canada and the U.K.

The relevance of this new systematic review on public policy in the U.S. and internationally is significant and immediate. First, as the majority of countries have no ban on any flavored tobacco product, results from this systematic review support the rationale for global regulations on non-menthol flavored tobacco products in order to positively impact public health outcomes related to reduced tobacco use. Second, it addresses in the U.S. the FDA's need for data on the role of certain flavored products in supporting reduction in or abstinence from the use of combustible tobacco products, as well as data on the role of flavored products in youth initiation use, as stated in the final deeming rule. Third, this research may help inform countries, such as Brazil, that have banned all tobacco flavors but face litigation from the tobacco industry. Fourth, it may strengthen efforts of local jurisdictions that have enacted more comprehensive bans on flavored tobacco products, such as New York City; such bans led to significant reductions in ever use of flavored tobacco products, from 20% in 2010 to 16% in 2013.[60]

Finally, this review may help some countries in strengthening their existing regulations. For instance, the 2010 Canadian Bill C-32, the Cracking Down on Tobacco Marketing Aimed Youth Act, prohibited the sale of all flavored cigarettes, little cigars and cigarillos, and blunt wraps that weighed less than 1.4 grams, with an exemption for menthol flavoring. The prevalence of flavored tobacco product use among Canadian high school students remained high even after the enactment of this legislation, in part because the tobacco industry reformulated flavored cigarillos to circumvent the bill (e.g., increased the product's weight to more than 1.4 grams). Bill C-32 also exempted many categories of tobacco products from regulation (e.g., pipe tobacco, smokeless tobacco and cigars).[61] In 2015, two Canadian provinces extended existing flavor bans on the sale of flavored tobacco products to include those with menthol flavors, but with exemptions for pipe tobacco and some cigars.[62] This

review can be helpful for jurisdictions in formulating more comprehensive and effective bans.

Our review has several limitations. This review did not include grey literature or non-English language articles, leading to the possibility that some relevant results could be missed. The inclusion of grey literature may have expanded the scope of the results and provided additional evidence that has not yet been published. While we assessed the risk of bias in individual studies using a validated tool, we did not set minimum threshold for study quality a priori, and we included several e-cigarette industry or advocacy user funded studies.[34, 53, 54] Caution should exist in extrapolating results from studies that scored lower in study quality. There also appeared to be a lack of homogeneity in the measures used in each study. Measures of perceptions and use behaviors varied across studies, and established reliability and validity measures are lacking. Invalidated measures may fail to adequately assess what needs to be measured and/or bias results.

Future research may elucidate specific mechanisms underlying the role of flavors in tobacco use perceptions and behaviors; many studies included in this review were not designed to assess flavors as the major predictor variable (Table 2). This resulted in some studies lacking power to detect differences in measures between flavored and non-flavored conditions (see Supplementary Table), thus causing our systematic review to likely underestimate the findings of flavors' impact due to non-significant results. The majority of studies used cross-sectional data and did not assess the impact of flavors on behavioral outcomes, such as continued use and abstinence; longitudinal research could examine changes over time in use patterns of tobacco products. Future research is also needed in countries that are not represented in this review, including those with weak tobacco regulatory frameworks, to fill the knowledge gap regarding the role of tobacco flavors in other populations and cultures, as products may differ greatly across countries because of sociocultural difference (e.g. smokeless tobacco in the U.S. is a different product than it is Southeast Asia). As the number of studies examining e-cigarettes and cigarettes included in this review far outweighed the number of studies examining other tobacco products, research examining different products and in different countries may help to elucidate the role that flavor plays in each identified behavioral outcome. Finally, our review did not examine the impact of menthol flavors on outcomes. A previous report of the Tobacco Product Scientific Advisory Committee found sufficient evidence that menthol flavorings in cigarettes increased experimentation and regular smoking and decreased the likelihood of smoking cessation compared to non-menthol cigarettes, findings similar to that of our review on non-menthol flavorings.[17] Future reviews should examine the literature on menthol flavorings to determine if the impact of menthol flavoring is the same as or different from other flavors in diverse tobacco products, particularly given the fact that menthol flavored cigarette smokers account for one third of all cigarette smokers in the U.S., and menthol flavored cigarette use has increased or remained stable despite significant decreases in non-menthol cigarette use. [63, 64]

CONCLUSIONS

While further exploration of the impact that flavors have on tobacco use and perceptions are needed, existing evidence provides a rationale for banning non-menthol flavoring in most tobacco products and thereby maximally protecting youth and other tobacco users enticed by flavors from tobacco use around the world. Further research examining flavored tobacco products should include the specification of the flavors' impact on tobacco use behaviors and perceptions, use standardized and validated measures, and adopt longitudinal research designs to measure changes, especially behavioral outcomes, over time in relation to flavors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

The study highlights the key role of flavors in tobacco products in influencing perceptions and multiple tobacco use patterns about most tobacco products, particularly for adolescents; thus providing a rationale for banning non-menthol flavoring in most tobacco products.

Further research on the impact of flavors, particularly given the increasing appeal and prevalence of flavored tobacco products among young populations, should include the specification of the flavors' impact on tobacco use behaviors and perceptions, longitudinal research designs, and reliability and validity of measures.

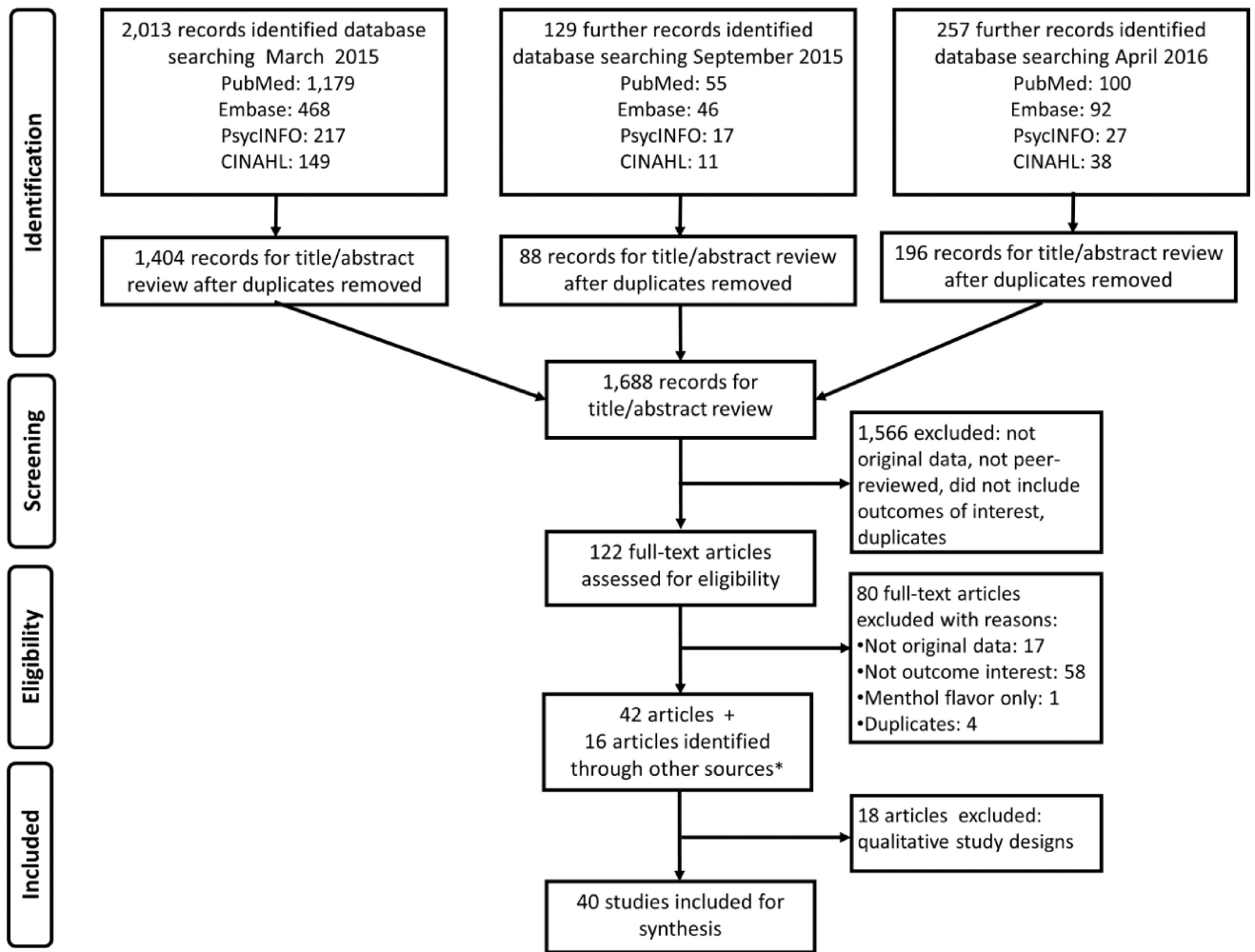


Figure 1. PRISMA Flow Diagram of article identification, screening and selection.
Note: *Checking reference lists of included articles.

Table 1

Product types and outcome measures of included studies

| Sample Characteristics | | N | US ^a Studies (n=23) | Non-US ^b Studies (n=17) |
|-------------------------------|--------------------------------------|----|--------------------------------------|--|
| Product Type | E-cigarette | 17 | 10 | 7 |
| | Cigarette | 10 | 4 | 6 |
| | Little cigar, cigarillo, cigar | 4 | 2 | 2 |
| | Hookah | 3 | 2 | 1 |
| | Various tobacco products | 3 | 2 | 1 |
| | Smokeless tobacco | 2 | 2 | 0 |
| | Bidi | 1 | 1 | 0 |
| Outcome Measures ^c | Taste, appeal, risk perceptions | 11 | 4 | 7 |
| | Preference | 10 | 4 | 6 |
| | Expectancies and beliefs | 6 | 3 | 3 |
| | Reasons for use | 7 | 5 | 2 |
| | Intention to try, initiation | 12 | 7 | 5 |
| | Progression to regular use | 2 | 1 | 1 |
| | Dual/poly use | 3 | 2 | 1 |
| | Quit intention and quitting behavior | 4 | 2 | 2 |

^aOne study included participants (13%) outside the U.S.[32]

^bOne study included participants (41%) from the U.S.[25]

^cCategories are not mutually exclusive.

Table 2

Sample characteristics, objectives, and main findings of included articles

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|--|--|---|--|
| E-cigarettes | | | |
| Amato, 2015 (US) | N=9,301 Adult (18+) Users, nonusers | Investigate patterns of e-cigarettes ' use in order to establish a standard definition of e-cigarette current use prevalence for the purpose of population surveillance. | <ul style="list-style-type: none"> Current e-cigarette users cited flavors as a reason for use more often than past users. |
| Berg, 2015 (US) | N=1,567 Young adult (18–34), e-cigarette users, nonusers; cigarette users, nonusers | Compare (1) e-cigarette never, current, and former users; (2) never, current, and former traditional cigarette smokers in relation to e-cigarette use characteristics, flavors preferred and reasons for use; and (3) reasons for discontinued use among former e-cigarette users across never, current, and former smokers. | <ul style="list-style-type: none"> Flavors were frequently indicated as reason for use across smoking and non-smoking e-cigarette users |
| Czoli, 2015 (Canada) | N=915 Youth and young adult users and non-users (16–24 years); Adult users (25+) | Determine the effect of distinct attributes of e-cigarettes (flavors, nicotine content, health warnings, price) and attribute levels on consumer choice. | <ul style="list-style-type: none"> Flavors in e-cigarettes significantly predicted lower perceptions of product harm and ability to help someone quit smoking |
| Etter, 2010 (France, Belgium, Canada, Switzerland) | N=81 Adult (19–65; median age=37) Users | Assess usage patterns of e-cigarettes , reasons for use and users' opinions of these products. | <ul style="list-style-type: none"> Adult e-cigarette users reported flavors as being the most positive feature of the product. |
| Farsalinos, 2013 (Survey online 10 languages) | N=4,618 Adults (32–49; mean age=40) Users | Examine the patterns and perceptions of flavoring use in e-cigarettes among dedicated users. | <ul style="list-style-type: none"> E-cigarette users who are former smokers were more likely to prefer fruit and sweet flavors compared to current smokers. E-cigarette users reported that the variability of e-cigarette flavors is an important factor in reducing or quitting cigarette smoking and a greater number of flavors used was associated with smoking abstinence. |
| Farsalinos, 2014 (Survey online 10 languages) | N=19,441 Adults (31–47; mean age=39) Users | Assess the characteristics and experiences of a large, worldwide sample of e-cigarette users and examine the differences between those who partially and completely substituted smoking with e-cigarette use. | <ul style="list-style-type: none"> The variability of flavors was cited as one of the reasons for initiating e-cigarette use, though it was not a primary reason. |
| Ford, 2014 (UK) | N=1,205 Youth (11–16), Users, non-users | Examine adolescents' awareness of e-cigarette marketing and investigate the impact of e-cigarette flavor descriptors on | <ul style="list-style-type: none"> Fruit and sweet flavors were perceived as more likely to be tried by young never smokers than adult smokers trying to quit. |

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|---------------------------|--|--|--|
| | | perceptions of product harm and user image. | <ul style="list-style-type: none"> ■ The perceived harmfulness of e-cigarettes was moderated by product flavors. |
| Kong, 2014 (US) | N=1,157 Youth, young adult Users | Assess reasons for e-cigarette experimentation and discontinuation and examine whether these reasons differed by school level (MS, HS, college) and cigarette smoking status. | <ul style="list-style-type: none"> ■ Availability of flavors was a primary reason for experimentation with e-cigarettes, and appealing flavors were particularly important to high school students. |
| Krishnan-Sarin, 2014 (US) | N=4,780 Youth (MS=12.18, HS=15.63) Users, nonusers | Examine e-cigarette awareness, use patterns, susceptibility to future use, preferences, product components used, and sources of marketing and access among youth. | <ul style="list-style-type: none"> ■ Use and preference for sweet e-cigarette flavors was high among adolescents regardless of cigarette smoking status. |
| Nonnemaker, 2015 (US) | N=765 Adults (18+), current or former smokers | Examines how e-cigarette attributes influence willingness to pay for e-cigarettes. | <ul style="list-style-type: none"> ■ For cigarette-only users, losing flavors significantly reduced the price participants are willing to pay for e-cigarettes. |
| Pepper, 2013 (US) | N=228 Youth (11–19), males Users, nonusers | Sought to understand awareness of and willingness to try e-cigarettes among adolescent males. | <ul style="list-style-type: none"> ■ Flavored e-cigarettes did not increase male adolescents' willingness to try e-cigarettes compared to plain varieties. |
| Pepper, 2014 (US) | N=3,878 Adult (18+) Users | Explore reasons for starting and then stopping e-cigarettes use and examine differences in discontinuation by reason for trying among population-based sample of US adults. | <ul style="list-style-type: none"> ■ Few adult e-cigarette users reported starting e-cigarette use because of the available flavors. |
| Shiffman, 2015 (US) | N=216 (teens) N=432 (adult) Youth nonusers (13–17) Adult users (19–80) | Compare e-cigarettes interest between nonsmoking teens and adult smoker, across flavors and assess differences in flavor preferences among adult smokers based on e-cigarettes use history. | <ul style="list-style-type: none"> ■ The interest of nonsmoking teens in trying flavored e-cigarettes was very low, and interest was not influenced by flavor descriptors. Though adult smokers' interest was also modest, their interest was significantly higher than that of nonsmoking teens for each flavor. |
| Shiplo, 2015 (Canada) | N=1,095 Younger non-smokers and smokers (16–24), Older smokers (25+) | Examines e-cigarette ever and current use, types of products used, and reasons for use. | <ul style="list-style-type: none"> ■ Use of flavored e-cigarettes varies by smoking status, with smokers being more likely to try flavors than non-smokers. ■ A common reason for e-cigarette use is for the taste. |
| Tackett, 2015 (US) | N=215 Adult (mean age=36.23) Users | Estimate e-cigarettes preference, e-cigarettes use behaviors, perceived harm and health beliefs of various smoking cessation medications, nicotine replacement therapies and nicotine/tobacco products, | <ul style="list-style-type: none"> ■ Most e-cigarette users reported a preference for vaping non-traditional flavors. ■ Those who reported vaping non-tobacco and non-menthol flavors |

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|---------------------------------------|---|---|---|
| | | and smoking history and current biochemically verified smoking status. | were more likely to have quit smoking. |
| Vasiljevic, 2015 (UK) | N=471 Youth (11–16) Nonusers | Assess the impact on appeal of tobacco smoking after exposure to advertisements for e-cigarettes with and without candy-like flavors. | <ul style="list-style-type: none"> Flavored, compared to non-flavored, e-cigarette advertisements elicited greater appeal, interest in buying and trying e-cigarettes. |
| Yingst, 2015 (US and other countries) | N=421 (87% in US; 13% outside US) Adult (mean age= 40) Users | Examine the frequency with which e-cigarette users transition between device types and identify device characteristics and user preferences that may influence such transitions. | <ul style="list-style-type: none"> Most e-cigarette users began use with a device shaped like a cigarette (first generation devices) and transitioned to a larger advanced generation device with a more powerful battery and a wider choice of liquid flavors. Advanced generation device e-cigarette users report the variety of flavors as being important characteristic of e-cigarettes. |
| Cigarettes | | | |
| Agaku, 2014 (EU) | N=26,566 Youth, young adults (15–24), adults (25+) Users, nonusers | Assess the role of cigarette design and marketing characteristics in initial smoking, cigarette brand choice and the perception of reduced harm of cigarette brands. | <ul style="list-style-type: none"> Few ever smokers reported specific flavors as being important in their initial smoking, but flavors were significantly associated with initial smoking in younger smokers. Current smokers, particularly female smokers, reported specific flavors as important in their cigarette brand preference. |
| Ashare, 2007 (US) | N=424 Young adult (mean age=19) Users, nonusers | Determine the appeal of flavored and non-flavored cigarettes among college student nonsmokers, regular smokers, and those susceptible to smoking. | <ul style="list-style-type: none"> Positive and negative expectancies were influenced by flavor, with higher positive and lower negative expectancies for flavored cigarettes compared to non-flavored cigarettes. Positive expectancies significantly predicted the likelihood of trying flavored cigarettes. |
| Doxey, 2011 (Canada) | N=826 Youth (18–19), female Users, nonusers | Examine the effects of cigarette brand descriptors, brand color, and imagery, as well as the impact of plain or standardized packaging on young female's beliefs about smoking. | <ul style="list-style-type: none"> No differences were observed between cigarette packs with and without flavor descriptors in ratings of tar delivery and health risk, though participants rated packs with flavor descriptors as better tasting and more appealing. |
| Hammond, 2011 (US) | N=826 Youth (18–19), female Users, nonusers | Examine the effects of cigarette brand descriptors, brand color, and imagery, as well as the impact of plain or standardized packaging on young female's beliefs about smoking. | <ul style="list-style-type: none"> Fully branded cigarette packs with flavor descriptors were rated as better tasting than the same packs without flavor descriptors. |

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|--|---|--|--|
| Hammond, 2013 (UK) | N=947 Youth (16–19), female Users, nonusers | Examine the effects of cigarette brand descriptors, brand color, and imagery, as well as the impact of plain or standardized packaging on young female's beliefs about smoking. | <ul style="list-style-type: none"> Removing flavor descriptors from cigarette packs significantly reduced measures of appeal and taste and increased measures of health risk. |
| Kaleta, 2014 (Poland) | N=2,254 Adult (15+) Users | Examine whether the use of flavored cigarettes varies by socio-demographic characteristics, awareness of the smoking health consequences and the perception of risk of use compared to regular cigarettes from current smokers. | <ul style="list-style-type: none"> Flavored cigarette use was associated with not intending to quit among females but not among males. |
| Manning, 2009 (US) | N=253 Youth (mean age=15.7) Users, nonusers | Examine the interactive effects of cigarette package flavor descriptors and sensation seeking on adolescents' brand perceptions. | <ul style="list-style-type: none"> Among high sensation-seeking adolescents, the flavor descriptors led to more favorable hedonic brand beliefs and higher trial intentions than the traditional descriptors. |
| O'Connor, 2007 (US) | N=20 Young adult (18–30), male Users | Explore differences in puff topography and cigarette ratings between flavored and unflavored Camels among college student smokers. | <ul style="list-style-type: none"> Preference and ratings of harshness/irritation were not related to whether the cigarette brand was flavored. |
| Thrasher, 2015 (US, Mexico, Australia) | N=4,154 (US) N=3,366 (Mexico) N=2,710 (Australia) Adult (18–64) Users | Assess trends, correlates of use and consumer perceptions related to product design innovation of flavor capsules in cigarette filters. | <ul style="list-style-type: none"> Adults who preferred brands with flavor capsules viewed their variety of cigarettes as having better taste and to be more appealing and less harmful (except Australian smokers) than other brand varieties compared to adult smokers of regular non-flavored cigarettes. Preference for flavor capsule cigarettes (though primarily menthol varieties) has significantly risen in the past few years in Mexico and Australia, particularly among young adults. |
| White, 2012 (Brazil) | N=640 Youth and Young adult (16–26), female Users, nonusers | Examine the effects of cigarette brand descriptors, brand color, and imagery, as well as the impact of plain or standardized packaging on young female's beliefs about smoking. | <ul style="list-style-type: none"> The plain packs with flavor descriptors were given significantly higher appeal and taste ratings than the plain without flavor descriptor packs, though no significant differences were observed between packs in health risk ratings. |
| Little cigars, cigarillos, and cigars | | | |
| Delnevo, 2015 (US) | N=6,678 Youth (12–17), young adult (18–25), adult (26+) Users, nonusers | Examine use and preference of flavored cigar brands among youth, young adults, and adults in US. | <ul style="list-style-type: none"> A clear preference was observed for cigar brands that produce flavored varieties among youth, young adult, female, and black cigar smokers. |

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|----------------------------|--|---|---|
| | | | <ul style="list-style-type: none"> Preference for flavored cigars was associated with current cigarette smoking. |
| Leatherdale, 2011 (Canada) | N=29,296 9 th -12 th grader Users, nonusers | Examine the prevalence of cigar, cigarillo, and little cigar use and factors associated with their use among nationally representative sample of Canadian youth. | <ul style="list-style-type: none"> Ever use of flavored tobacco was associated with being a current cigar, cigarillo, or little cigar smoker. |
| Yates, 2014 (Canada) | N=133 Young adult and adult users (age 19-29; mean age=23.6) | Examine the patterns, attitudes, and beliefs regarding cigarillo use and co-use of cigarillos and cigarettes among young adults. | <ul style="list-style-type: none"> Flavor was the primary reason cited for smoking cigarillos. |
| Hookah | | | |
| Dani, 2015 (India) | N=447 College students, users and nonusers | Assess perception among young adults in a college environment towards using hookah for smoking tobacco. | <ul style="list-style-type: none"> A significant difference between users and non-users was found, where more users indicated that hookah "contains pleasant flavors" compared to non-users |
| Salloum, 2015 (US) | N=367 Adult (18+ mean age 21.9) college students, users | Measure preferences for waterpipe smoking and determine which product characteristics are most important to smokers. | <ul style="list-style-type: none"> Participants preferred fruit-flavored varieties to tobacco flavor. |
| Smith, 2011 (US) | N=689 Youth (mean age=17.1) Users, nonusers | Examine patterns of use (e.g., initiation, cessation), risk perception, and psychosocial factors among users, former users, and nonusers of hookah among high school students | <ul style="list-style-type: none"> High school students cited flavors of the hookah as one of the reasons they believed hookah to be safer or less addictive than cigarettes. |
| Smokeless tobacco | | | |
| Adkison, 2014 (US) | N=1,000 Youth (14-17), young adult (18-25), adult (26-65) Users, nonusers | Evaluate the association between smokeless tobacco packaging elements with knowledge of health risks and perceptions of novelty and appeal. | <ul style="list-style-type: none"> The majority of respondents indicated no difference in opinions regarding health risk and appeal between smokeless tobacco product packaging with or without flavor descriptors. Among those who did report differences, youth and young adults were more likely to indicate the smokeless tobacco pack with the flavor descriptor as more appealing, attractive, and having reduced health risks. |
| Oliver, 2013 (US) | N=468 Adult (18-70) Users | Examine the choice of brand flavor in the course of smokeless tobacco use, from initiation to regular use, in an intervention seeking population and examine whether users of flavored smokeless tobacco | <ul style="list-style-type: none"> A majority of respondents' first and current choice of smokeless tobacco product was mint flavored. A significant number of respondents switched from a non- |

| Study ID (Country) | Sample size & study population (years old) | Study aim | Main findings |
|--------------------------|--|---|--|
| | | products differ from nonflavored users in their use patterns. | flavored to a flavored smokeless tobacco product. |
| Bidi | | | |
| CDC, 1999 (US) | N=642 7 th -12 th grader | Determine the prevalence of bidi use among urban youth. | <ul style="list-style-type: none"> ■ Few adolescents cited liking the flavor as a reason for smoking bidis rather than cigarettes. |
| Various tobacco products | | | |
| Ambrose, 2015 (US) | N=13,651 Youth (12-17) Users | Examine role of flavors in use of various tobacco products among a nationally representative sample of US youth. | <ul style="list-style-type: none"> ■ Majority of ever-users reported the first product they used was flavored ■ Product flavoring consistently reported as a reason for tobacco product use across all types or products |
| King, 2014 (US) | N=18,866 6 th -12 th grader Users, nonusers | Assess the prevalence and sociodemographic correlates of flavored little cigar and flavored cigarette smoking among US middle and high school students. | <ul style="list-style-type: none"> ■ Respondents who used flavored cigars or cigarettes had a lower intent to quit than non-flavored users. |
| Lee, 2015 (US) | N=24,658 6 th -12 th grader Users, nonusers | Assess the prevalence and concurrent use of patterns of various tobacco products and examine associated risk factors among US youth. | <ul style="list-style-type: none"> ■ The use of flavored products was associated with multiple product use. |
| Minaker, 2015 (Canada) | N=17,396 Youth (grades 9-12), never smokers | Examines smoking susceptibility and alternative tobacco product use in Canadian youth. | <ul style="list-style-type: none"> ■ Never smokers who have ever tried ATPs, and particularly flavored ATPs, are at significantly increased odds of being susceptible to cigarette smoking. |

Table 3

Risk of bias assessed by Quality Assessment Tool

| Study ID (Author, Year) | Adkison, 2014 | Agaku, 2014 | Amato, 2015 | Amrbose, 2015 | Ashare, 2007 | Berg, 2016 | CDC, 1999 | Czoli, 2016 | Delnevo, 2015 | Doxey, 2011 | Etter, 2010 | Farsalinos, 2013 | Farsalinos, 2014 |
|---|---------------|-------------|-------------|---------------|--------------|------------|-----------|-------------|---------------|-------------|-------------|------------------|------------------|
| Total score | 19 | 21 | 35 | 31 | 25 | 29 | 13 | 31 | 31 | 25 | 20 | 16 | 19 |
| % ^a | 45% | 50% | 83% | 74% | 60% | 69% | 31% | 74% | 74% | 60% | 48% | 38% | 45% |
| Explicit theoretical framework | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Statement of aims/objectives in main body of report | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| Clear description of research setting | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Evidence of sample size considered in terms of analysis | 0 | 1 | 3 | 2 | 0 | 3 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| Representative sample of target group of a reasonable size | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 2 | 1 | 2 |
| Description of procedure for data collection | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 |
| Rationale for choice of data collection tool(s) | 0 | 1 | 3 | 3 | 2 | 2 | 0 | 2 | 3 | 2 | 1 | 1 | 1 |
| Detailed recruitment data | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| Statistical assessment of reliability and validity of measurement tool(s) | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Fit between stated research question and method of data collection | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 2 |
| Fit between research question and method of analysis | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 2 | 2 | 2 |
| Good justification for analytical method selected | 1 | 2 | 1 | 2 | 3 | 2 | 0 | 3 | 3 | 2 | 1 | 1 | 1 |
| Evidence of user involvement in design | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Strengths and limitations critically discussed | 3 | 1 | 3 | 3 | 2 | 3 | 0 | 3 | 3 | 3 | 2 | 2 | 2 |

| Study ID (Author, Year) | Ford, 2016 | Hammond, 2011 | Hammond, 2013 | Kaletka, 2014 | King, 2014 | Kong, 2014 | Krishnan-Sarin, 2014 | Leatherdale, 2011 | Lee, 2015 | Manning, 2009 | Minaker, 2016 | Nonnemaker, 2016 | O'Connor, 2007 |
|---|------------|---------------|---------------|---------------|------------|------------|----------------------|-------------------|-----------|---------------|---------------|------------------|----------------|
| Total score | 32 | 26 | 26 | 28 | 32 | 31 | 26 | 29 | 28 | 35 | 33 | 24 | 25 |
| % ^a | 76% | 62% | 62% | 67% | 76% | 74% | 62% | 69% | 67% | 83% | 79% | 57% | 60% |
| Explicit theoretical framework | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Statement of aims/objectives in main body of report | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| Study ID (Author, Year) | Ford, 2016 | Hammond, 2011 | Hammond, 2013 | Kaletka, 2014 | King, 2014 | Kong, 2014 | Krishnan-Sarin, 2014 | Leatherdale, 2011 | Lee, 2015 | Manning, 2009 | Minaker, 2016 | Nonnenaker, 2016 | O'Connor, 2007 |
|---|------------|---------------|---------------|---------------|------------|------------|----------------------|-------------------|-----------|---------------|---------------|------------------|----------------|
| Clear description of research setting | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Evidence of sample size considered in terms of analysis | 3 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 2 | 0 | 1 |
| Representative sample of target group of a reasonable size | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 |
| Description of procedure for data collection | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| Rationale for choice of data collection tool(s) | 2 | 2 | 2 | 2 | 3 | 3 | 0 | 2 | 2 | 3 | 2 | 0 | 3 |
| Detailed recruitment data | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 1 | 1 |
| Statistical assessment of reliability and validity of measurement tool(s) | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| Fit between stated research question and method of data collection | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| Fit between research question and method of analysis | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Good justification for analytical method selected | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| Evidence of user involvement in design | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | 0 |
| Strengths and limitations critically discussed | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 |

| Study ID (Author, Year) | Oliver, 2013 | Oswal, 2015 | Pepper, 2013 | Pepper, 2015 | Salloum, 2015 | Shiffman, 2015 | Shiplo, 2015 | Smith, 2011 | Tackett, 2015 | Thrasher, 2015 | Vasiljevic, 2016 | White, 2012 | Yates, 2014 | Yingst, 2015 |
|---|--------------|-------------|--------------|--------------|---------------|----------------|--------------|-------------|---------------|----------------|------------------|-------------|-------------|--------------|
| Total score | 20 | 15 | 34 | 35 | 31 | 26 | 27 | 24 | 26 | 32 | 33 | 29 | 19 | 21 |
| % <i>d</i> | 48% | 36% | 81% | 83% | 74% | 62% | 64% | 57% | 62% | 76% | 79% | 69% | 45% | 50% |
| Explicit theoretical framework | 0 | 0 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Statement of aims/objectives in main body of report | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Clear description of research setting | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Evidence of sample size considered in terms of analysis | 1 | 0 | 1 | 1 | 0 | 2 | 3 | 0 | 3 | 3 | 3 | 0 | 0 | 0 |

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| Study ID (Author, Year) | Oliver, 2013 | Oswal, 2015 | Pepper, 2013 | Pepper, 2014 | Salloum, 2015 | Shiffman, 2015 | Shiplo, 2015 | Smith, 2011 | Tackett, 2015 | Thrasher, 2015 | Vasiljevic, 2016 | White, 2012 | Yates, 2014 | Yingst, 2015 |
|---|--------------|-------------|--------------|--------------|---------------|----------------|--------------|-------------|---------------|----------------|------------------|-------------|-------------|--------------|
| Representative sample of target group of a reasonable size | 1 | 2 | 2 | 3 | 2 | 1 | 2 | 2 | 1 | 3 | 2 | 2 | 1 | 2 |
| Description of procedure for data collection | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 2 |
| Rationale for choice of data collection tool(s) | 2 | 0 | 2 | 3 | 3 | 2 | 0 | 2 | 2 | 2 | 3 | 3 | 1 | 1 |
| Detailed recruitment data | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 3 |
| Statistical assessment of reliability and validity of measurement tool(s) | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 0 |
| Fit between stated research question and method of data collection | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| Fit between research question and method of analysis | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| Good justification for analytical method selected | 2 | 0 | 3 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 1 | 3 | 2 | 1 |
| Evidence of user involvement in design | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 |
| Strengths and limitations critically discussed | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |

Note.

^aPercentage = the total score of a study / the full score 42 (14 items × 3 per item)