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# Impact of non-menthol flavours in tobacco products on perceptions and use among youth, young adults and adults: a systematic review

Li-Ling Huang,<sup>1</sup> Hannah M Baker,<sup>2</sup> Clare Meernik,<sup>2</sup> Leah M Ranney,<sup>1,2</sup>  
Amanda Richardson,<sup>1</sup> Adam O Goldstein<sup>1,2</sup>

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<sup>1</sup>Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, North Carolina, USA

<sup>2</sup>Department of Family Medicine, Tobacco Prevention and Evaluation Program, School of Medicine, University of North Carolina, Chapel Hill, North Carolina, USA

## Correspondence to

Dr Li-Ling Huang, Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, Chapel Hill, NC 27599, USA; [huangl@email.unc.edu](mailto:huangl@email.unc.edu)

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## ABSTRACT

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

**Data sources** English-language peer-reviewed publications indexed in 4 databases were searched through April 2016.

**Study selection** A search strategy was developed related to tobacco products and flavours. Of 1688 articles identified, we excluded articles that were not English-language, were not peer-reviewed, were qualitative, assessed menthol-flavoured tobacco products only and did not contain original data on outcomes that assessed the impact of flavours in tobacco products on perceptions and use behaviour.

**Data extraction** Outcome measures were identified and tabulated. 2 researchers extracted the data independently and used a validated quality assessment tool to assess study quality.

**Data synthesis** 40 studies met the inclusion criteria. Data showed that tobacco product packaging with flavour descriptors tended to be rated as more appealing and as less harmful by tobacco users and non-users. Many tobacco product users, especially adolescents, reported experimenting, initiating and continuing to use flavoured products because of the taste and variety of the flavours. Users of many flavoured tobacco products also showed decreased likelihood of intentions to quit compared with non-flavoured tobacco product users.

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

## INTRODUCTION

In 2010, WHO Framework Convention on Tobacco Control guidelines recommended restrictions or bans on flavours in tobacco products and recognised 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’.<sup>1</sup> Jurisdictions (including cities, states/provinces and countries) around the world have taken legislative measures to regulate flavours in tobacco products with different levels of restrictions to reduce tobacco product attractiveness, especially among youth. The 2009 US Family Smoking

Prevention and Tobacco Control Act (FSPTCA) banned cigarettes containing non-menthol flavourings,<sup>2</sup> 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, flavour bans to include other tobacco products and even menthol flavour.<sup>3</sup>

The passage of the FSPTCA was influenced by data showing that candy-flavoured and fruit-flavoured cigarettes may be marketed to selectively appeal to and attract younger consumers.<sup>4–6</sup> An examination of tobacco industry documents outlines perceived benefits of flavoured products to consumers, including pleasing aromas and aftertaste, increased excitement about the flavours and smoking enjoyment and a ‘high curiosity to try factor’.<sup>4</sup> Flavouring 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.<sup>7</sup> Owing to the reported rapid rise of novel tobacco products and the concern over their effects on public health, the US Food and Drug Administration (FDA) finalised a rule in May 2016 to extend its authority over all tobacco products (also known as the ‘deeming rule’).<sup>8</sup> FDA cited the high prevalence of flavoured tobacco use among youth and young adults as a reason for extending their authority over other tobacco products.<sup>8</sup> However, FDA has not banned flavours in non-cigarette tobacco products in the final deeming rule but intends to issue a proposed product standard for prohibiting flavoured cigars, including cigarillos and little cigars.<sup>9</sup>

Despite recent bans on flavoured cigarettes in some countries, the marketing and sale of flavoured cigarettes still occurs in many countries. Further, the marketing and sale of exempted flavoured non-cigarette tobacco products is still broadly allowed, and the tobacco industry continues to introduce new flavours in non-cigarette products into the market.<sup>10</sup> The use of flavoured non-cigarette tobacco products remains high. For example, in 2014, ~12% of US middle and high school students used flavoured tobacco products in the past 30 days,<sup>11</sup> and a 2012 study found that 19% of US young adults reported past 30-day use of flavoured tobacco products.<sup>12</sup> The prevalence of flavoured tobacco product use in the last 30 days among Canadian students in grades 9 through 12 is also high, at 10% in 2013.<sup>13</sup>

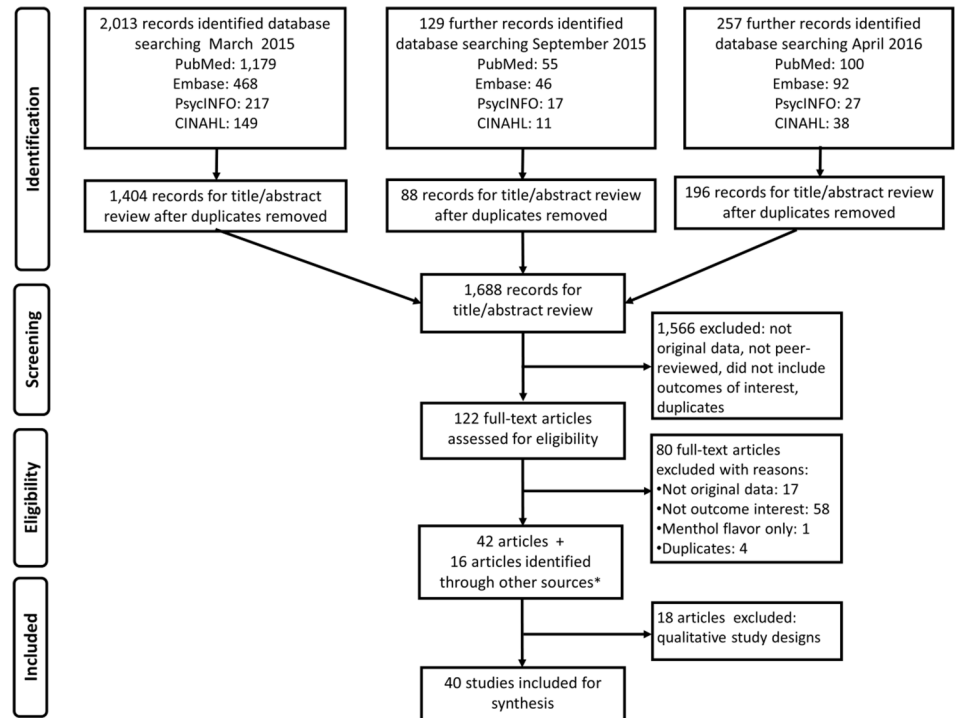
Understanding the impact of flavouring on tobacco use is a research priority outlined by FDA



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**Figure 1** PRISMA flow diagram of article identification, screening and selection. \*Checking reference lists of included articles.



Center for Tobacco Products,<sup>14</sup> and it is an area of interest for tobacco researchers and government bodies worldwide.<sup>15</sup> While FDA and its affiliated Tobacco Products Scientific Advisory Committee have investigated the effect of menthol flavouring on public health,<sup>16 17</sup> more limited work has investigated the impact of non-menthol flavouring on youth and adult perceptions, initiation, use and cessation of diverse tobacco products.

A recent systematic review examined the use of and attitudes towards non-menthol flavoured tobacco products,<sup>18</sup> but its scope was limited to US studies only, and only studies prior to September 2013 were included.<sup>18</sup> While this review did examine the prevalence of flavoured tobacco use and the relationships between flavoured tobacco use and age, it did not critically examine the role that non-menthol flavouring plays in tobacco use behaviours, such as initiation and cessation, and whether the flavouring in tobacco products specifically affects these relationships. Given the rapid pace at which the marketplace and research on flavoured tobacco products are evolving, and the interest of the topic to domestic and international policymakers, we conducted a systematic review of articles published through April 2016 to investigate the role of non-menthol flavoured tobacco products in attitudes, perceptions, intentions, use and cessation of tobacco products in the USA 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 flavoured tobacco products; did not address the impact of flavours on tobacco product perceptions and use behaviours; were related to smoking marijuana and limited findings to menthol flavoured 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 flavoured tobacco products; perceptions about product taste, appeal and health risks; expectancies and beliefs; intention to try; intention to quit; use behaviours, 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 flavour for PubMed,<sup>i</sup> 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 2013 articles resulted from searching the 4 databases during the initial search

<sup>i</sup>Final 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 flavouring OR flavoring OR flavourants OR flavorants)) OR (kretek OR kreteks OR bidi OR bidis)).

(March 2015) (figure 1). After authors removed duplicates, 1404 articles remained for title and abstract review. The second search (September 2015) identified 88 additional articles for title/abstract review after de-duplication. Owing to the rapid pace of research on flavoured 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 (L-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). Eighteen 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 L-LH) independently extracted data using a pilot-tested data extraction sheet, which assessed study aim, type of flavoured tobacco product, characteristics of study populations and study design, and main results and findings related to the impact of flavours 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.<sup>19</sup> 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.<sup>19</sup> 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 are based. To ensure agreement in data extraction and quality assessment, two authors (CM and L-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. Owing to the heterogeneity in outcomes across studies, a meta-analysis was not conducted.

### RESULTS

Over half of the 40 included studies were conducted in the USA (table 1), and most studies (90%) were published between 2010 and 2016. The majority of the studies used cross-sectional data, with one study using a longitudinal design.<sup>21</sup> 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 are in the online supplementary table).

#### Taste, appeal, risk perceptions

Eleven studies examined taste, appeal and perceived risk for flavoured tobacco products. Four studies with similar study designs assessed the impact of cigarette packaging descriptors with and without flavours among girls and young women in Brazil,<sup>46</sup> Canada,<sup>40</sup> the UK<sup>42</sup> and the USA.<sup>41</sup> Results indicated that removing flavour descriptors from packs significantly reduced measures of taste<sup>40-42</sup> and appeal.<sup>40 42 46</sup> Further,

**Table 1** Product types and outcome measures of included studies

Sample characteristics	N	US* studies (n=23)	Non-US† studies (n=17)
<b>Product type</b>			
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
<b>Outcome measures‡</b>			
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 behaviour	4	2	2

\*One study included participants (13%) outside the USA.<sup>20</sup>

†One study included participants (41%) from the USA.<sup>21</sup>

‡Categories are not mutually exclusive.

two of the studies found that packs with flavour descriptors were more likely to be rated as lower health risk than packs without descriptors,<sup>42</sup> and young girls were significantly more likely to rate packs with flavour descriptors as less harmful than young women.<sup>46</sup> Similarly, a smokeless tobacco packaging study of 1000 participants in the USA found that among those who reported a difference between packaging elements on their product opinions, more youth and young adults perceived the pack with flavour descriptors as having better taste and as more appealing compared with the pack without flavour descriptors.<sup>53</sup> Young adults were also more likely than older adults to report that packs without flavour descriptors would deliver more dangerous chemicals than those with flavour descriptors.<sup>53</sup> A longitudinal study with large numbers of participants from the USA, Mexico and Australia examined cigarette brands with flavour capsules and found that, compared with adult smokers of regular non-flavoured cigarettes, adults who preferred brands with flavour capsules viewed their variety of cigarettes as having better taste, as more appealing and less harmful (except Australian smokers) than other brand varieties.<sup>21</sup> A UK study of 1205 adolescents assessed the impact of electronic cigarette (e-cigarette) flavour descriptors on perceptions of product harm and also found perceptions of harm differed depending on the flavours.<sup>28</sup> Tobacco flavoured e-cigarettes were perceived as being more harmful, while cherry and candy floss flavours were perceived as less harmful.<sup>28</sup> An online study conducted among 915 Canadians aged 16 years and older found that flavours 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.<sup>24</sup> Younger smokers and non-smokers particularly perceived cherry-flavoured or coffee-flavoured e-cigarettes as less harmful, while older smokers indicated tobacco flavour as being less harmful.<sup>24</sup> In a UK study of 471 e-cigarette and cigarette non-users, aged 11–16 years, flavoured e-cigarette advertisements were more appealing than non-flavoured e-cigarette

Table 2 Sample characteristics, objectives and main findings on flavours' impact of included articles

Study ID (country)	Sample size and study population (years old)	Study aim	Main findings on flavours' impact
E-cigarettes			
Anato <i>et al.</i> <sup>22</sup> 2016 (USA)	N=9301 Adult (18+) Users, non-users	Investigate patterns of <i>e-cigarettes</i> ' use in order to establish a standard definition of <i>e-cigarette</i> current use prevalence for the purpose of population surveillance	<ul style="list-style-type: none"> <li>▶ Current <i>e-cigarette</i> users cited flavours as a reason for use more often than past users</li> </ul>
Berg, <sup>23</sup> 2016 (USA)	N=1567 Young adult (18-34), <i>e-cigarette</i> users, non-users; cigarette users, non-users	Compare (1) <i>e-cigarette</i> never, current and former users; (2) never, current and former traditional cigarette smokers in relation to <i>e-cigarette</i> use characteristics, flavours preferred and reasons for use; and (3) reasons for discontinued use among former <i>e-cigarette</i> users across never, current and former smokers	<ul style="list-style-type: none"> <li>▶ Flavours were frequently indicated as reason for use across smoking and non-smoking <i>e-cigarette</i> users</li> </ul>
Czoli <i>et al.</i> <sup>24</sup> 2016 (Canada)	N=915 Youth and young adult users and non-users (16-24 years); adult users (25+)	Determine the effect of distinct attributes of <i>e-cigarettes</i> (flavours, nicotine content, health warnings, price) and attribute levels on consumer choice	<ul style="list-style-type: none"> <li>▶ Flavours in <i>e-cigarettes</i> significantly predicted lower perceptions of product harm and ability to help someone quit smoking</li> </ul>
Etter, <sup>25</sup> 2010 (France, Belgium, Canada, Switzerland)	N=81 Adult (19-65; median age=37) Users	Assess usage patterns of <i>e-cigarettes</i> , reasons for use and users' opinions of these products	<ul style="list-style-type: none"> <li>▶ Adult <i>e-cigarette</i> users reported flavours as being the most positive feature of the product</li> </ul>
Farsalinos <i>et al.</i> <sup>26</sup> 2013 (survey online 10 languages)	N=4618 Adults (32-49; mean age=40) Users	Examine the patterns and perceptions of flavouring use in <i>e-cigarettes</i> among dedicated users	<ul style="list-style-type: none"> <li>▶ <i>E-cigarette</i> users who were former smokers were more likely to prefer fruit and sweet flavours compared with current smokers</li> <li>▶ <i>E-cigarette</i> users reported that the variability of <i>e-cigarette</i> flavours was an important factor in reducing or quitting cigarette smoking and a greater number of flavours used was associated with smoking abstinence</li> <li>▶ The variability of flavours was cited as one of the reasons for initiating <i>e-cigarette</i> use, though it was not a primary reason</li> </ul>
Farsalinos <i>et al.</i> <sup>27</sup> 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 <i>e-cigarette</i> users and examine the differences between those who partially and completely substituted smoking with <i>e-cigarette</i> use	<ul style="list-style-type: none"> <li>▶ Fruit and sweet flavours were perceived as more likely to be tried by young never smokers than adult smokers trying to quit</li> <li>▶ The perceived harmfulness of <i>e-cigarettes</i> was moderated by-product flavours</li> </ul>
Ford <i>et al.</i> <sup>28</sup> 2016 (UK)	N=1205 Youth (11-16), Users, non-users	Examine adolescents' awareness of <i>e-cigarette</i> marketing and investigate the impact of <i>e-cigarette</i> flavour descriptors on perceptions of product harm and user image	<ul style="list-style-type: none"> <li>▶ Availability of flavours was a primary reason for experimentation with <i>e-cigarettes</i>, and appealing flavours were particularly important to high school students</li> <li>▶ Use and preference for sweet <i>e-cigarette</i> flavours was high among adolescents regardless of cigarette smoking status</li> </ul>
Kong <i>et al.</i> <sup>29</sup> 2015 (USA)	N=1157 Youth, young adult Users	Assess reasons for <i>e-cigarette</i> experimentation and discontinuation and examine whether these reasons differed by school level (middle school, high school, college) and <i>e-cigarette</i> smoking status	<ul style="list-style-type: none"> <li>▶ For cigarette-only users, losing flavours significantly reduced the price participants were willing to pay for <i>e-cigarettes</i></li> </ul>
Krishnan-Sarin <i>et al.</i> <sup>30</sup> 2015 (USA)	N=4780 Youth (middle school mean age=12.18, high school mean age=15.63) Users, non-users	Examine <i>e-cigarette</i> 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"> <li>▶ Flavoured <i>e-cigarettes</i> did not increase male adolescents' willingness to try <i>e-cigarettes</i> compared with plain varieties</li> </ul>
Nonnemaker <i>et al.</i> <sup>31</sup> 2016 (USA)	N=765 Adults (18+), current or former smokers	Examines how <i>e-cigarette</i> attributes influence willingness to pay for <i>e-cigarettes</i>	<ul style="list-style-type: none"> <li>▶ Few adult <i>e-cigarette</i> users reported starting <i>e-cigarette</i> use because of the available flavours</li> </ul>
Pepper <i>et al.</i> <sup>32</sup> 2013 (USA)	N=228 Youth (11-19), males Users, non-users	Sought to understand awareness of and willingness to try <i>e-cigarettes</i> among adolescent males	<ul style="list-style-type: none"> <li>▶ The interest of non-smoking teens in trying flavoured <i>e-cigarettes</i> was very low, and interest was not influenced by flavour descriptors. Though adult smokers' interest was also modest, their interest was significantly higher than that of non-smoking teens for each flavour</li> </ul>
Pepper <i>et al.</i> <sup>33</sup> 2014 (USA)	N=3878 Adult (18+) Users	Explore reasons for starting and then stopping <i>e-cigarettes</i> use and examine differences in discontinuation by reason for trying among population-based sample of US adults	
Shiffman <i>et al.</i> <sup>34</sup> 2015 (USA)	N=216 (teens) N=432 (adult) Youth non-users (13-17) Adult users (19-80)	Compare <i>e-cigarettes</i> interest between non-smoking teens and adult smoker, across flavours and assess differences in flavour preferences among adult smokers based on <i>e-cigarettes</i> use history	

Continued

Table 2 Continued

Study ID (country)	Sample size and study population (years old)	Study aim	Main findings on flavours' impact
Shiplo <i>et al.</i> , <sup>35</sup> 2015 (Canada)	N=1095 Younger non-smokers and smokers (16–24), older smokers (25+)	Examines <i>e-cigarette</i> ever and current use, types of products used and reasons for use	<ul style="list-style-type: none"> <li>▶ Use of flavoured <i>e-cigarettes</i> varies by smoking status, with smokers being more likely to try flavours than non-smokers</li> <li>▶ A common reason for <i>e-cigarette</i> use is for the taste</li> </ul>
Tackett <i>et al.</i> , <sup>36</sup> 2015 (USA)	N=215 Adult (mean age=36.2) Users	Estimate <i>e-cigarettes</i> preference, <i>e-cigarettes</i> use behaviours, perceived harm and health beliefs of various smoking cessation medications, nicotine replacement therapies and nicotine/tobacco products and smoking history and current biochemically verified smoking status	<ul style="list-style-type: none"> <li>▶ Most <i>e-cigarette</i> users reported a preference for vaping non-traditional flavours.</li> <li>▶ Those who reported vaping non-tobacco and non-menthol flavours were more likely to have quit smoking</li> </ul>
Vasiljevic <i>et al.</i> , <sup>37</sup> 2016 (UK)	N=471 Youth (11–16) Non-users	Assess the impact on appeal of tobacco smoking after exposure to advertisements for <i>e-cigarettes</i> with and without candy-like flavours	<ul style="list-style-type: none"> <li>▶ Flavoured, compared with non-flavoured, <i>e-cigarette</i> advertisements elicited greater appeal, interest in buying and trying <i>e-cigarettes</i></li> </ul>
Yingst <i>et al.</i> , <sup>20</sup> 2015 (USA and other countries)	N=421 (87% in USA, 13% outside USA) Adult (mean age=40) Users	Examine the frequency with which <i>e-cigarette</i> users transition between device types and identify device characteristics and user preferences that may influence such transitions	<ul style="list-style-type: none"> <li>▶ Most <i>e-cigarette</i> users began use with a device shaped like a <i>cigarette</i> (first-generation devices) and transitioned to a larger advanced generation device with a more powerful battery and a wider choice of liquid flavours</li> <li>▶ Advanced generation device <i>e-cigarette</i> users report the variety of flavours as being important characteristic of <i>e-cigarettes</i></li> </ul>
<b>Cigarettes</b>			
Ajaku <i>et al.</i> , <sup>38</sup> 2014 (EU)	N=26 566 Youth, young adults (15–24), adults (25+) Users, non-users	Assess the role of <i>cigarette</i> design and marketing characteristics in initial smoking, <i>cigarette</i> brand choice and the perception of reduced harm of <i>cigarette</i> brands	<ul style="list-style-type: none"> <li>▶ Few ever smokers reported specific flavours as being important in their initial smoking, but flavours were significantly associated with initial smoking in younger smokers</li> <li>▶ Current smokers, particularly female smokers, reported specific flavours as important in their <i>cigarette</i> brand preference</li> <li>▶ Positive and negative expectancies were influenced by flavour, with higher positive and lower negative expectancies for flavoured <i>cigarettes</i> compared with non-flavoured <i>cigarettes</i>. Positive expectancies significantly predicted the likelihood of trying flavoured <i>cigarettes</i></li> <li>▶ No differences were observed between <i>cigarette</i> packs with and without flavour descriptors in ratings of tar delivery and health risk, though participants rated packs with flavour descriptors as better tasting and more appealing</li> <li>▶ Fully branded <i>cigarette</i> packs with flavour descriptors were rated as better tasting than the same packs without flavour descriptors</li> </ul>
Ashare <i>et al.</i> , <sup>39</sup> 2007 (USA)	N=424 Young adult (mean age=19) Users, non-users	Determine the appeal of flavoured and non-flavoured <i>cigarettes</i> among college student non-smokers, regular smokers and those susceptible to smoking	<ul style="list-style-type: none"> <li>▶ Removing flavour descriptors from <i>cigarette</i> packs significantly reduced measures of appeal and taste and increased measures of health risk</li> </ul>
Doxey and Hammond, <sup>40</sup> 2011 (Canada)	N=826 Youth (18–19), female Users, non-users	Examine the effects of <i>cigarette</i> brand descriptors, brand colour and imagery, as well as the impact of plain or standardised packaging on young female's beliefs about smoking	<ul style="list-style-type: none"> <li>▶ Flavoured <i>cigarette</i> use was associated with not intending to quit among females but not among males</li> </ul>
Hammond <i>et al.</i> , <sup>41</sup> 2011 (USA)	N=826 Youth (18–19), female Users, non-users	Examine the effects of <i>cigarette</i> brand descriptors, brand colour and imagery, as well as the impact of plain or standardised packaging on young female's beliefs about smoking	<ul style="list-style-type: none"> <li>▶ Among high sensation-seeking adolescents, the flavour descriptors led to more favourable hedonic brand beliefs and higher trial intentions than the traditional descriptors</li> <li>▶ Preference and ratings of harshness/irritation were not related to whether the <i>cigarette</i> brand was flavoured</li> </ul>
Hammond <i>et al.</i> , <sup>42</sup> 2013 (UK)	N=947 Youth (16–19), female Users, non-users	Examine the effects of <i>cigarette</i> brand descriptors, brand colour and imagery, as well as the impact of plain or standardised packaging on young female's beliefs about smoking	<ul style="list-style-type: none"> <li>▶ Adults who preferred brands with flavour capsules viewed their variety of <i>cigarettes</i> as having better taste and to be more appealing and less harmful (except Australian smokers) than other brand varieties compared with adult smokers of regular non-flavoured <i>cigarettes</i>.</li> </ul>
Kaletka <i>et al.</i> , <sup>43</sup> 2014 (Poland)	N=2254 Adult (15+) Users	Examine whether the use of flavoured <i>cigarettes</i> varies by sociodemographic characteristics, awareness of the smoking health consequences and the perception of risk of use compared with regular <i>cigarettes</i> from current smokers	
Manning <i>et al.</i> , <sup>44</sup> 2009 (USA)	N=253 Youth (mean age=15.7) Users, non-users	Examine the interactive effects of <i>cigarette</i> package flavour descriptors and sensation seeking on adolescents' brand perceptions	
O'Connor <i>et al.</i> , <sup>45</sup> 2007 (USA)	N=20 Young adult (18–30), male Users	Explore differences in puff topography and <i>cigarette</i> ratings between flavoured and unflavoured Camels among college student smokers	
Thrasher <i>et al.</i> , <sup>21</sup> 2016 (USA, Mexico, Australia)	N=4154 (USA) N=3366 (Mexico) N=2710 (Australia) Adult (18–64) Users	Assess trends, correlates of use and consumer perceptions related to product design innovation of flavour capsules in <i>cigarette</i> filters	

Continued

Table 2 Continued

Study ID (country)	Sample size and study population (years old)	Study aim	Main findings on flavours' impact
White <i>et al.</i> , <sup>46</sup> 2012 (Brazil)	N=640 Youth and young adult (16–26), female Users, non-users	Examine the effects of <i>cigarette</i> brand descriptors, brand colour and imagery, as well as the impact of plain or standardised packaging on young female's beliefs about smoking	<ul style="list-style-type: none"> <li>▶ Preference for flavour capsule cigarettes (though primarily menthol varieties) has significantly risen in the past few years in Mexico and Australia, particularly among young adults</li> <li>▶ The plain packs with flavour descriptors were given significantly higher appeal and taste ratings than the plain without flavour descriptor packs, though no significant differences were observed between packs in health risk ratings</li> </ul>
Little cigars, cigarillos and cigars			
Delnevo <i>et al.</i> , <sup>47</sup> 2015 (USA)	N=6678 Youth (12–17), young adult (18–25), adult (26+) Users, non-users	Examine use and preference of flavoured <i>cigar</i> brands among youth, young adults and adults in USA.	<ul style="list-style-type: none"> <li>▶ A clear preference was observed for cigar brands that produce flavoured varieties among youth, young adult, female, and black cigar smokers</li> <li>▶ Preference for flavoured cigars was associated with current cigarette smoking.</li> </ul>
Leatherdale <i>et al.</i> , <sup>48</sup> 2011 (Canada)	N=29 296 9th–12th grader Users, non-users	Examine the prevalence of <i>cigar</i> , <i>cigarillo</i> and <i>little cigar</i> use and factors associated with their use among nationally representative sample of Canadian youth	<ul style="list-style-type: none"> <li>▶ Ever use of flavoured tobacco was associated with being a current cigar, cigarillo or little cigar smoker</li> </ul>
Yates <i>et al.</i> , <sup>49</sup> 2014 (Canada)	N=133 Young adult and adult users (age 19–29; mean age=23.6)	Examine the patterns, attitudes and beliefs regarding <i>cigarillo</i> use and cause of cigarillos and cigarettes among young adults	<ul style="list-style-type: none"> <li>▶ Flavour was the primary reason cited for smoking cigarillos</li> </ul>
Hookah			
Dani <i>et al.</i> , <sup>50</sup> 2015 (India)	N=447 College students, users and non-users	Assess perception among young adults in a college environment towards using <i>hookah</i> for smoking tobacco	<ul style="list-style-type: none"> <li>▶ A significant difference between users and non-users was found, where more users indicated that <i>hookah</i> 'contains pleasant flavors' compared with non-users</li> </ul>
Salloum <i>et al.</i> , <sup>51</sup> 2015 (USA)	N=367 Adult (18+ mean age 21.9) college students, users	Measure preferences for <i>waterpipe</i> smoking and determine which product characteristics are most important to smokers	<ul style="list-style-type: none"> <li>▶ Participants preferred fruit-flavoured varieties to tobacco flavour</li> </ul>
Smith <i>et al.</i> , <sup>52</sup> 2011 (USA)	N=689 Youth (mean age=17.1) Users, non-users	Examine patterns of use (eg, initiation, cessation), risk perception and psychosocial factors among users, former users and non-users of <i>hookah</i> among high school students	<ul style="list-style-type: none"> <li>▶ High school students cited flavours of the hookah as one of the reasons they believed hookah to be safer or less addictive than cigarettes</li> </ul>
Smokeless tobacco			
Adkison <i>et al.</i> , <sup>53</sup> 2014 (USA)	N=1000 Youth (14–17), young adult (18–25), adult (26–65) Users, non-users	Evaluate the association between <i>smokeless tobacco</i> packaging elements with knowledge of health risks and perceptions of novelty and appeal	<ul style="list-style-type: none"> <li>▶ The majority of respondents indicated no difference in opinions regarding health risk and appeal between <i>smokeless tobacco</i> product packaging with or without flavour descriptors</li> <li>▶ Among those who did report differences, youth and young adults were more likely to indicate the <i>smokeless tobacco</i> pack with the flavour descriptor as more appealing, attractive and having reduced health risks.</li> </ul>
Oliver <i>et al.</i> , <sup>54</sup> 2013 (USA)	N=468 Adult (18–70) Users	Examine the choice of brand flavour in the course of <i>smokeless tobacco</i> use, from initiation to regular use, in an intervention seeking population and examine whether users of flavoured <i>smokeless tobacco</i> products differ from non-flavoured users in their use patterns	<ul style="list-style-type: none"> <li>▶ A majority of respondents' first and current choice of <i>smokeless tobacco</i> product was mint flavoured.</li> <li>▶ A significant number of respondents switched from a non-flavoured to a flavoured <i>smokeless tobacco</i> product</li> </ul>
Bidi			
CDC, <sup>55</sup> 1999 (USA)	N=642 7th–12th grader	Determine the prevalence of <i>bidi</i> use among urban youth	<ul style="list-style-type: none"> <li>▶ Few adolescents cited liking the flavour as a reason for smoking <i>bidis</i> rather than cigarettes</li> </ul>
Various tobacco products			
Ambrose <i>et al.</i> , <sup>56</sup> 2015 (USA)	N=13 651 Youth (12–17) Users	Examine role of flavours in the use of <i>various tobacco products</i> among a nationally representative sample of US youth	<ul style="list-style-type: none"> <li>▶ Majority of ever-users reported the first product they used was flavoured</li> <li>▶ Product flavouring consistently reported as a reason for tobacco product use across all types or products</li> </ul>

Continued

Table 2 Continued

Study ID (country)	Sample size and study population (years old)	Study aim	Main findings on flavours' impact
King <i>et al.</i> <sup>57</sup> 2014 (USA)	N=18 866 6th–12th grader Users, non-users	Assess the prevalence and sociodemographic correlates of flavoured <i>little cigar</i> and flavoured <i>cigarette</i> smoking among US middle and high school students	▲ Respondents who used flavoured cigars or cigarettes had a lower intent to quit than non-flavoured users
Lee <i>et al.</i> <sup>58</sup> 2015 (US)	N=24 658 6th–12th grader Users, non-users	Assess the prevalence and concurrent use of patterns of <i>various tobacco products</i> and examine associated risk factors among US youth	▲ The use of flavoured products was associated with multiple product use
Minaker <i>et al.</i> <sup>59</sup> 2015 (Canada)	N=17 396 Youth (grades 9–12), never smokers	Examines smoking susceptibility and <i>alternative tobacco product</i> use in Canadian youth	▲ Never smokers who have ever tried ATPs, and particularly flavoured ATPs, are at significantly increased odds of being susceptible to cigarette smoking

advertisements.<sup>37</sup> A study of 689 US adolescents cited flavours as one of the reasons why they perceived hookah to be safer or less addictive than cigarettes.<sup>52</sup> However, a small US study of 20 college smokers did not detect an appreciable difference in harshness or irritation between flavoured and non-flavoured cigarettes.<sup>45</sup>

### Preference

Ten studies examined preference for flavoured tobacco products. One US study of 4780 middle and high school students found that preference for sweet e-cigarette flavours was high, with most lifetime and current e-cigarette users reporting they preferred sweet flavours compared with menthol and tobacco flavours when they smoked e-cigarettes.<sup>30</sup> A UK study of 1205 adolescents also found that fruit, sweet and coffee flavours in e-cigarettes were perceived as more likely to be tried by young never smokers compared with tobacco flavour, and these flavours were perceived as more likely to be used or tried by young never smokers than adult smokers trying to quit smoking.<sup>28</sup> Three studies among adult e-cigarette users reported that the variety of flavour choices was rated as important by the majority of users (85.4%) and influenced device choice;<sup>20</sup> most users (72%) preferred vaping non-traditional flavours such as fruity and candy/nuts to traditional flavours (ie, menthol or tobacco),<sup>36</sup> and former cigarette smokers were more likely to use fruit and sweet flavours.<sup>26</sup> Similarly, a US study of 6678 participants reported a clear preference among youth, young adults, female and black cigar smokers for cigar brands that produce flavoured varieties.<sup>47</sup> Many current adult cigarette smokers (33%) in 27 EU countries, particularly female smokers, reported specific sweet, menthol or fruity flavours as important in their cigarette brand preference.<sup>38</sup> Preference for flavour capsule cigarette brands has significantly risen in recent years in Mexico and Australia, particularly among young adults (though the majority of the flavour capsule varieties reported refer to menthol).<sup>21</sup> But a US study of 20 college smokers did not find a relationship between preference and whether the brand of cigarette was flavoured or non-flavoured.<sup>45</sup> An online study of 367 US college hookah users found that participants preferred fruit-flavoured varieties to tobacco flavour.<sup>51</sup> Further, flavour accounted for almost two-thirds of the hookah use decision, compared with price (22%) and nicotine content (13%).<sup>51</sup>

### Expectancies and beliefs

Six studies examined expectancies and beliefs of flavoured tobacco products that influence consumers' decisions. An online study conducted among 915 Canadians found that flavours in e-cigarettes had a moderate influence (25%) on judgements of product efficacy in quitting smoking compared with other product attributes such as nicotine content (10%), price (26%) and health warnings (39%).<sup>24</sup> Another online US study of 765 adult smokers that estimated the value smokers placed on attributes of e-cigarettes found that removing the attribute 'coming in flavours' significantly reduced the price smokers were willing to pay among e-cigarette-only users.<sup>31</sup> Among 424 US college students, Camel Exotics (flavoured cigarettes) produced greater positive expectancies than did Camel Lights (non-flavoured cigarettes), with the strongest difference among susceptible/experimenters.<sup>39</sup> In addition, participants rated Camel Lights more negatively than Camel Exotics; this relationship held true across non-smokers, susceptible/experimenters and regular smokers. A cigarette packaging study among 253 high school students in the USA found that flavour descriptors led to more positive beliefs about the hedonic qualities (eg, enjoyable,

relaxing, good tasting) of brands than the traditional descriptors, although this interaction was only significant among high sensation seekers.<sup>44</sup> 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 flavours (18% of total open-ended comments).<sup>25</sup> A study of 447 young adults in India that assessed perception of hookah use, 36.8% of hookah users indicated that hookah 'contains pleasant flavours', which was significantly higher than non-users (24.6%).<sup>50</sup>

### Reasons for use

Seven studies addressed reasons for using flavoured tobacco products. In a US study of 13 651 adolescents, product flavouring 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%).<sup>56</sup> An online study of 1567 adults found that a majority of e-cigarette users (60%) and one-third of non-users reported reasons or interest for using e-cigarettes because 'they come in appealing flavors' and 'I like experimenting with various flavors'.<sup>23</sup> This study also found that flavours were a common reason for discontinued use of e-cigarettes among former e-cigarette users because they 'don't like the flavor(s)'.<sup>23</sup> 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%).<sup>35</sup> In a US 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 flavours (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.<sup>22</sup> In an online US study of 3878 adults, 8% of e-cigarette users reported flavours as a reason for first trying e-cigarettes compared with 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.<sup>33</sup> In an urban sample of 133 Canadian young adults, the primary reason reported for smoking cigarillos was because of the flavour (56%).<sup>49</sup> Among a convenience sample of 642 youth in Massachusetts, only 1% reported using bidis instead of cigarettes because of the flavour, but 23% said bidis tasted better than cigarettes.<sup>55</sup>

### Intention to try/initiation

Twelve studies assessed intention to try or initiation of flavoured tobacco products. In a US study of 13 651 adolescents, the majority of ever users (80.8%) reported that the first product they had used was flavoured, 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%).<sup>56</sup> The majority of past 30-day users (79.8%) also reported that the products used were flavoured.<sup>56</sup> One US study of 468 adult users reported a majority (60%) of participants' first smokeless tobacco product used was mint flavoured.<sup>54</sup> A study in the EU found that though few ever adult cigarette smokers (1.4%) reported specific flavours as being important in their initial smoking, flavours were significantly associated with initial smoking in younger smokers aged 15–24.<sup>38</sup> Among US adolescents and young adults, flavoured cigarette brands led to higher trial intentions compared with non-flavoured cigarette brands in two different studies.<sup>39 44</sup> In an online study of 915 Canadians aged 16 years and older, flavour accounted

for 24% of consumers' intentions to try e-cigarettes, showing a moderate influence compared with other product attributes.<sup>24</sup> Younger smokers and non-smokers were particularly interested in trying cherry-flavoured e-cigarettes, while older smokers indicated greater interest in trying tobacco flavour.<sup>24</sup> A US study of 1157 adolescent and young adult ever e-cigarette users found that the availability of flavours was a primary reason for experimentation with the product, particularly among high school students compared with college students.<sup>29</sup> An online study of 1095 Canadians showed that younger non-smokers were less likely to try a flavoured e-cigarette than younger smokers and older smokers.<sup>35</sup> In a UK study of 471 e-cigarette and cigarette non-users aged 11–16 years, flavoured e-cigarette advertisements elicited greater interest in buying and trying e-cigarettes than non-flavoured e-cigarette advertisements, but the appeal of using e-cigarettes was low for both sets of advertisements.<sup>37</sup> A US study of 228 male adolescents found that their willingness to try e-cigarettes compared with plain varieties did not differ based on flavour status, although virtually none of the males (<1%) had tried e-cigarettes previously.<sup>32</sup> An online European study, financially underwritten by an e-cigarette users advocacy group, reported that initiating e-cigarette use to enjoy the variability of flavours was ranked as a 3 on a 5-point scale from 1 (not important) to 5 (most important).<sup>27</sup> A US 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 flavour, but adult smokers' interest did.<sup>34</sup>

### Progression to regular use

Two studies examined the impact of flavoured tobacco on the progression from tobacco initiation to regular use of flavoured products.<sup>48 54</sup> A US 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-flavoured products, 64.4% reported current use of flavoured products, whereas 48.7% of those who started using non-flavoured products continued to use non-mint-flavoured products.<sup>54</sup> A nationally representative sample of 29 296 high school students from the Canadian Youth Smoking Survey reported a strong association between flavoured tobacco use and being a current cigar, cigarillo or little cigar smoker.<sup>48</sup> Respondents who reported ever using flavoured tobacco were more likely to currently use cigars, cigarillos or little cigars compared with respondents who had never used flavoured tobacco products.<sup>48</sup> 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 flavours in dual or poly use of tobacco products. One survey among 24 658 middle and high school students in the USA assessed the association between types of use (singular tobacco product vs multiple tobacco products) and found that among current cigarette smokers, the use of flavoured products was significantly associated with dual and poly tobacco use.<sup>58</sup> Another study found that cigar brands offering flavoured varieties were preferred more by cigar smokers who were also current cigarette smokers.<sup>47</sup> A Canadian study of 17 396 young never smokers found that those who had ever tried or tried a flavoured tobacco product in the past 30 days had significantly higher odds of being susceptible to cigarette smoking.<sup>59</sup>



### Quit intention and quitting behaviour

Four studies assessed flavoured tobacco use and intention to quit. A study of 18 866 US middle and high school students found that flavoured cigar (59.7%) and cigarette (49.3%) users had a higher prevalence of not thinking about quitting tobacco than non-flavoured cigar (18.4%) and cigarette (9.8%) users.<sup>57</sup> Similarly, a study in Poland of 2254 adult users reported that females who smoked flavoured cigarettes were less likely to intend to quit than females who smoked non-flavoured cigarettes.<sup>43</sup> US adult e-cigarette users who reported vaping non-tobacco and non-menthol flavours were more likely to have quit smoking than e-cigarette users who vaped traditional flavours.<sup>36</sup> One study of adult e-cigarette users, financially underwritten by an e-cigarette user advocacy group, reported that the variability of e-cigarette flavours was an important factor in reducing or quitting smoking and a greater number of flavours regularly used was associated with smoking abstinence among dedicated long-term e-cigarette users.<sup>26</sup>

### 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 online supplementary table). 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).<sup>26 34 54</sup> 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 (eg, power calculations for sample size consideration often not reported due to word count constraints). Three studies were financially supported by e-cigarette companies or advocacy groups of e-cigarette users.<sup>26 27 34</sup>

### DISCUSSION

This systematic review highlights and extends in important ways what policymakers and public health practitioners strongly suspect: flavours play a key role in influencing perceptions and multiple tobacco use patterns about most tobacco products, particularly for adolescents. Flavours 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 flavours,<sup>24 29 37 46 47 53 56</sup> are reported as a reason for using most tobacco products,<sup>22 23 33 49 51 55 56</sup> and appear to play a more important role in the use of e-cigarettes, hookah, little cigars and cigarillos among younger people.<sup>48 49 56</sup> The availability of non-menthol flavoured tobacco products and their appeal to adolescents have the potential to undermine progress gained on reducing tobacco use.<sup>8</sup> Flavoured tobacco products were perceived as having better taste and were more appealing by users and non-users, especially among younger age groups.<sup>21 40–42 46 53</sup> Flavoured 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 flavoured products were less harmful compared with non-flavoured products.<sup>21 24 28 42 53</sup> Tobacco product users and non-users showed a clear preference for sweet, fruit-flavoured varieties over traditional tobacco

flavours,<sup>20 21 30 36 38 47 51</sup> and flavours give tobacco products higher positive expectancies and beliefs about hedonic qualities, product features and values that may influence consumers' decisions more than non-flavoured tobacco products.<sup>24 25 31 39 44 50</sup> Not surprisingly, given the strong impact of flavours in perceptions of tobacco products, flavours were associated with progression to regular use and dual and poly use of tobacco products. Tobacco users tended to switch to flavoured products and maintain multiple flavoured products.<sup>47 48 54 58 59</sup> Finally, results from this review showed that the use of flavoured tobacco products, such as cigarettes and cigars, may be associated with lower quit intentions.<sup>43 57</sup> However, two e-cigarette studies, one funded by a user advocacy group, found that flavours in e-cigarettes may help adult e-cigarette users in quitting cigarette smoking.<sup>26 36</sup>

Our systematic review significantly expands on a recent systematic review by Feirman *et al*<sup>18</sup> of US studies published through 2013. Our review includes articles that critically summarised data for the first time on the role of flavours in tobacco use perceptions as well as tobacco use behaviours. We specifically examined flavours 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 behaviour. Our review also includes 17 non-US 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 US versus non-US studies, it is important to note that most of the non-US studies were conducted in highly developed countries with moderate to strong tobacco regulatory frameworks, such as Canada and the UK.

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

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 flavoured cigarettes, little cigars and cigarillos, and blunt wraps that weighed <1.4 g, with an exemption for menthol flavouring.<sup>61</sup> The prevalence of flavoured tobacco product use among Canadian high school students remained high even after the enactment of this legislation, in part because the tobacco industry reformulated flavoured cigarillos to circumvent the bill (eg, increased the product's weight to more than 1.4 g).<sup>61</sup> Bill C-32 also exempted many categories of tobacco products from regulation (eg, pipe tobacco, smokeless tobacco and cigars).<sup>61</sup> In 2015, two Canadian provinces extended existing flavour bans on the sale of flavoured tobacco products to include those with menthol

flavours, but with exemptions for pipe tobacco and some cigars.<sup>62</sup> 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.<sup>26 27 34</sup> 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 behaviours 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 flavours in tobacco use perceptions and behaviours; many studies included in this review were not designed to assess flavours as the major predictor variable (table 2). This resulted in some studies lacking power to detect differences in measures between flavoured and non-flavoured conditions (see online supplementary table), thus causing our systematic review to likely underestimate the findings of flavours' impact due to non-significant results. The majority of studies used cross-sectional data and did not assess the impact of flavours on behavioural 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 flavours in other populations and cultures, as products may differ greatly across countries because of sociocultural difference (eg, smokeless tobacco in the USA 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 flavour plays in each identified behavioural outcome. Finally, our review did not examine the impact of menthol flavours on outcomes. A previous report of the Tobacco Product Scientific Advisory Committee found sufficient evidence that menthol flavourings in cigarettes increased experimentation and regular smoking and decreased the likelihood of smoking cessation compared with non-menthol cigarettes,<sup>17</sup> findings similar to that of our review on non-menthol flavourings. Future reviews should examine the literature on menthol flavourings to determine if the impact of menthol flavouring is the same as or different from other flavours in diverse tobacco products, particularly given the fact that menthol flavoured cigarette smokers account for one-third of all cigarette smokers in the USA, and menthol flavoured cigarette use has increased or remained stable, despite significant decreases in non-menthol cigarette use.<sup>63 64</sup>

## CONCLUSIONS

While further exploration of the impact that flavours have on tobacco use and perceptions are needed, existing evidence provides a rationale for banning non-menthol flavouring in most tobacco products to maximally protect youth from being enticed by flavours from tobacco use around the world. Further

## What this paper adds

- ▶ The study highlights the key role of flavours 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 flavouring in most tobacco products.
- ▶ Further research on the impact of flavours, particularly given the increasing appeal and prevalence of flavoured tobacco products among young populations, should include the specification of the flavours' impact on tobacco use behaviours and perceptions, longitudinal research designs and reliability and validity of measures.

research examining flavoured tobacco products should include the specification of the flavours' impact on tobacco use behaviours and perceptions, particularly the impact of flavoured e-cigarettes on adults cessation patterns with combustible tobacco, use standardised and validated measures and adopt longitudinal research designs to measure changes, especially behavioural outcomes, over time in relation to flavours.

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