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ABSTRACT
Objective To systematically review the literature regarding relative risk perceptions (RRPs) across non-combustible nicotine products.

Data sources MEDLINE and PsycINFO databases were searched for articles published up to October 2014.

Study selection Of the 5266 records identified, articles not published in English that did not quantitatively assess RRP across categories of non-combustible nicotine products were excluded, yielding 55 records.

Data extraction One reviewer extracted measures and findings of RRP for product comparisons of smokeless tobacco (SLT), e-cigarettes (ECs) and nicotine replacement therapy (NRT) to one another, and to combustible cigarettes (CCs).

Data synthesis A total of 157 samples from 54 studies were included in the analyses. The accuracy of RRP differed based on the products being compared: although the accuracy of RRP was variable across studies, 40% of respondents did not know the relative harmfulness of SLT versus CCs, as well as of ECs versus NRT. In contrast, respondents in many studies correctly perceived NRT and ECs as less harmful than CCs. Cigarette smokers and users of non-combustible nicotine products tended to correctly perceive the relative harmfulness of products more often than non-users. Measures used to assess RRP varied across studies, with different approaches characterised by certain strengths and limitations.

Conclusions The highly variable and context-specific nature of non-combustible nicotine product RRP have direct implications for researchers and present several challenges for policymakers working with modified risk products, including issues of measurement, health risk communication and behaviour change.

INTRODUCTION
Tobacco and nicotine products fall on a continuum of risk based on the mode of nicotine delivery and product constituents.1 Combustible cigarettes (CCs) are in fact highly toxic, containing a large number of toxic constituents in smoke and the highly efficient delivery of nicotine. The least hazardous are nicotine replacement therapy (NRT) products, which deliver nicotine with fewer toxic by-products and have been evaluated for clinical safety and efficacy. Various non-combustible products fall between CCs and NRT, including smokeless tobacco (SLT) and electronic cigarettes (ECs).1

Smokeless tobacco products are available in many forms, including chewing tobacco, snuff, snus and dissolvable tobacco products, and may be used orally or nasally.2,3 Use of SLT products can cause addiction, precancerous oral lesions and cancer of the oral cavity, oesophagus and pancreas, as well as adverse reproductive effects, and is associated with increased risk of ischaemic heart disease, stroke and diabetes.4 Although the health risks posed by SLT use can vary by product, in general, they are lower relative to those of combusted tobacco.5,6 E-cigarettes are highly variable products that deliver nicotine via an aerosol and may contain additives and flavours.7 Although evidence to date indicates that ECs are likely to pose substantially less risk than CCs, the long-term health effects of these products remain unknown.8–11

The combined effects of tobacco control policies and technological innovation have created a very distinct nicotine market. The changing landscape presents SLT and ECs as modern, acceptable alternatives, creating new challenges for public health. While non-combustible nicotine products are likely to pose fewer risks to individual users, the impact of these products on public health will be determined by their effect on smoking prevalence.12–14

Consumer perceptions of risk have played a fundamental role in reducing the prevalence of smoking over the past 50 years. Concerns about the health risks of smoking are the most common motivation to quit smoking as reported by current and former smokers.15,16 This message has been promoted by major public health authorities, including websites in the USA, such as those of the Centers for Disease Control and Prevention (CDC) and the National Cancer Institute (NCI), among others.17,18 Although factually true, this message does not reflect the epidemiological evidence supporting the differential risks of tobacco products, and may lead to inaccurate perceptions of relative risks of tobacco products.17 In addition, lack of proactive public health communication effectively means that the industry controls information related to product design and consumer behaviour.1

There is a need for more effective health risk communication concerning nicotine products.
Public health authorities require evidence on how consumers perceive the relative risk of different products to guide labelling policies and risk communication efforts. For instance, the US Food and Drug Administration (FDA) considers applications from manufacturers who seek to market ‘modified risk products’ and wish to use messaging that a given product poses fewer health risks than a reference product.\(^{15-19}\) There is also a need to develop the research methodology for assessing perceptions of relative risk, given that past assessments have been inconsistent. To date, however, there has been no systematic review of evidence concerning relative risk perceptions (RRPs) across the nicotine spectrum. The current review aims to examine the evidence regarding RRPs of non-combustible nicotine products; describe the methods of assessment of RRPs; and discuss implications for public health policy.

**METHODS**

**Search strategy**

One investigator searched MEDLINE and PsycINFO in October 2014 for all published articles using a search strategy built on three key concepts: risk, perception and nicotine products (see Supplementary table S1).

**Study selection**

Identified articles were reviewed to determine eligibility according to the following criteria: were original empirical investigations; quantitatively assessed RRPs across categories of nicotine products (eg, SLT vs CCs); and were published in English in peer-reviewed journals. The review was limited to examination of RRPs for product comparisons of SLT (chew, dip, snuff, snus, dissolvables), ECs and NRT (gum, patch, lozenge) to one another, and to CCs. Potentially reduced exposure products and fringe products (eg, nicotine lollipops, tobacco heat sticks) were excluded. The removal of duplicates (n=211) resulted in 5266 unique records. As outlined in figure 1, further assessment yielded 55 final records. Of these, two pairs of records\(^{20,21}\), \(^{22,23}\) reported findings from the same study; as a result, these were paired together. In addition, one record\(^{24}\) reported findings from two distinct surveys; as a result, this record was split (denoted as \(^{24A,24B}\) in Supplementary table 2). Thus, a total of 55 records (54 studies from 55 articles) were included in the analysis.

**Data extraction**

A data extraction table was used to summarise the study findings. Measures of RRPs were extracted from the identified studies as follows. First, question stems were categorised as either ‘closed judgements’, in which a particular RRP was presented as a statement and solicited respondents’ evaluation of this judgement; or ‘open questions’, which allowed respondents to select a RRP from a list. Second, response options were classified as either ‘categorical’, eliciting a discrete choice from respondents; ‘continuous’, allowing respondents to select an answer from a continuum or range of options; or ‘mixed’, involving a combination of categorical and continuous dimensions. Measures consisting of a continuous response were further classified as using a rating technique, requiring respondents to indicate the degree of a particular attribute or the degree to which they endorse an attitude; or a ranking technique, requiring respondents to place in order a series of alternatives.\(^{25}\)

Results were summarised as comparisons made across products, denoted as X versus Y (reference), using mathematical operators. Findings for the full sample and any subsamples related to use of nicotine products were recorded. Users of CCs included both former smokers (individuals who had smoked at least 100 cigarettes in their lifetime but had not smoked in the past 30 days) and current smokers (individuals who had smoked at least 100 cigarettes in their lifetime and had smoked in the past 30 days). Users of non-combustible nicotine products included individuals who had ever used such a product in their lifetime.

**Data synthesis**

Results were analysed using the narrative synthesis approach.\(^{26}\) Specifically, results were categorised by product comparisons across nicotine product classes: NRT versus CCs, SLT versus CCs, SLT versus NRT, ECs versus CCs and ECs versus NRT. Within each product comparison, RRPs were examined overall, as well as with respect to several samples: general samples (ie, non-targeted recruitment), cigarette smokers and users of non-combustible nicotine products. The variability of RRPs across samples was described in terms of whether a discernable majority of respondents held a particular RRP. The findings were categorised as follows: a majority of respondents held a particular RRP (eg, perception of a product as having less risk than a reference product), or they did not know the relative risk between given products. In addition, samples in which a particular RRP was not held by a majority of respondents were classified as ‘none’, and samples for which insufficient information was given to discern whether a majority of respondents held a particular RRP were classified as ‘unknown’. These findings were examined overall across all study samples and stratified by the sampling method. Other quantitative findings that did not represent proportions of respondents who held particular RRPs were considered separately. Finally, the findings were examined with respect to whether they accurately reflected the epidemiological continuum of risk.

**RESULTS**

In all, 54 studies met the inclusion criteria. A majority of studies were observational in nature (n=52), including cross-sectional surveys (n=48) and longitudinal studies (n=4), while two studies were experimental. The studies were conducted between 1983 and 2013 in various countries, with a majority of studies in the USA (n=31). A majority of the observational studies used probability-based sampling methods (n=35), while both experimental studies used non-probability-based sampling methods (n=2). Several studies purposively recruited nicotine product users, including users of CCs (n=21), ECs (n=4) and SLT (n=1). A detailed description of the studies is available online (see Supplementary table S2).

**RRPs by product comparison**

Perceptions of relative risk appeared to be specific to particular product comparisons across the non-combustible nicotine spectrum. Table 1 shows the proportion of samples in which a majority of respondents held a particular RRP for each product comparison (see Supplementary table S3 for findings stratified by sampling method).

SLT versus CCs

RRPs for comparisons of SLT with CCs were examined in 83 samples from 30 studies.\(^{27-36}\) Among the observational study samples (n=77), RRPs of SLT versus CCs were highly variable: in 18% and 13% of samples, a majority of respondents perceived SLT to be less harmful than CCs, and SLT to be as harmful as CCs, respectively. Further, in about one-quarter of

\(^{2}\)

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samples (27%) there was no discernible majority RRP, while in about one-third of samples (32%), there was insufficient information to ascertain whether a majority of respondents held a particular RRP. The pattern of findings among probability-based (n=56) and non-probability-based (n=21) samples generally agreed with those described above (when RRPs of ‘less’ and ‘less or equal’ for non-probability-based samples are combined). In addition, Smith and colleagues found that respondents in their study ranked SLT as significantly less harmful than CCs.

When RRPs were compared with objective risks, the epidemiologically correct RRP was held by a majority of respondents in just 18% of samples.

ECs versus CCs
RRPs for this product comparison were examined in 50 samples from 23 studies. In 70% of observational study samples (n=46), a majority of respondents perceived ECs as less harmful than CCs; while in 17% of samples, no clear RRP emerged among a majority of respondents. Among samples recruited using probability-based methods (n=32), this pattern was generally consistent, albeit a majority of respondents perceived ECs as less harmful than CCs in a smaller proportion of samples, while a majority of respondents held this RRP in all non-probability-based samples (n=14). In addition, Harrell et al. and Pokhrel et al. reported that respondents in their studies perceived ECs as less harmful than CCs. With respect to the epidemiological continuum of risk, respondents correctly perceived ECs as less harmful than CCs in most studies.

NRT versus CCs
RRPs for this product comparison were examined in 20 samples from 8 studies. Although in approximately one-third of samples (35%), a majority of respondents viewed NRT as less harmful than CCs, these findings should be interpreted with caution, given that in half of the samples (50%), there was insufficient information to ascertain whether a majority of respondents held a particular RRP. Sampling strategy had an effect on the results, whereby in a large minority of probability-based samples (40%), a majority of respondents perceived NRT and CCs as equally harmful, while in almost one-half (47%) of non-probability-based samples, a majority of respondents perceived NRT as less harmful than CCs. In addition, a large proportion of both probability-based (60%) and non-probability-based (47%) samples did not report on the full spectrum of RRPs, limiting this analysis. Although the findings should be interpreted with caution given this limitation, overall, in a large minority of samples, respondents correctly perceived the relative harmfulness of NRT and CCs.

SLT versus NRT
Perceptions of relative risk of SLT compared to NRT were examined in two samples from a nationally representative survey...
conducted in the USA by Regan et al. In both study samples, a majority of respondents indicated that they did not know the relative harmfulness of these products.

ECs versus NRT
Risk perceptions of ECs relative to NRT were examined in two samples from two studies. In a probability-based sample of smokers in Great Britain, RRP s were highly variable, with no clear majority emerging. In addition, Harrell and colleagues reported that respondents in their study incorrectly perceived ECs as less harmful than NRT.

RRPs among key subpopulations
As shown in table 1, in general, users of non-combustible nicotine products more often held accurate RRP s than did non-users when comparing the harmfulness of their products to CCs. This pattern held for comparisons of each of SL T, ECs and NRT versus CCs: whereas a majority of respondents in 75% of samples of users of the respective non-combustible nicotine products, in no samples of non-users did a majority share this view. In addition, cigarette smokers more often held epidemiologically correct RRP s than did samples of the general population when comparing ECs with CCs (81% and 64%, respectively), and were almost on par when comparing SL T with CCs (13% and 18%, respectively). However, smokers fared worse than the general population when asked to compare the relative harmfulness of NRT and CCs: whereas a majority of respondents in 75% of samples drawn from the general population perceived NRT as less harmful than CCs, adult smokers greatly overestimated the relative risks of NRT, with a majority of respondents in just 25% of samples sharing this view.

Amenability of RRP s to change
Although limited, evidence from longitudinal and experimental studies indicates that RRP s can change over time or under certain conditions, highlighting their potential to serve as targets for health interventions. For instance, Borland et al. showed that an educational fact sheet could lower false relative health beliefs among smokers, potentially encouraging them to switch to products that carry less risk. Furthermore, Callery et al. demonstrated the plasticity of RRP s under various conditions involving a health warning label (text or pictorial) and a relative health-risk message ("Using smokeless tobacco is less harmful than smoking cigarettes"). The findings showed that pictorial health warning labels increased false health beliefs about SL T compared to CCs, whereas text warning labels did not. In addition, the relative health-risk message decreased false health beliefs about the relative harmfulness of SL T, indicating the potential use of such messages in communicating relative health-risk information.

Measures of RRP s
Question structure and mechanics
A total of 57 measures were used to examine RRP s across 54 studies. As shown in table 2, measures of RRP s were highly variable and exhibited many characteristics. Although a majority of measures (n=41) operationalised risk as an overall concept of harm, some were based on distinct dimensions.

Table 1  Relative risk perceptions held by a majority of respondents, overall and for key subpopulations

<table>
<thead>
<tr>
<th>Product comparison</th>
<th>Samples*</th>
<th>Proportion of samples in which a majority of respondents held a particular perception of relative risk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td>SL T vs CCs (ref)</td>
<td>Overall (n=77)</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>General population (n=20)</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Smokers (n=38)</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>SL T users (n=13)</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>SL T non-users (n=6)</td>
<td>0</td>
</tr>
<tr>
<td>ECs vs CCs (ref)</td>
<td>Overall (n=46)</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>General population (n=11)</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Smokers (n=16)</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Non-smokers (n=2)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>EC users (n=16)</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>EC non-users (n=1)</td>
<td>0</td>
</tr>
<tr>
<td>NRT vs CCs (ref)</td>
<td>Overall (n=20)</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>General population (n=4)</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Smokers (n=12)</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>NRT users (n=2)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>NRT non-users (n=2)</td>
<td>0</td>
</tr>
<tr>
<td>SL T vs NRT (ref)</td>
<td>Overall (n=2)</td>
<td>0</td>
</tr>
<tr>
<td>ECs vs NRT (ref)</td>
<td>Overall (n=1)</td>
<td>0</td>
</tr>
</tbody>
</table>

Bold results indicate the proportion of samples in which a majority of respondents held the epidemiologically correct perception of relative risk, for each product comparison. Sample sizes reflect those extracted from observational studies for which quantitative comparable findings were reported. Samples from the following studies were excluded due to their experimental nature: SL T versus CCs. Samples from the following studies were excluded due to use of an incompatible measure: SL T versus CCs; ECs versus CCs; RRPs among key subpopulations.

The findings showed that pictorial health warning labels increased false health beliefs about SL T compared to CCs, whereas text warning labels did not. In addition, the relative health-risk message decreased false health beliefs about the relative harmfulness of SL T, indicating the potential use of such messages in communicating relative health-risk information.

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<td>0</td>
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<tr>
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<td>EC users (n=16)</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>EC non-users (n=1)</td>
<td>0</td>
</tr>
<tr>
<td>NRT vs CCs (ref)</td>
<td>Overall (n=20)</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>General population (n=4)</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Smokers (n=12)</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>NRT users (n=2)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>NRT non-users (n=2)</td>
<td>0</td>
</tr>
<tr>
<td>SL T vs NRT (ref)</td>
<td>Overall (n=2)</td>
<td>0</td>
</tr>
<tr>
<td>ECs vs NRT (ref)</td>
<td>Overall (n=1)</td>
<td>0</td>
</tr>
</tbody>
</table>
of risk, such as perceived severity, and perceived susceptibility, and perceived likelihood. In addition, several used aids to help guide respondents, such as an awareness prompt or visual aids, such as product images (n=2). A majority of measures were direct in nature (n=50), requiring respondents to make a direct comparison of the products, whereas seven measures were indirect, in which the responses to separate questions were compared. Among the direct measures (n=50), question stems were either open (n=36), or closed (n=14). Among the direct measures (n=50), 36 were continuous, and 5 were categorical. Of the continuous measures (n=36), a majority involved a rating task (n=35), while 1 involved a ranking task.

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Table 2 Relative risk perception question structure and mechanics

<table>
<thead>
<tr>
<th>Question risk operationalisation</th>
<th>Sample measure</th>
<th>Response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall harm</td>
<td>41</td>
<td>5-point Likert scale: strongly agree to strongly disagree</td>
</tr>
<tr>
<td>Perceived severity</td>
<td>4</td>
<td>… far higher for snus users, somewhat higher for snus users, more or less equal for snus users and smokers, somewhat higher for smokers, or far higher for smokers</td>
</tr>
<tr>
<td>Perceived susceptibility</td>
<td>15</td>
<td>5-point Likert scale: no reduction in risk to would they no longer be at risk</td>
</tr>
<tr>
<td>Perceived likelihood</td>
<td>1</td>
<td>… more likely, about as likely, or less likely</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question presentation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation via survey’s mode of administration</td>
<td>46</td>
<td>–</td>
</tr>
<tr>
<td>Inclusion of awareness prompt</td>
<td>9</td>
<td>No/Yes</td>
</tr>
<tr>
<td>Use of visual aid</td>
<td>2</td>
<td>Image of a pouch of snus</td>
</tr>
<tr>
<td>Question mechanics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>50</td>
<td>5-point Likert scale: strongly disagree to strongly agree</td>
</tr>
<tr>
<td>Indirect</td>
<td>7</td>
<td>2-point scale: not at all harmful (1) to extremely harmful (7) Differences between means for a) and b) were examined using t-tests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question stem (among direct measures, n=50)</th>
<th>Response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>… more harmful, equally harmful, or less harmful …</td>
</tr>
<tr>
<td>Closed</td>
<td>5-point Likert scale: strongly agree to strongly disagree</td>
</tr>
</tbody>
</table>

| Response options (among direct measures, n=50) |                |
| Continuous                                   | 36              | 5-point Likert scale ranging from strongly agree to strongly disagree |
| Categorical                                  | 9               | Yes, they are more harmful than tobacco cigarettes / Yes, they are as harmful as tobacco cigarettes / Yes, but they are less harmful than tobacco cigarettes ; No, they are absolutely not harmful |
| Mixed                                        | 5               |                |

| Response option tasks (among direct continuous measures, n=26) |                |
| Rating task                                   | Compared to cigarettes, do you think that SLT is … to a person’s health? |
| Ranking task                                  | Use 1, 2, 3 and 4 |

<table>
<thead>
<tr>
<th>Question stem (among direct measures, n=35)</th>
<th>Response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light cigarette vs. regular cigarettes</td>
<td>… a little more harmful, or a lot more harmful …</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Categorical</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td></td>
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</tbody>
</table>

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Effect of direct versus indirect measures on RRPCs

Figure 2A illustrates the proportion of respondents who correctly perceived SLT to be less harmful than CCs for studies using direct and indirect measures. The proportion of respondents who correctly perceived SLT to be less harmful than CCs ranged from 2% to 93% for direct measures, and from 41% to 59% for indirect measures. A study by Popova and Ling applied both a direct measure and an indirect measure within a representative sample of US smokers to assess RRPs of snus versus CCs. As depicted in figure 2B, using the direct measure, 22% of respondents reported that snus was less harmful than CCs, and the overall mean comparative harmfulness of snus was 0.02 (SD=1.16), which was not significantly different from 0 (t(1779)=0.691; p=0.5); however, using the indirect measure, 52% of respondents rated snus as less harmful than CCs, and the mean harmfulness of CCs and snus was 5.91 (SD=1.23) and 4.97 (SD=1.55), respectively, with a mean difference of 0.94 (SD=1.68), which was significantly different from 0 (t(1788)=23.690; p<0.001). Although the direct and indirect measures were correlated (r=0.31 (p<0.001)), the findings demonstrate that measurement methods can influence estimates of RRPs. Indeed, the parallel results found in the current review appear to further support this finding.

CONCLUSIONS

The results of this review indicate that accurate perceptions about the basic risk of nicotine products are rare. In most studies, respondents held variable, yet inaccurate, RRPs when comparing SLT to CCs, and ECs to NRT. In addition, in most studies, respondents did not know the relative harmlessness of SLT versus NRT. The findings relating to comparisons of ECs versus NRT and of SLT versus NRT should be interpreted with caution, given the limited number of samples examined. In contrast, in many studies, respondents correctly perceived NRT as less harmful than CCs, although these findings also require caution, given data limitations. Finally, the exception to this general pattern lies with the comparison of ECs and CCs, in which respondents in most studies correctly perceived ECs as the less harmful product.

The variability of RRPs across product comparisons is not surprising. First, not all individuals may be familiar with specific products. Second, individuals may lack the knowledge about these products’ health effects needed to judge their relative harmlessness. Indeed, research indicates that although some members of the public understand that smoking is ‘bad for you’, most cannot identify its health consequences. Third, individuals may have been misled by public health authorities, which have provided misinformation on the risks of SLT relative to CCs in the USA, where most of the reviewed population surveys were conducted. Evidence from qualitative research may help reveal the reasons underlying RRPs. Perceptions of relative risk also varied among key subpopulations, with smokers and users of non-combustible nicotine products more likely to correctly perceive the relative harmlessness of products compared to non-users. Although this finding may be explained by theories of selective exposure and perception, according to which users’ perceptions are coloured by their experiences of product use, the cross-sectional nature of most of the reviewed studies precludes an examination of the temporal relationship between user perceptions and behaviour. The finding that smokers more often held epidemiologically correct RRPs than did samples of the general population when comparing ECs with CCs may be due to targeted EC marketing strategies, and greater personal relevance of such information to smokers. However, smokers fared worse than the general population when asked to compare the relative harmlessness of NRT and CCs, with most smokers greatly overestimating the harmlessness of NRT. This finding may reflect an attempt to bolster positive perceptions of CCs as a means to alleviate cognitive dissonance, potentially extending the defensive behaviour exhibited by smokers with respect to justifications for their smoking to product perceptions. Alternatively, this may reflect the common misperception held by smokers that nicotine is the most harmful constituent of tobacco. Similarly, users of non-combustible nicotine products fared well with respect to the accuracy of their RRPs. This pattern held consistently for comparisons of each of SLT, ECs and NRT to CCs, which may reflect the formation of positive preferences for users’ own products, which carry less risk.

Comparisons of ECs and CCs are noteworthy, given that this was the only product comparison for which most respondents held RRPs that coincided with epidemiological data. This may be due to the rapid growth of the EC market, in which the public has been greatly exposed to the ‘disruptive innovation’ of ECs through the media. In addition, the fact that ECs do not contain tobacco distinguishes them from tobacco products, which may lend itself to more accurate RRPs. Furthermore, from the perspective of smokers, the greater appeal of ECs may give these products an advantage in overall receptivity over NRT. These distinct findings suggest that policymakers take particular note of these novel products and monitor them closely.

Evidence from longitudinal and experimental studies demonstrated the amenability of RRPs to change, highlighting their potential to serve as targets for health interventions and in health risk communication. Given the paucity of available evidence, researchers should consider employing intervention and experimental designs to further test the plasticity and potential use of RRPs in promoting health behaviour change. Borland et al and Callery et al suggest examining various types of educational interventions over time, such as product package inserts and point-of-sale displays. Irrespective of the communication mode, factors such as the length, relevance, readability and interpretation of the presented information by consumers, and any potential effects these may have on behaviour should also be examined. For instance, the delivery of relative risk information for NRT in a manner that is compelling to smokers may help correct their misperceptions, thereby assisting in cessation efforts.

Implications for policymakers

The findings of this review present several challenges for tobacco control policymakers. First, the high degree of contextual variability highlights the challenges of measuring RRPs across the nicotine spectrum. Although the FDA aims to assess RRPs among the public, particularly with respect to the introduction and postmarket surveillance of modified risk tobacco products, a ‘one size fits all’ approach seems unlikely to work. Second, the extent of inaccurate health beliefs regarding these products implies that significant efforts will be required to bring the public’s knowledge in line with objective evidence. For instance, although Swedish Match received approval for the sale of its snus products in the USA, an advisory panel to the FDA did not approve the company’s request for a reduced harm claim, in part because the company had not adequately tested whether consumers would understand or correctly interpret the proposed claim. Irrespective of the anticipated difficulty involved in constructing relative health-risk messages, public
health authorities must attempt to address this need. In the absence of evidence-based health-risk communication from such authorities, the public’s reliance on industry-sponsored marketing, media and anecdotal evidence,\(^1\) is likely to increase. Next, in addition to developing appropriate content, authorities need to ensure that the communication of health-risk information is designed and executed to maximise consumer understanding. Furthermore, policymakers should consider the appropriate threshold of prevalence of inaccurate health beliefs that would require regulatory action. Although a majority (>50%) threshold was used to describe RRPs in the current analysis, it is not clear whether this should be applied to the policy domain. For instance, from a population perspective, addressing inaccurate risk perceptions even at the level of 10% can be critically important, considering that in countries such as the USA, this amounts to many millions of individuals.\(^8\,9\)

Recommendations for researchers

Despite the challenges of measuring subjective RRPs, several practices can improve research methods. For instance, visual aids may improve the specificity of relative risk tasks, particularly for novel products. Next, it is not always clear what respondents mean when they indicate that a product is ‘less harmful’ than another.\(^10\) To reduce this ambiguity, researchers should construct their measures so as to suit their study population. For instance, questions that embody distinctions between product dose, duration and mode of use tend to be better suited to populations of product users.\(^9\) Overall, measures should be tested to ensure that they are familiar and relevant to, as well as understood by, study respondents.\(^9\)

Several technical dimensions of measures of risk should be noted. First, RRP measures should use response options with verbal qualitative comparisons (eg, ranging from ‘no risk’ to ‘great risk’), rather than numerical scales (eg, ranging from 0% to 100%), given the difficulty lay people experience in understanding and using numerical estimates of risk.\(^7\,8\) Second, indirect measures may help reduce social desirability bias, particularly in contexts where the ‘no safe tobacco product’ message resounds. Third, research regarding the validity of direct and indirect measures is also warranted. Fourth, measures should be constructed with open question stems, for example, ‘Do you think e-cigarettes are … more harmful/equally harmful/less harmful … than regular cigarettes to health?’ as these allow researchers to clearly delineate all potential RRPs. In contrast, measures employing closed question stems, for example, ‘Please indicate your level of agreement with the following statement: SLT is less harmful than cigarettes. 5-point Likert scale: strongly agree to strongly disagree’, result in ambiguities, as researchers are unable to ascertain what respondents perceive when they indicate that they disagree with a proposed statement. Furthermore, such measures may be more susceptible to acquiescence bias. Fifth, measures with continuous (rather than categorical) response options are likely to reflect RRPs more appropriately, given that these attitudinal constructs lend themselves to measurement along a scale.\(^2\) Next, both rating and ranking tasks can be employed to measure RRPs: while rating tasks focus attention on one or two products, ranking tasks encourage participants to consider the full product spectrum, while also reducing social desirability bias.\(^2\) Finally, although researchers may be interested in a particular RRP between products, it is recommended that they measure and report on the full range of RRPs so that these may be available in

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**Figure 2** Comparison of relative risk perceptions of SLT versus CCs using direct and indirect measures in the current review (A) and in Popova & Ling (B).\(^5\)\(^1\) (A) Proportion of respondents by study sample who perceived SLT as less harmful than CCs using direct measures (n\_SAMPLE=74; n\_STUDY=25)* and indirect measures (n\_SAMPLE=4; n\_STUDY=4)*. *Samples included in this analysis were those for which quantitative comparable findings were reported. Samples from the following studies were excluded due to use of an incompatible direct measure,\(^4\) and incompatible indirect measures.\(^4\)\(^1\) (B) Proportion of respondents perceiving snus as less harmful, equally harmful or more harmful than CCs in Popova and Ling.\(^5\)\(^1\) CCs, combustible cigarettes; SLT, smokeless tobacco.

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\(^7\) Czoli CD, \textit{et al.} \textit{Tob Control} 2016;0:1–10. doi:10.1136/tobaccocontrol-2016-053060
the literature. By reducing the ambiguity of findings, such practices will improve the understanding of RRRs as well as the capacity to intervene and correct misperceptions.

Strengths and limitations of this review

To the best of our knowledge this review is the first to summarise empirical data on perceptions of relative risk across the non-combustible nicotine spectrum, although it has several limitations. First, given the heterogeneity of studies with respect to quality, populations, policy contexts and measures included in this review, readers should interpret the findings with care: although the findings provide a summary of RRRs across products, additional research is needed to examine these factors’ influence in greater detail. In addition, due to the fact that the descriptive analyses conducted here depend in part on the epidemiological evidence base of the risks of non-combustible nicotine products, the findings are relative to this evidence base and the product market at this point in time, and may change as these elements evolve.

In summary, perceptions of relative risk of non-combustible nicotine products are highly variable and specific to particular products and subpopulations. Overall, in most studies, respondents’ RRRs of non-combustible nicotine products do not accurately reflect the products’ underlying objective differences in risk, presenting several challenges for policymakers. In addition, researchers ought to be aware of the differences in question mechanics and the effects these may have on the risk, presenting several challenges for policymakers. In addition, reviewing readers should interpret the findings in order to ensure accurate monitoring. The central role played by perceptions of relative risk in health behaviour implies that the challenges surrounding the measurement, communication and intervention on these perceptions must be met in order to shift tobacco users away from the deadliest nicotine-delivery device to less harmful forms, in addition to assisting cessation efforts. Public health policy that addresses these challenges will better reflect the complexity of the nicotine market and better address the substantial risks of combusted tobacco.

What this paper adds

Consumer perceptions of relative risk of non-combustible nicotine products play an important role in influencing how existing and emerging products are used and by whom. This systematic review found that:

- Perceptions of relative risk of non-combustible nicotine products are highly variable and specific to particular products and subpopulations;
- Accurate perceptions of the relative risks of non-combustible nicotine products are rare, although respondents in most studies correctly perceived e-cigarettes as less harmful than cigarettes;
- Cigarette smokers and users of non-combustible nicotine products tend to correctly perceive the relative harmfulness of products more often than non-users.

Researchers and policymakers must address the challenges of measuring and communicating relative health risk information across the nicotine spectrum in order to better reflect the complexity of the current nicotine market and better address the substantial risks of combusted tobacco.

Czoli CD, et al. Tob Control 2016;0:1–10. doi:10.1136/tobaccocontrol-2016-053060

Contributors

CDC and DH conceptualised the study objectives and analytic approach. CDC conducted the literature review, analysed the data and drafted the manuscript. GTF, DM and DH provided substantial contributions to the writing and finalising of the manuscript. All approved the final version.

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None declared.

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