**Does the content and source credibility of health and risk messages related to nicotine vaping products have an impact on harm perception and behavioural intentions? A systematic review**

Daniel A Erku1, 2, 3, Linda Bauld4, Lynne Dawkins5, Coral E Gartner6, 7, Kathryn J Steadman3, Seth M Noar8, Shakti Shrestha3 and Kylie Morphett6

1Centre for Applied Health Economics, Griffith University, Nathan, QLD, Australia

2Menzies Health Institute Queensland, Griffith University, Gold Coast, QLD, Australia

3School of Pharmacy, The University of Queensland, 20 Cornwall Street, Woolloongabba 4102, QLD, Australia

4Usher Institute and SPECTRUM Consortium, College of Medicine and Veterinary Medicine, University of Edinburgh, Teviot Place, Edinburgh EH8 9AG Edinburgh, Scotland

5Centre for Addictive Behaviours Research, School of Applied Sciences, London South Bank University, 103 Borough Road, London

6School of Public Health, The University of Queensland, Herston Road, Herston 4006, QLD, Australia

7Queensland Alliance for Environmental Health Sciences, The University of Queensland, 20 Cornwall Street, Woolloongabba 4102, QLD, Australia

8Hussman School of Journalism and Media, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-3365.

**Running head:** Communicating health risks of nicotine vaping products

**Word count:** 4,300

**Competing interest:** LD has provided consultancy for the pharmaceutical industry relating to the development of smoking cessation products. All other authors declare that there is no actual or potential conflict of interest.

**Abstract**

**Aims:** To systematically review the literature on (1) whether and how various risk messages about nicotine vaping products (NVPs) alter harm perception and behavioural intentions of smokers and non-smokers and (2) how trust in sources of NVP risk communication affects message reception and behavioural intentions.

**Methods**: Seven electronic databases and reference lists of relevant articles were searched for articles published up to April 2020. Experimental and quasi-experimental studies on message effects and cross-sectional studies on source credibility were included. The Newcastle-Ottawa Scale and the Evidence Project Risk of Bias Tool were employed to assess the quality of observational and intervention studies, respectively. For each outcome variable, we indicated whether there was an effect (as a ‘yes or ‘no’) and employed effect direction plots to display information on the direction of effects.

**Results:** Nicotine addiction messages resulted in greater health and addiction risk perceptions, relative risk messages comparing the health risks of NVPs to cigarette smoking increased the perception that NVPs are less harmful than combustible cigarettes, and a nicotine fact sheet corrected misperceptions of nicotine and NVPs. Smokers’ intention to purchase, try or switch to NVPs was higher when exposed to a relative risk message and lower when exposed to nicotine addiction warnings. Trust in NVP risk information from public health agencies was associated with lower odds of: i) NVP use and ii) perceiving NVPs as less harmful, whereas those who trusted information from NVP companies were more likely to perceive NVPs as less harmful than combustible cigarettes.

**Conclusions:** Relative risk messages may help improve the accuracy of harm perceptions of nicotine vaping products and increase smokers’ intentions to quit smoking and/or to switch to vaping, although the literature is nascent.

**Introduction**

Tobacco use remains a leading cause of preventable death and disease globally.1 While nicotine is the highly addictive substance found in tobacco,2 its role in causing smoking-related diseases such as cancer and respiratory diseases is minimal. Rather, most of these smoking-related diseases are the consequence of exposure to harmful constituents in tobacco smoke. Even where nicotine has been suggested to play a role in adverse health effects (e.g. cardiovascular events), the risk of using nicotine replacement therapy is much less than that of continuing to smoke.3 The relative safety of tobacco and nicotine products can thus be put in the context of a continuum of risk based on product constituents and mode of nicotine delivery. Combustible tobacco products are the most dangerous nicotine delivery systems as the smoke contains thousands of harmful and potentially harmful chemicals. On the other hand, licenced nicotine replacement therapies (NRTs) are the least harmful, and their safety and efficacy has been extensively investigated.4 All other nicotine containing products including smokeless tobacco and nicotine vaping products (NVPs) fall between combustible cigarettes and NRTs on the continuum of risk.5,6

Consumer knowledge and perceived risk of various tobacco and nicotine products can play a fundamental role in motivating smokers to quit and reducing smoking uptake. Absolute risk messages provide information about the risks of NVPs independently of other products.7 For example, one study compared NVP warning labels that contained text-only warnings about health effects or potential for addiction, versus those with a pictorial representation of the risk (e.g. ‘E-cigarettes contain harmful chemicals’) and found that pictorial labels about health effects resulted in greater intention to quit vaping amongst participants who used NVPs.8 A number of studies have reported that a considerable proportion of smokers and the public lack knowledge about the relative safety of NVPs compared with cigarettes,or believe NVPs are equally as harmful as combustible cigarettes.9-11 Similar misperceptions have been reported for nicotine in general, with a belief that nicotine is responsible for most smoking-related morbidity and mortality.12 A number of authoritative evidence reviews13-15 now strongly point to NVPs potentially playing an important a role in reducing the harm from tobacco use by reducing exposure to toxicants. However, NVP use could also result in net public health loss if smokers engage in dual use and it deters them from quitting smoking completely, if non-smoking youths engage in persistent long-term use, or if it results in initiation of smoking among non-users or relapse in former smokers.15 Thus, there is an urgent need for optimal messaging about NVPs to discourage access to and uptake by youth and non-smokers, while encouraging smokers who are unable or unwilling to quit smoking to switch to NVPs.

There is substantial evidence demonstrating how health risk communication (e.g., health warnings, communication campaigns) reduces tobacco use by influencing knowledge, beliefs, and behaviour.16-18 For instance, warning labels that describe the harmful effects of tobacco products using text and/or pictures are important health communication tools to increase knowledge about the dangers of smoking. They are also effective in reducing smokers’ desire for cigarettes, promoting smoking cessation, preventing relapse in former smokers,19 and discouraging people from initiating smoking.20-22 Risk communication is complicated by the need to discourage uptake amongst some populations (non-smokers, young people), while providing accurate information about risk reduction in other populations (current smokers). While the existing literature on methods of communicating about combustible cigarette risks is broad, data regarding health risk communication for non-combustible tobacco products is still emerging. Ross et al.(2017)23 conducted a systematic review of health communication for non-cigarette tobacco products (last search in May 2016) and concluded that more research is needed in this area, particularly for novel nicotine delivery products such as NVPs. A number of studies have since been published that have explored the impact of various health warnings (with diverse design features, content, and delivery modes), or public education for NVPs on user’s perceived harm and intention to use and/or switch to NVPs.24-28

In addition to the message content and design features, the credibility or trustworthiness of the message source affects message reception, thereby influencing attitudes and behavioural intentions.29 This is particularly important with new or evolving products such as NVPs, for which consumers lack adequate knowledge and/or experience to assess the risks, and thus may be more reliant upon the risk assessments of health agencies and experts in the field than for other more familiar products.

The aim of this systematic review is to comprehensively examine whether and how various risk messages about NVPs alter harm perceptions and behavioural intentions of smokers and non-smokers. We also examined how trust in sources of NVP risk communication affects message reception and behavioural intentions. Identifying what NVP health communication strategies are effective (and ineffective) is vital to inform policies, highlight gaps in the current literature, and guide future research.

**Methods**

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline30 and the study protocol was registered with PROSPERO (CRD42020166645).

**Data sources and search strategy**

We searched seven electronic databases (PsycINFO, PubMed, EMBASE, Web of Science, Communication & Mass Media Complete, CINAHL, and Google scholar) for studies that assessed content, format, and source of NVP-related message (such as warning labels, absolute and relative risk messages) in relation to harm perception and behavioural intentions. This was followed by complementary searches including forward and backward citation searches of included articles, and Google searches to further locate eligible articles that were not identified in the database searches. The keywords used in the search strategy were built on three key concepts (risk communication, perception, and nicotine products), and tailored to each database (Table 1). Boolean operators and truncations varied depending on the database. The search included articles published in English language from 2003 (to cover the literature from when NVPs first entered the market) to the 23rd of April, 2020.

**[Table 1]**

**Eligibility screening**

Studies were included if they were: 1) randomized controlled trials, experimental or quasi-experimental (pre-post) studies that tested health messages regarding NVPs (e.g. health warnings, absolute and relative risk messages) and included harm perception and/or behavioural intentions as an outcome, or 2) quantitative studies that evaluated the level of trust in sources of risk messages about NVPs. We excluded: 1) quasi-experimental studies that showed participants NVP-related health messages without a control condition, and 2) observational studies that asked people to report on NVP-related health messages they had been exposed to outside of a research environment. Conference or dissertation abstracts without the full text available for retrieval (after contacting authors) were also excluded. The articles identified were then exported to COVIDENCE (Veritas Health Innovation Ltd), and two independent reviewers screened all titles, abstracts and full texts based on the eligibility criteria. Any discrepancies or disagreements between reviewers were resolved through discussion to reach consensus. The detailed search strategy and eligibility screening is presented in Figure 1.

**Quality appraisal**

Quality appraisal tools were employed for this review to interpret the findings in light of the quality of the included articles, rather than as an inclusion criteria. We employed the Newcastle–Ottawa Scale for observational studies,31 and the Evidence Project Risk of Bias Tool32 to assess study rigor for both observational and intervention studies. The latter tool, developed by a collaboration between researchers from the Medical University of South Carolina and the Johns Hopkins Bloomberg School of Public Health,32 consists of eight items (scored as ‘Yes’, ‘No’ or ‘Not Applicable’): three items regarding the study design (presence of cohort, control or comparison group, and pre-post intervention data), and the remaining six items consider the study rigor (random assignment of participants to the intervention, random selection of participants for assessment, follow-up rate of 80% or more, comparison groups equivalent on sociodemographic variables, and comparison groups equivalent at baseline on outcome measures).

**[Figure 1]**

**Data extraction and synthesis**

Two reviewers independently extracted detailed information about the study characteristics (such as publication details, country, study design, sample size, risk of bias etc.) and key study findings from each included study using a standardized abstraction form, which was developed a priori. A third reviewer resolved any disagreements.

Key findings were extracted and grouped into subcategories according to the Message Impact Framework (MIF). The framework describes factors contributing to health message effectiveness16,33, and draws on communication and psychological theory and prior research on tobacco prevention and control. The framework includes six main categories: (1) attention or recall, (2) warning reactions (i.e., credibility, cognitive elaboration or processing messages by thinking critically, emotional responses, and believability), (3) social interactions (e.g., talking to others about the message), (4) knowledge, attitudes and beliefs, 5) behavioural intentions (i.e., intentions to purchase or use NVPs, to quit smoking or switch to NVPs etc.), and (6) behaviour (e.g., NVP use). In addition, perceived message effectiveness was also examined. Definitions of all outcome variables are summarised in Table 2.

Meta-analysis was not feasible because of study heterogeneity in terms of study design, message manipulations, and outcome measurement. Rather, we narratively synthesised and reported the findings according to the Synthesis Without Meta-analysis (SWiM) reporting guideline (see supplementary file 1). We employed vote counting based on direction of effect as a standardised metric to synthesise and compare the number of effects showing benefit (i.e. intended outcome) to the number of effects showing harm (i.e. unintended outcome) for a particular outcome measure. This method of synthesis was deemed appropriate as there was no consistent effect measure or data reported across included studies. For each outcome measure, a standardized binary metric (categorized as showing benefit or harm based on the observed direction of effect) was created, which were then compared and narratively summarised. Examples of ‘benefit’ of intervention (i.e. NVP-related health message) include increased intention among smokers to quit smoking or switch to NVPs, and increased perceptions that NVPs are less harmful than cigarettes. Examples of ‘harm’ or unintended outcome of NVP-related health message include engaging or increased intentions to engage in dual use (both combustible cigarettes and NVPs) or to purchase NVPs among non-smokers.

**[Table 2]**

**Results**

**Study characteristics**

After removal of duplicates and publications that did not meet the inclusion criteria, a total of 31 articles were included7,8,24-28,34-57 (Table 3) reporting results from studies involving a total of 52,425 participants (ranging from 95 to 16,051). Twenty six of the included studies were experiments and the remaining were cross-sectional surveys. The studies were conducted between 2014 and 2020 and were either from the United States of America (88%) or the United Kingdom (12%). Participants in seven studies were young adults, and two studies either focused only on or reported only results for adolescents. Most studies reported on current cigarette (n=23) and NVP use status (n=17).

**[Table 3]**

The risk of bias of the 26 studies with an experimental design was assessed using the Evidence Project Risk of Bias Tool. All experimental studies had a control or comparison group, and seven studies included complete pre- and post-intervention data.26,36,39,40,44,47,54 While the majority of the studies (n=23) randomly assigned participants to an intervention, only five studies36,39,44,47,54 had a follow-up rate of more than 80%. All cross-sectional studies included had an overall quality of either average (score 5 out of 9)42 or above average (score ≥7 out of 9)35,48,50,57, according to the Newcastle-Ottawa scale. Details of the risk of bias assessment for included studies are presented in Supplementary file 2.

**Study findings**

Key findings and outcome variables organised using the MIF (Figure 2) are summarised below. Where possible and relevant, we report details for samples stratified by various sociodemographic characteristics. For each outcome variable, we indicated (as ‘yes’ or ‘no’) whether there was an effect and employed effect direction plots to display information on the direction of effects. Supplementary file 3 summarises the direction of effects from experimental studies.

**[Figure 2]**

**Type of message content**

Findings from studies testing the effects of NVP health and risk messages were categorised by message content, with many studies reporting findings on multiple types of message content. The messages were categorised as: health effects (e.g. ‘E-cigarette aerosol may contain chemicals that are harmful to the lungs and are known to cause cancer’)8, addiction (e.g. ‘This product contains nicotine which is a highly addictive substance’)38, relative risk (e.g. ‘No tobacco product is safe, but this product presents substantially lower risks to health than cigarettes’)25, chemical constituents including nicotine (e.g. ‘Among other things, e-cigarettes contain nicotine, which is an addictive chemical’), and scientific uncertainty (e.g. ‘Not enough scientific evidence exists to say for sure how using electronic vaping products could affect your health in the short or long term’).50

**Attention and recall**

Four studies assessed attention and recall of the health warnings.7,8,41,47 A study conducted to examine the impact of varying NVP warning types (text warnings about nicotine addiction, health risks of use, or both health hazards and harms of use vs pictorial warnings)7 reported higher attention attraction for both text and pictorial warnings compared to control text about littering.7 With respect to varying label design features, participants reported greater attention and recall and lower perceived addictiveness when they viewed warning labels regarding nicotine addiction on red vs white backgrounds.41 Relative risk warnings resulted in lower message recall compared to standard warnings (‘absence of relative harm warning’).8 A study exploring the impact of a public education campaign about relative safety of NVPs (messages included ‘NVPs do not contain tobacco’ and ‘vaping is far less harmful than smoking’) reported that the awareness campaign was recognised by over a third of participants in a post-campaign evaluation.47

**Perceived message effectiveness and message reactions**

Comparative risk messages that emphasised the benefits of NVPs over cigarettes evoked less negative and more positive emotions, and were rated as more novel and effective in motivating switching from smoking to vaping53,55 compared with relative risk messages that highlighted the harms of continued smoking. However, both message types resulted in low message reactance.53 Both text and pictorial warnings emphasising nicotine addiction or health hazards of NVP use led to more negative affective reactions, such as fear, guilt, disgust, anxiety and sadness, and elicited greater anticipated message avoidance and message reactance compared with control text about littering.7 Pictorial warnings led to higher scores than text warnings in all of the above variables. Text warnings that stressed the health hazards of NVP use led to higher perceived message effectiveness, attention, anticipated social interactions, cognitive elaboration, and elicited more message reactance compared with the nicotine addiction text warnings.7

One study8 reported thathealth warnings with the included comparative health message (‘NVPs may cause harm to health but are less harmful than cigarettes’) were perceived as less believable and credible in informing people about NVP health risks compared with a warning without the relative health statement. Exposure to both ingredient-themed (‘[NVPs] contain at least 10 toxic substances including lead and formaldehyde’)and tobacco industry-themed (‘Some [NVPs] are made by tobacco companies that have been convicted of fraud and racketeering’) warning statements were also associated with lower NVP cravings and susceptibility among current NVP users and smokers who experienced any craving.46

**Attitudes and beliefs**

One study53 tested two types of comparative risk messages, one emphasising the benefits of NVPs compared with cigarettes (CR messages) and the other emphasising the harms of continued smoking while presenting NVPs as a safer alternative (‘CR-tobacco harm’ messages). While both CR and ‘CR-tobacco harm’ messages increased perceptions that NVPs are less harmful than cigarettes compared with control, CR messages reduced self-exempting beliefs and perceived risks of NVPs while ‘CR-tobacco harm’ messages led to greater self-efficacy to quit smoking.53 When combined with a nicotine fact sheet, CR messages produced higher levels of response efficacy and produced higher odds of people disagreeing with the false statement that nicotine is the main cause of smoking-related health problems compared to the other CR messages.55 A nicotine fact sheet alone also corrected misperceptions of nicotine and NVPs compared with control or no message conditions.49,52

A small number of studies reported that the inclusion of graphic warning labels7,44 or combining graphic health warning and text warnings24 in NVP advertisements lowered positive attitudes towards NVPs*.* Viewing messages about scientific uncertainty surrounding NVPs in the form of a brief fact sheet about NVPs and additional text explaining the inconclusive body of literature resulted in lower ratings of perceived risk than viewing just the brief fact sheet about NVPs.43 Two studies25,38 demonstrated the effects of NVP warning variations (addiction warning vs relative risk message) on risk perceptions. In both studies, nicotine addiction warnings (‘This product contains nicotine which is a highly addictive substance. It is not recommended for non-smokers’) resulted in greater health and addiction risk perceptions whereas the relative risk messages (‘Use of this [NVP] product is much less harmful than smoking’)increased the perception that NVPs are less harmful than combustible cigarettes.25,38 Moreover, respondents who saw an addiction warning7 or tobacco industry-themed warning46 reported greater health-risk beliefs, but also rated NVPs as less addictive.

Predictably, smokers perceived combustible cigarettes to be more harmful than NVPs when told that the amount of chemicals in cigarettes was higher than in NVPs.28 Non-smokers aged 30 or older who were exposed to a relative risk health message estimated NVP harm to be significantly lower compared to a message about exercise, diet and sleep.27

**Behavioural intentions**

Several studies assessed behavioural intentions including intentions to use/purchase NVPs (n=10), quit smoking (n=3), switch to NVPs (n=3) or engage in dual use (n=4). Smoker intention to purchase NVPs was lower when exposed to nicotine addiction warning statements [including those produced by Tobacco Products Directive (TPD)36or US Food and Drug Administration (FDA)39], but increased when exposed to a relative risk message.38 Another study reported that participants exposed to text-based nicotine addiction warning messages alone reported significantly greater perceived risk and addictiveness of NVPs than an advertisement only and advertisements with nicotine addiction warning messages.40 The remaining studies8,27,41,43,45,49 found no association between message type and intention to purchase (or try) NVPs.

A study exploring the impact of a public education campaign about relative safety of NVPs reported that the intervention was associated with an increase in smoker motivation to quit.47 Two studies found no association between message exposure (a targeted message stratified by smoker group51 and a nicotine education message49) and smoker intention to quit smoking. Exposure to relative risk messages (compared to control conditions such as a bottled water advert) was associated with higher intentions among smokers to switch from smoking to vaping.53,55 One study found no association of nicotine education messages with intentions to switch from smoking to vaping.49 There was no association between dual use intentions and relative risk message conditions or nicotine fact sheet messages,53-55 but perception about the presence of more chemicals in cigarettes (and thus greater harm) compared with NVPs was associated with increased intentions towards dual use NVPs and cigarettes.28

**Sources of NVP related health information and impact on risk perceptions**

Five cross-sectional surveys, all from the USA, assessed the levels of trust that consumers place in various information sources (such as public health agencies, the news media, and the tobacco and/or NVP industry) regarding NVPs and how trust was associated with risk perceptions and behavioural intentions. Respondents rated healthcare professionals (such as doctors, pharmacists) and government health agencies as the mosttrusted sources, whereasnews media and entities with a commercial interest in NVPs (such as the NVP and tobacco industry, vape shop employees) were rated as less credible sources.35,42,50 However, those who had used NVPs reported significantly lower trust in public health agencies and higher trust in the NVP industry compared to never users,35 and these groups are more likely to be from racial/ethnic minority, low income, or low education groups.48,50 Trust in health information from public health agencies35 and religious organizations57 were associated with lower odds of: i) NVP use, and ii) perceiving NVPs as less harmful, whereas those who trusted information from NVP companies were more likely to perceive NVPs as less harmful than combustible cigarettes.35,48,57

**Discussion**

**Principal findings**

In this study, we systematically collected and synthesized published research on the association between various risk messages about NVPs, and credibility of sources of risk communication, with harm perception and behavioural intentions among smokers and non-smokers. According to the findings, nicotine addiction messages were associated with greater health and addiction risk perceptions, and relative risk messages were associated with increased perception that NVPs are less harmful than combustible cigarettes. In addition, a nicotine fact sheet (with or without relative risk messages) corrected misperceptions of nicotine and NVPs compared with control conditions. Exposure to relative risk messages were associated with higher intention to purchase (or try) NVPs, and/or to switch from smoking to vaping compared with a nicotine addiction warning (including those produced by TPDor FDA) or other message conditions. Trust in NVP risk information from public health agencies and religious organizations were associated with lower odds of both NVP use and perceiving NVPs as less harmful, whereas those who trusted information from NVP companies were more likely to perceive NVPs as less harmful than combustible cigarettes.

There is a general consensus among public health experts and policymakers that more research into effective and accurate ways of communicating relative risks of NVPs compared with combustible cigarettes is needed.9,58 Governments in many countries are mandating nicotine addiction warnings on NVP packaging as a starting point for informing consumers about the potential risks of NVPs. Our findings suggest that although health warnings, such as those mandated by the US Food and Drug Administration and the European Union TPD, resulted in greater health and addiction risk perceptions, they also resulted in inadvertently deterring smoker intention to switch to vaping. Conversely, evidence from the few studies that have examined the impact of relative risk messages found that such messages increase the perception that NVPs are less harmful than combustible cigarettes, and increased smoker intention to switch from smoking to vaping. While addiction warnings are likely to increase misperceptions around NVP relative risk and decrease intentions to switch, ‘low risk’ messages could also have an unintended consequence of encouraging non-smokers to use NVPs. Therefore, embedding relative risk messages in standard warnings (e.g. nicotine addiction warnings) could be a sensible risk communication strategy. It is interesting to note that although inclusion of relative risk messages in warnings labels were not perceived as being less understandable than warnings labels without relative risk messages, and were not associated with higher NVP use intentions among non-smokers, they appeared to reduce recall of the message, and were perceived as less believable and credible compared with warning labels alone. This can be partially explained by the fact that: 1) shorter messages (such as those in warning labels) are easier to remember than relative risk messages presented within warning labels;59 and 2) participants may be familiar with the content of standard warning labels (e.g. nicotine addition, harms of smoking), and thus process messages based on pre-existing beliefs.

Amid the ongoing debate surrounding NVPs, public trust in individuals and organizations responsible for public education and risk communication is paramount to ensuring that the public has evidence-based information to make informed judgments. Early findings suggest that racial/ethnic minority, low income, or low education groups are more trusting of NVP companies, and that this trust is associated with increased NVP use among non-users of NVPs, including young people. The content of future public education efforts regarding NVPs should take the target audience into consideration when preparing campaign materials. The positive impact of relative risk communications can also be greatly improved by accompanying messages with quantifiable evidence, and attributing the message to a credible public health organisation.29

**Gaps and future directions**

This review identified several areas for future research. Firstly, NVP-related health messages should inform non-smokers about risks and discourage NVP use, while at the same time encouraging current and former smokers to switch to NVPs for harm reduction. Only a few studies included in our review have reported data on the unintended consequences of health messages on specific populations. Thus, evaluations of any NVP risk communications (both anti- and pro-NVP messages) need to explore whether these health messages result in unintended consequences (e.g. increased uptake of combustible cigarettes, engaging in long term dual use, enticing young people to take up vaping), and how different populations might be affected differently by these messages (e.g. youth vs. adult smokers). Future research should also explore the most appropriate design features for relative risk messages (e.g. wording, size, colour, location, formatting, and use of images) and the most effective way of embedding NVP warnings (such as nicotine addiction warnings) in order to maximize potential public health benefits while minimizing unintended consequences.

Second, the majority of studies included in this review have primarily examined how variations in the warning message content affect consumer beliefs and behavioural intentions. However, variations to the design of NVP warnings (e.g., size and background colour) can also play a vital role in affecting how consumers respond to the messages. This is partially supported by early findings from one study41 that consumers are more likely to report visually attending to NVP warning labels on red versus white backgrounds. The optimal combination of label design features, however, remains to be developed and examined.

Third, the negative correlation between trust in healthcare professionals and perceiving that NVPs are as harmful as combustible cigarettes highlights the need for training and educational support for healthcare professionals, enabling them to provide consistent and accurate messaging regarding NVPs. Fourth, as all studies come from either the USA or the UK, and there is a need for evidence from other countries with different regulatory landscapes as awareness of and perceptions about the relative harmfulness of NVPs is likely to be influenced by how a country regulates the sale and supply of NVPs. Findings from the International Tobacco Control Policy Evaluation (ITC) survey showed that: 1) awareness and use of NVPs are greater in countries with liberal approaches to the use and marketing of NVPs, such as the UK60, and 2) the perception that NVPs are less harmful than combustible cigarettes was considerably higher in the UK than in Australia, reflecting the UK’s less restrictive regulatory environment for NVPs.61 Furthermore, all of the studies on source credibility were conducted in the USA where public health agencies including the FDA have generally focussed on the potential risks of NVPs in their communications, whereas public health agencies in countries such as the UK (e.g. Public Health England) framed NVPs in a gain rather than loss context. Thus, the findings regarding source credibility might have been confounded by the content of the messages that are provided by the corresponding source. In general, there is a need for more studies on how health messages and source credibility impact tobacco and NVP use intentions, and long-term behaviour adjustments such as quitting smoking, switching to NVPs or engaging in dual use, for different populations.

**Strength and limitations**

Although we have employed rigorous and standard approaches to summarise and present empirical data on NVP risk communication from the published literature, our review is not without limitations. First, the heterogeneity of included studies, and variations between study designs and outcome measures precluded us from conducting random effects meta-analysis. Although the same outcome measures were used by some of the studies, the study population, control group and/or intervention were too diverse to yield a meaningful summary estimate of message effects. Rather, we employed a narrative synthesis using direction of effect and vote counting as the standardised metric. We reported the findings according to the Synthesis Without Meta-analysis (SWiM) reporting guideline (see Supplementary file 1).62 However, as such methods only address the question “is there any evidence of an [intervention] effect?”, not “what is the average intervention effect?”, the findings should be regarded as signifying associations rather than a cause-effect relationship. Second, the exclusion of grey literature and the potential for publication (or reporting) bias in NVP research and the tobacco control area in general (e.g. possibility of bias introduced by failing to disclose conflicts of interest) may limit the generalisability of the findings. Third, although the content validity and inter-rater reliability of the Newcastle-Ottawa Scale has been established31, its validity has been questioned in the literature.63 However, given the lack of a single obvious tool for this purpose and because we found high agreement between reviewers in our appraisal, we are confident that the use of this tool in our evidence-based review is an acceptable and reliable method. The tool has also recently been applied successfully in other systematic reviews in this field64, and it is simple and easy to use. Due to NVPs being a relatively new product, the area of research around NVP risk communication is still emerging. Findings from this review should, therefore, be interpreted in light of the current evidence base and be regarded as a snapshot in time, and it will be worthwhile to update this review as more studies are published.

**Conclusions**

Our findings suggest that relative risk messages may help increase the accuracy of relative harm perceptions of NVPs compared with combustible cigarettes, and increase smoker intention to switch to vaping. However, when combined with standard warnings about nicotine addiction, they are associated with lower message recall, and are more likely to be perceived as less believable and credible in informing people about relative health risks. Future research examining the effects of NVP health messaging should explore the most effective way of pairing relative risk messages with standard warning labels in order to maximize potential public health benefits while minimizing unintended consequences. Future studies should also include multiple follow-up assessments, utilise validated and standardised tools for measuring risk perceptions, and monitor the type and frequency of nicotine product use. Generally, our review demonstrates a need for more experimental and longitudinal studies with larger and diverse samples in order to better understand what works most effectively in communicating NVP product risk to consumers and the public.

**Funding**

DAE was supported by University of Queensland (UQ) Research and Training Scholarship. No other financial support was gained to conduct this study.

**Author contributions:**

**Daniel Erku:** Conceptualization; Data curation; Formal analysis; Methodology; Roles/Writing - original draft; Writing - review & editing; **Linda Bauld:** Conceptualization; Data curation; Methodology; Project administration; Writing - review & editing; **Lynne Dawkins:** Conceptualization; Data curation; Methodology; Writing - review & editing; **Seth Noar:** Conceptualization; Methodology; Formal analysis; Writing - review & editing; **Shakti Shrestha:** Conceptualization; Methodology; Writing - review & editing; **Kylie Morphett:** Conceptualization; Data curation; Methodology; Supervision; Writing - review & editing; **Coral Gartner:** Conceptualization; Methodology; Supervision; Writing - review & editing; **and Kathryn Steadman:** Conceptualization; Data curation; Methodology; Supervision; Writing - review & editing.

**Legends**

**Table 1.** Key words

**Table 2.** Definitions of outcome variables according to the Message Impact Framework (MIF).

**Table 3.** Characteristics of included studies (n=31)

**Figure 1.** Preferred reporting items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram

**Figure 2.** Message Impact Framework (MIF) summary of outcome variables

**Table 1.** Key words employed in the search strategy

|  |  |
| --- | --- |
| **Topic** | **Keywords** |
| Risk communication | (‘risk’ OR ‘harm’ OR ‘harmful’ OR ‘healthier’ OR ‘safer’ OR ‘risk assessment’ OR ‘relative risk’ OR ‘communication’ OR ‘warning’ OR ‘campaign’ OR ‘media’ OR ‘health’ OR ‘message’); AND |
| Perception | (‘belief’ OR ‘attitude’ OR ‘perception’ OR ‘misperception’ OR ‘perceived’ OR ‘behavioural intentions’ OR ‘behavio\*’), AND |
| Nicotine products | (‘Electronic Nicotine Delivery System\*’ OR ‘Electronic Nicotine Delivery Devices’ OR ‘electronic vaping product\*’ OR ‘electronic cigarette\*’ OR ‘e- cig\*’ OR ‘vaping’ OR ‘tobacco’ OR ‘tobacco product\*’ OR ‘cigar\*’ OR ‘smoking product’ OR ‘nicotine’ OR ‘smok\*’). OR |
| Source credibility | (‘trust’, ‘trustworthiness’, ‘credibility’, and ‘source credibility’) |

**Table 2.** Definitions of outcome variables according to the Message Impact Framework (MIF).

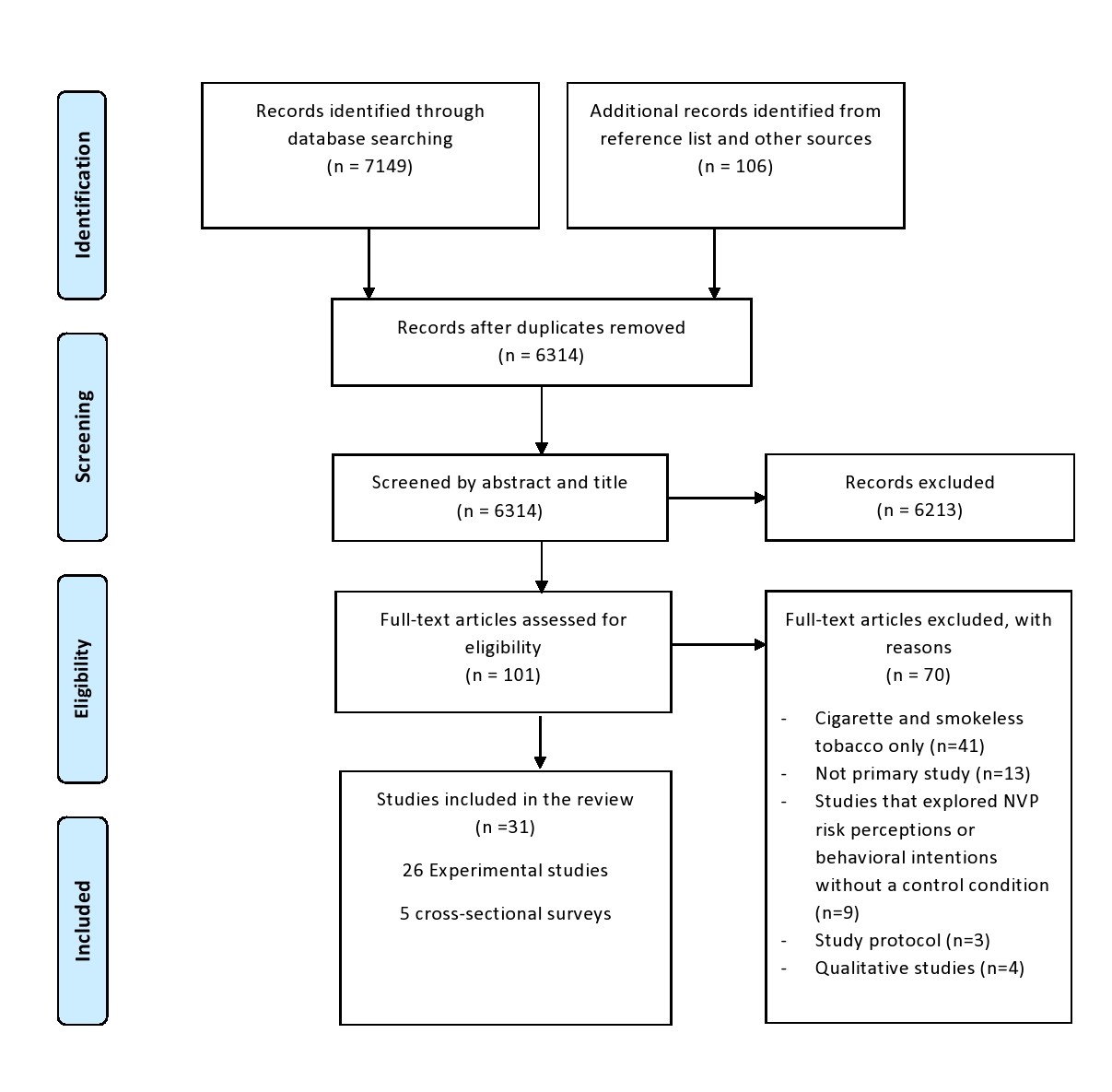
|  |  |  |
| --- | --- | --- |
| **MIF domains** | **Definition of construct** | **Example measurements** |
| **Attention and recall** | | |
| Message recall or recognition | Whether the participant could remember the message following exposure | An open-ended response item following exposure to the stimuli.41  “Which of the following warning statements do you recall seeing on the ads you viewed earlier?8” |
| Attention-attracting | The extent to which the message attracted or grabbed the participant’s attention | “How much does this message grab your attention?”7 |
| **Message reactions** | | |
| Cognitive elaboration | The extent to which the participant thought about the message’s content | “How much do the messages cause you to think about…?”7 |
| Affective reactions | Emotional reactions (positive or negative) to the message (e.g. fear or disgust) | “How much do the messages make you feel…?”7 |
| Credibility | Perceptions of believability or truthfulness of the message | “How believable is this message?”7 |
| Craving to use | The extent to which one craves a product (cigarette or NVPs) | “After having viewed the e-cigarette ad, how much do you want to  smoke an e-cigarette right now?”24 |
| Reactance | Negative reaction in response to a perceived threat to one’s freedom | “The messages are trying to manipulate me.”7 |
| **Attitudes and beliefs** | | |
| Risk perceptions | Participants’ belief towards absolute and relative risks of NVPs. | “Is using electronic cigarettes (vapes) less harmful, about the same or more harmful than smoking regular cigarettes?”55 |
| Self-efficacy | Confidence in one’s ability to quit smoking or vaping | “It is easy for me to switch completely to e-cigarettes.”55 |
| **Behavioural intentions** | | |
| Intention to use/purchase NVP | Likelihood of using or purchasing NVPs after message exposure | “How willing would you be to use an e-cigarette?”36 |
| Intention to quit smoking | Likelihood of quitting smoking after message exposure | “How confident are you that you can quit smoking cigarettes?”49 |
| Intention to switch to NVPs | Likelihood of switching to NVPs after message exposure | “How likely are you to switch completely from using regular  cigarettes to electronic cigarettes in the next 6 months?”55 |
| Intention to dual use | Likelihood of using both cigarettes and NVPs after message exposure | “Which of the following are you most likely to do in the next month (e.g. Smoke cigarettes and use e-cigarettes about the same amount)?”55 |
| **Perceived effectiveness of message to…** | | |
| Be generally effective | Perception of the general effectiveness of the message | Objective measure |
| Motivate to quit, switch or not to start | Perception of message’s motivational value for participant quitting smoking, switching to NVPs, or not starting smoking. | “This message discourages  me from wanting to vape”7 |

**Table 3.** Characteristics of included studies (n=31)

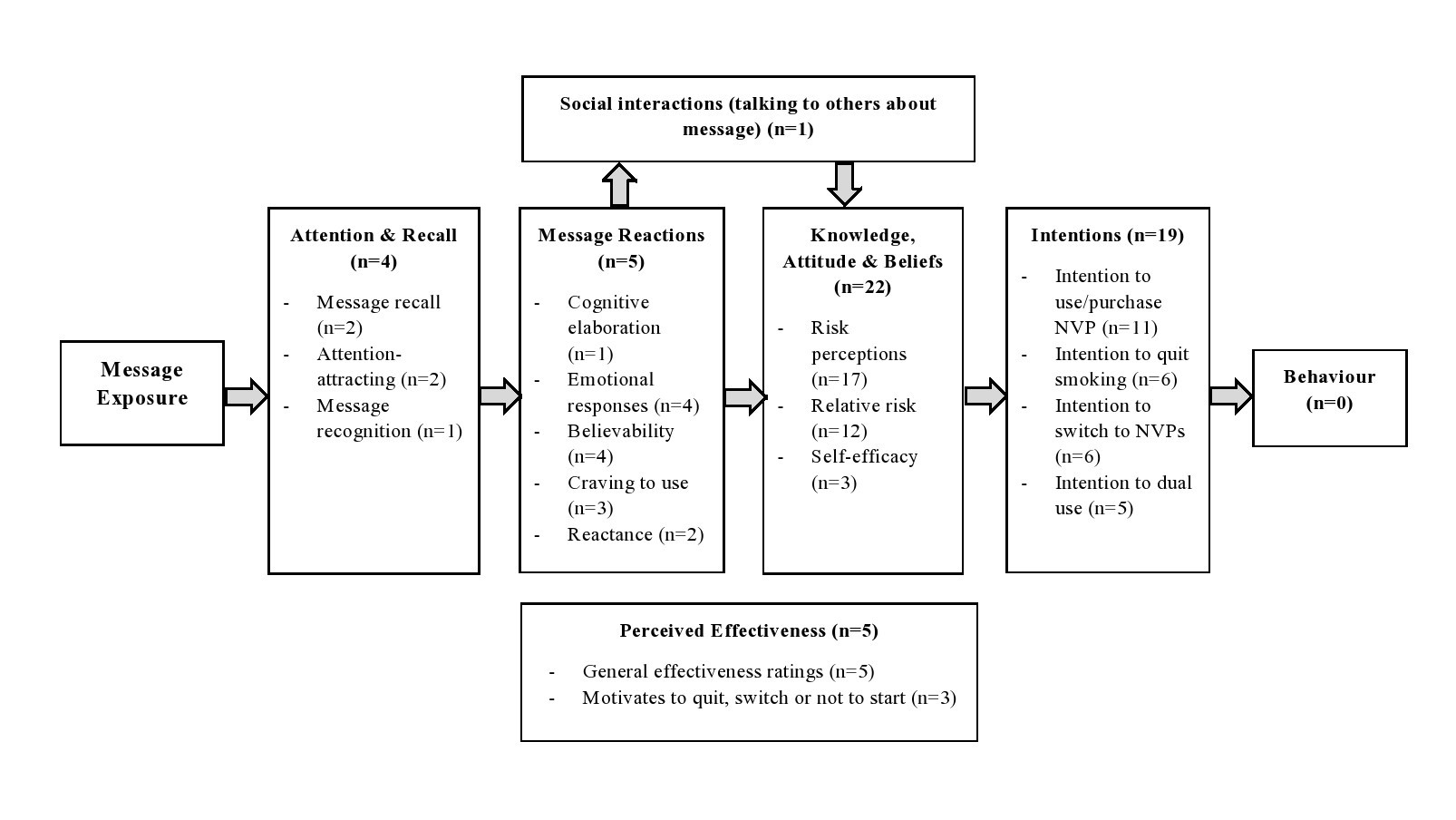
|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Sample and study characteristics** | | | | | | **Message characteristics** | |
|  | **Sample (n)** | **Smoking status** | **NVP use (%)** | **Age cohorts** | **Country** | **Study type** | **Type** | **Message content** |
| Andrews et al. 201924 | 1011 | NR | NR | Adolescents | USA | Exp | Warning on print adverts | Health effects; addiction; Relative risk |
| Berry et al. 201925 | 672 | Current use (26%) | Current use (24.5%) | Adults | USA | Exp | Warning only | Health effects; Chemical constituents; Addiction; Relative risk |
| Berry et al. 201734 | 460 | NR | NR | Adults | USA | Exp | Warning on print advert | Health effects; Addiction |
| Brewer et al. 20197 | 2218 | Daily use (40%) | Daily use (20%) | Adults | USA | Exp | Warning only | Health effects; Addiction; Relative risk |
| Cox et al. 201836 | 95 | Current use (100%) | None | Adults | UK | Exp | Warning, and  health messages based on textual formats | Health effects; Addiction; Relative risk |
| Katz et al. 201837 | 451 | Current use (33%) | Current use (24%) | Adults | USA | Exp | Warning and health messages based on textual formats | Health effects; Relative risk |
| Keating 201826 | 404 pre- & 192 post test | NR | NR | Young adults | USA | Pre-post | Health messages based on textual formats | Health effects; Chemical constituents; Relative risk |
| Kimber et al. 201938 | 2495 | Daily use (44%); never (48%) | Never (79%); daily use (7%); occasional use (22%) | Adults | UK | Exp | Warning, and Health messages based on textual formats | Health effects; Chemical constituents; Addiction; Relative risk |
| Lee et al. 201839 | 666 | NR | Ever use (70.4%) | Young adults | USA | Pre-post | Warning on packaging | Health effects; Chemical constituents; Addiction; Relative risk |
| Mays et al. 201640 | 436 | Never (4%); Tried (36%); experimented (23%) | Ever use (32%); never (68%) | Young adults (18 to 30 years) | USA | Exp | Warning only, and in print advert | Health effects; Addiction |
| Mays et al. 201941 | 544 | Current use (47%) | Current use (19.7%) | Young adults (18 to 30 years) | USA | Exp | Warning in print advert | Health effects; Addiction; Relative risk |
| Mumford et al. 201927 | 773 | Current use (15.2%) | Current use (5.8%) | Adults | USA | Exp | Health messages | Health effects; Relative risk |
| Pepper et al. 201728 | 1164 | Current use (100%) | Ever use (69%); use in the past 30 days (32%) | Adults | USA | Exp | Health messages | Health effects; Chemical constituents; Relative risk |
| Pepper et al. 201943 | 2508 | Current use (50%); never (50%) | Daily use (23%) | Adults | USA | Exp | Health message;  Fact sheet | Health effects; Scientific uncertainty;  Relative risk |
| Popova et al. 201444 | 483 | NR | NR | Adults | USA | Exp | Warning on print advert | Health effects; Chemical constituents; Relative risk |
| Rohde et al. 202045 | 557 | Current use (2%) | Current use (36%) | Young adults | USA | Exp | Anti-smoking video adverts | Health effects; Chemical constituents; Addiction |
| Tattan-Birch et al. 201947 | 2217 | Current use: 37% pre- and 19% post campaign | Current use: 29% pre- and  36% post campaign | Adults | UK | Pre-post | Public education; media campaign | Health effects; Chemical constituents; Addiction; Relative risk |
| Sanders-Jackson et al. 201546 | 847 | Daily use (29%); | Current use (21.4%); former (20%); never (59%) | Young adults (18-34 years) | USA | Exp | Warning on TV advert | Health effects; Chemical constituents; addiction; Relative risk |
| Villanti et al. 201949 | 521 | Use in the past 30 days (18%) | Use in the past 30 days (8%) | Adults | USA | Exp | Fact sheet | Health effects; Chemical constituents; Addiction; Relative risk |
| Wackowski et al. 20198 | 876 | Current use (35.7); never (64%) | Ever use (61%); Current use (26.2) | Young adults | USA | Exp | Warning on print advert | Health effects; Chemical constituents; Relative risk |
| Yang et al. 201853 | 1400 | Current use (100%) | NR | Adults | USA | Exp | Health messages based on textual formats | Health effects; Relative risk |
| Yang et al. 201851 | 580 | Current use (100%) | NR | Adults | USA | Exp | Health messages based on textual formats | Health effects; Chemical constituents; Relative risk |
| Yang et al. 201955 | 1528 | Current use (100%) | NR | Adults | USA | Exp | Health messages; warning only | Health effects; Addiction; Chemical constituents; Relative risk |
| Yang et al. 201956 | 1400 | Current use (100%) | NR | Adults | USA | Exp | Health messages based on textual formats | Health effects; Chemical constituents; Relative risk |
| Yang et al. 201952 | 1202 | Current use (100%) | NR | Adults | USA | Exp | Health messages based on textual formats | Health effects; Chemical constituents; Relative risk |
| Yang et al. 201954 | 756 | Current use (63.4%) | Current use (47%), former (23%), never (29%) | Adults | USA | Exp | Fact sheet | Health effects; Addiction |
| Alcalá et al. 201957 | 3738 | Current use (15.6%), former (25%). Never (60%) | Ever use (19%) | Adults | USA | CS | NA | NA |
| Case et al. 201735 | 3738 | NR | NR | Adults | USA | CS | NA | NA |
| Owusu et al. 201942 | 16,051 | NR | NR | Adults | USA | CS | NA | NA |
| Weaver et al. 201750 | 6051 | Current use (14.8%); never (57%) | Current use (8.5%), never (81%) | Adults | USA | CS | NA | NA |
| Vereen et al. 201848 | 3738 | Current use (15%); former (25%), and never (60%) | Ever use (21%) | Adults | USA | CS | NA | NA |

**Abbreviations:** CDC: Centers for Disease Control and Prevention; CS: cross-sectional survey; Exp: experimental design; FDA: the Food and Drug Administration; NA: not applicable; NVP: Nicotine vaping products; NR = not reported; NRT: nicotine replacement therapies

Figure 1. Preferred reporting items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram



**Figure 2.** Message Impact Framework (MIF) summary of outcome variables



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S

Supplementary Table 1a: Quality assessment of cross-sectional studies using the Newcastle-Ottawa Scale.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Criteria** | | **Author, year** | | | | |
| Alcalá et al, 201965 | Case et al, 201735 | Owusu et al 201942 | Vereen et al, 201848 | Weaver et al, 201750 |
| Selection (maximum 4 stars) | Representativeness of the sample | ★ | ★ | ★ | ★ | ★ |
| Sample size | ★ | ★ | ★ | ★ | ★ |
| Non-respondents | 0 | 0 | 0 | 0 | ★ |
| Ascertainment of the exposure (risk factor) | ★ | ★ | ★ | ★ | ★ |
| Comparability (maximum 2 stars) | Comparability on the basis of the study design or analysis | ★★ | ★★ | 0 | ★★ | ★★ |
| Outcome (maximum 3 stars) | Assessment of outcome | ★ | ★ | ★ | ★ | ★ |
| Statistical test | ★ | ★ | ★ | ★ | ★ |
| **Overall quality** | **Total number of stars (0-9)** | **7** | **7** | 5 | **7** | 8 |

Supplementary Table 1b**:** Risk of bias assessment for experimental studies using Evidence Project risk of bias tool.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Author, year** | **Cohort** | **Control or comparison group** | **Pre/post intervention data** | **Random assignment of participants to the intervention** | **Random selection of participants for assessment** | **Follow-up rate of 80% or more** | **Comparison groups equivalent on socio-demographics** | **Comparison groups equivalent at baseline on outcome measures** |
| Andrews et al 201966 | No | Yes | No | Yes | No | NA | NR | NR |
| Berry et al, 201967 | No | Yes | No | Yes | No | NA | NR | NR |
| Berry et al, 201734 | No | Yes | No | Yes | No | NA | NR | NR |
| Brewer et al 20197 | No | Yes | No | Yes | No | NA | NR | NR |
| Cox et al, 201836 | Yes | Yes | Yes | Yes | No | Yes | Yes | NR |
| Katz et al, 201837 | No | Yes | No | Yes | No | NA | NR | NR |
| Keating, 201826 | Yes | No | Yes | No | No | No | NA | NA |
| Kimber et al 201938 | No | Yes | No | Yes | No | NA | Yes | Yes |
| Lee et al, 201839 | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Mays et al, 201640 | No | Yes | Yes | Yes | No | NA | Yes | NR |
| Mays et al, 201941 | No | Yes | No | Yes | No | NA | Yes | NA |
| Mumford et al 201927 | No | Yes | No | Yes | Yes | NA | Yes | NR |
| Pepper et al, 201728 | No | Yes | No | Yes | Yes | NA | Yes | NR |
| Pepper et al, 201943 | No | Yes | No | Yes | No | NA | Yes | NR |
| Popova et al, 201444 | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Rohde et al, 202068 | No | Yes | No | Yes | No | NA | NR | NR |
| Tattan-Birch et al, 201969 | Yes | Yes | Yes | No | No | Yes | NR | NR |
| Sanders-Jackson et al, 201546 | No | Yes | No | Yes | No | NA | Yes | NR |
| Villanti et al, 201949 | No | Yes | No | Yes | No | NA | Yes | NR |
| Wackowski et al 20198 | No | Yes | No | Yes | No | NA | Yes | NR |
| Yang et al, 201853 | No | Yes | No | Yes | No | NA | Yes | Yes |
| Yang et al, 201851 | No | Yes | No | No | No | NA | NA | NR |
| Yang et al, 201970 | No | Yes | No | Yes | No | NA | Yes | Yes |
| Yang et al, 201956 | No | Yes | No | Yes | No | NA | NR | NR |
| Yang et al, 201952 | No | Yes | No | Yes | No | NA | NR | NR |
| Yang et al (6) 201954 | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes |

Supplementary file 1a: PRISMA checklist

|  |  |  |  |
| --- | --- | --- | --- |
| **Section/topic** | **#** | **Checklist item** | **Reported on page #** |
| **TITLE** | | |  |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |
| **ABSTRACT** | | |  |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 2 |
| **INTRODUCTION** | | |  |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 3-4 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 5 |
| **METHODS** | | |  |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | 6 |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 6 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 6 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | Page 20, Table 1 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 6-7 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 7 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | Page 21, Table 2 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | 7 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | NA |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis. | NA |
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | NA |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | NA |
| **RESULTS** | | |  |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 8-9 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | Page 10;  Page 22, Table 3 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | 9 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 9-12;  Page 22, Table 3 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | NA |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | 9 |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | NA |
| **DISCUSSION** | | |  |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | 14 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 16 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 15 |
| **FUNDING** | | |  |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | 18 |

Supplementary file 1b: Synthesis Without Meta-analysis (SWiM) reporting items

|  |  |  |  |
| --- | --- | --- | --- |
| **SWiM reporting item** | **Item description** | **Page in manuscript where item is reported** | **Other\*** |
| *Methods* | | | |
| **1** Grouping studies for synthesis | 1a) Provide a description of, and rationale for, the groups used in the synthesis (e.g., groupings of populations, interventions, outcomes, study design) | 7 and 8 (i.e. Message Impact Framework) |  |
| 1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the synthesis | NA |  |
| **2** Describe the standardised metric and transformation methods used | Describe the standardised metric for each outcome. Explain why the metric(s) was chosen, and describe any methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing any methodological guidance consulted | 8 |  |
| **3** Describe the synthesis methods | Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to undertake a meta-analysis of effect estimates | 8 |  |
| **4** Criteria used to prioritise results for summary and synthesis | Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a particular study, for the main synthesis or to draw conclusions from the synthesis (e.g., based on study design, risk of bias assessments, directness in relation to the review question) | 8 |  |
| **SWiM reporting item** | **Item description** | **Page in manuscript where item is reported** | **Other\*** |
| **5** Investigation of heterogeneity in reported effects | State the method(s) used to examine heterogeneity in reported effects when it was not possible to undertake a meta-analysis of effect estimates and its extensions to investigate heterogeneity | 8-9 |  |
| **6** Certainty of evidence | Describe the methods used to assess certainty of the synthesis findings | 7 |  |
| **7** Data presentation methods | Describe the graphical and tabular methods used to present the effects (e.g., tables, forest plots, harvest plots).  Specify key study characteristics (e.g., study design, risk of bias) used to order the studies, in the text and any tables or graphs, clearly referencing the studies included | Supplementary file 3: direction of effect plot |  |
| *Results* | | | |
| **8** Reporting results | For each comparison and outcome, provide a description of the synthesised findings, and the certainty of the findings. Describe the result in language that is consistent with the question the synthesis addresses, and indicate which studies contribute to the synthesis | 9-13 |  |
| *Discussion* |  |  |  |
| **9** Limitations of the synthesis | Report the limitations of the synthesis methods used and/or the groupings used in the synthesis, and how these affect the conclusions that can be drawn in relation to the original review question | 17 |  |

Supplementary file 2. Summary of direction of effects from experimental studies

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study characteristics** | | **Outcomes: risk perception and behavioural intentions** | | | | | | | | | | | | |
| **Author, year** | **Intervention** | **Risk perception** | | | | **Behavioural intentions** | | | | | | | | |
|  |  | **General NVP health risk** | **Nicotine (health risk, addiction)** | **Relative risk (NVPs vs cigarettes)** | | **Intention (interest) to start smoking** | | **Intention to purchase (start) vaping** | | **Intention to switch to NVPs** | | **Intention to quit smoking** | **Intention to quit vaping** | **Intention to dual use** |
| Berry et al. 201925 | NVP addiction warning | \* |  |  | |  | |  | |  | |  |  |  |
| Berry et al. 201734 | NVP addiction warning |  |  |  | |  | |  | |  | |  |  |  |
| Brewer et al. 20197 | Text-only or pictorial NVP warning |  |  |  | |  | |  | |  | |  |  |  |
| Cox et al. 201836 | Nicotine addiction message |  |  |  | |  | |  | |  | |  |  |  |
| Katz et al. 201837 | NVP warning label |  |  |  | |  | |  | |  | |  |  |  |
| Kimber et al. 201938 | NVP health warning only |  |  |  | |  | |  | |  | |  |  |  |
|  | Comparative harm message alone |  |  |  | |  | |  | |  | |  |  |  |
| Lee et al. 201839 | NVP warning labels |  |  |  | |  | |  | |  | |  |  |  |
| Mays et al. 201640 | NVP health warning |  |  |  | |  | |  | |  | |  |  |  |
| Mumford et al. 201927 | Relative risk message |  |  |  | |  | |  | |  | |  |  |  |
| Pepper et al. 201728 | A statement about the amount of harmful chemicals present in cigarettes and NVPs (cigarettes have more harmful chemicals than NVPs) |  |  |  | |  | |  | |  | |  |  |  |
| Pepper et al. 201943 | Message about scientific uncertainty |  |  |  | |  | |  | |  | |  |  |  |
| Popova et al. 201444 | Graphic warning label |  |  |  | |  | |  | |  | |  |  |  |
| Rohde et al. 202045 | The Real Cost NVP prevention ads |  |  |  | |  | |  | |  | |  |  |  |
| Tattan-Birch et al. 201947 | NVP-related educational advertising campaign |  |  |  | |  | |  | |  | |  |  |  |
| Sanders-Jackson et al. 201546 | Ingredient- or industry-themed warning statements in TV Ad for NVPs |  |  |  | |  | |  | |  | |  |  |  |
| Villanti et al. 201949 | Nicotine education  messages |  |  |  | |  | |  | |  | |  |  |  |
| Wackowski et al. 20198 | Varying warning themes with RR statement |  |  |  | |  | |  | |  | |  |  |  |
| Yang et al. 201853 | Comparative risk messages |  |  |  | |  | |  | |  | |  |  |  |
| Yang et al. 201851 | Targeted message (by smoker groups) |  |  |  | |  | |  | |  | |  |  |  |
| Yang et al. 201955 | Comparative risk messages plus addiction warning |  |  |  | |  | |  | |  | |  |  |  |
| Yang et al. 201954 | Nicotine fact sheet |  |  |  | |  | |  | |  | |  |  |  |
| **Study characteristics** | | **Outcomes: message attention, recall, reaction and perceived effectiveness** | | | | | | | | | | | | |
| **Author, year** | **Intervention** | **Attention or recall** | | | | | **Message reactions** | | | | | | | **Perceived message effectiveness** |
|  |  | **Message recall** | **Attention attracting** | | **Message recognition** | | **Negative affective reactions** | **Cognitive elaboration** | **Believability** | | **Craving to use NVPs** | | **Reactance** |  |
| Andrew et al. 201924 | NVP text warning with/without graphic health warning |  |  | |  | |  |  |  | |  | |  |  |
| Berry et al. 201925 | NVP addiction warning |  |  | |  | |  |  |  | |  | |  |  |
| Berry et al. 201734 | Addiction warning |  |  | |  | |  |  |  | |  | |  |  |
| Brewer et al. 20197 | Text-only or pictorial NVP warning |  |  | |  | |  |  |  | |  | |  |  |
| Mays et al. 201941 | Varying NVP warning label design features |  |  | |  | |  |  |  | |  | |  |  |
| Popova et al. 201444 | Graphic warning label |  |  | |  | |  |  |  | |  | |  |  |
| Sanders-Jackson et al. 201546 | Ingredient- or industry-themed warning statements in TV Ad for NVPs |  |  | |  | |  |  |  | |  | |  |  |
| Wackowski et al. 20198 | Varying warning themes with RR statement |  |  | |  | |  |  |  | |  | |  |  |

Effect direction: : increase ; : decrease ; : outcome reported, no statistically significant difference found/no change \*For specific risk perceptions related to cancer, lung disease, heart disease, and harm to an unborn baby, reduced-risk warnings resulted in greater risk perceptions than the addiction warning.