A FRAMEWORK FOR THE PUBLIC HEALTH ASSESSMENT OF ELECTRONIC CIGARETTES

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Abstract

Background. Electronic cigarettes (e-cigarettes) are relatively new products with substantial public health impacts. Evidence on their effects is diverse and emerging rapidly, presenting challenges to high-quality policymaking and decision-making. This paper addresses these challenges by developing and presenting a framework for the public health assessment of e-cigarettes, using the Australian context as an example.

Methods. Framework development involved stakeholder engagement, development of guiding principles, and consideration of existing relevant frameworks and the evidence requirements of current policy options, identified in published and grey literature.

Results. Guiding principles include the need for the framework to: be evidence-based; include consideration of the likely balance of benefits and risks of e-cigarettes, uncertainty and safety; support equity; support the ongoing application of evidence to high-quality policy and practice; and consider potential competing interests. The framework draws upon: health technology assessment; health impact assessment; environmental health risk assessment; healthcare recommendations evidence evaluation; consumer goods regulation; medicine and chemical scheduling; tobacco product evaluation; previous reviews and the precautionary principle. Final framework components are: (1) characterisation of products under consideration; (2) definition of populations of interest; (3) characterisation of tobacco smoking, control and impacts on health and wellbeing; (4) review of evidence on patterns of e-cigarette use; (5) review of evidence on e-cigarette use and health outcomes; (6) assessment of likely risks, benefits and safety; (7) identification and assessment of policy options to optimise health outcomes.

Conclusions. Structured and ongoing public health assessment of e-cigarette use is likely to support health through enhancing evidence-based decision-making.

Keywords: Public health, Public policy, Electronic nicotine delivery devices, Prevention

Introduction

Use of electronic cigarettes (e-cigarettes) has increased rapidly since their introduction to various markets around 2004. Use results in a complex and highly variable array of chemical and physical exposures, with the main aerosol constituents being propylene glycol, vegetable glycerine and flavouring agents.[1] Most include nicotine, although variable labelling standards can make reliable identification of constituents problematic.[2, 3]

The health impacts of e-cigarettes are direct – caused by exposure to e-cigarettes themselves – and indirect – caused by the effects of e-cigarettes on other exposures, particularly tobacco smoking. The latter includes potential for increased exposure (eg, 'gateway' and 'smoking renormalisation' effects) and reduced exposure (eg, smoking cessation effects). Dual e-cigarette and combustible tobacco use can result in both indirect and direct effects, and bystander exposure may lead to direct effects.

Tobacco smoking remains the leading preventable cause of death and disability globally, responsible for over 8 million deaths annually.[4] Potential for prolonged and widespread exposure to products with the potential to influence smoking prevalence, and of influencing health themselves, is therefore of paramount public health importance.

Appropriate evidence-based policy on e-cigarettes requires the ongoing integration of current and emerging evidence and its interpretation and application, including consideration of risks and benefits, contextual factors and policy options. In keeping with their recent introduction and their complexity, evidence on the health impacts of e-cigarettes is emerging and will continue to develop over the coming decades.

The aim of this paper is to present a framework supporting a structured, evidence-based and

comprehensive assessment of the public health effects of e-cigarettes and policy options to optimise health. The framework aims to provide practical guidance to summarise the relevant scientific evidence to support high-quality decision-making on e-cigarettes, as well as enabling the ongoing interpretation and application of emerging evidence. It focuses on the Australian context as an example, although it is likely to have broader application and implications, including for novel tobacco products and other exposures.

Methods

Approach

The approach to developing the public health assessment framework was iterative and used searches of the scientific and policy literature and consultation with experts. It was informed by recent large-scale independent reviews of the health effects of e-cigarettes[5, 6] and included:

1. Engagement with stakeholders and experts at the Australia Government Department of Health, including initial scoping discussions with staff working on tobacco and e-cigarettes, agreement on principles prior to commencement of work, drafting of the framework and feedback on final versions. The framework was also reviewed by the Electronic Cigarettes Working Committee of the National Health and Medical Research Council of Australia (NHMRC) – which consists of independent experts in the field[7] – and by the committee secretariat, to ensure the framework would cover the evidence required to update the statement on e-cigarettes of the NHMRC chief executive officer.
2. Scoping of relevant established high-quality public health assessment frameworks, principles and systems. Initial online searches of websites prioritised internationally approved methods, including those recommended by the WHO, and those relevant to the Australian context - such as those from the NHMRC and the Australian Therapeutic Goods Administration. Searches of the published literature were conducted using Scopus and Google Scholar, with terms relating to human health risk assessment, human impact

assessment, evaluating health impact and benefit-risk assessments, as well as searches of reference lists and forward citation searches of key articles.

3. Identification of policy frameworks likely to contain options relevant to e-cigarettes, through online searches relevant to regulation of consumer goods, tobacco products, therapeutic products and other public health measures.

Integrated consideration of these elements was used to derive components and processes for a rigorous evidence-based public health assessment of e-cigarette use and identification of appropriate policy options, while meeting the principles outlined below and stakeholder requirements.

Principles

The public health assessment framework for e-cigarettes was guided by the following principles, derived in consultation with the Australian Government Department of Health:

1. Being based on appropriate high-quality evidence, including focusing on peer-reviewed research and high-quality independent reviews of such evidence, using best-practice methods.
2. Including consideration of the likely balance of benefits and risks, uncertainty and safety.
3. Supporting equity, including by considering impacts of e-cigarettes on the health of the whole population and on important population subgroups. The framework should support policies to maximise the health of the whole population and of priority subgroups and to avoid creating situations whereby the health of one group is improved at the expense of risks and health impacts in another.
4. Supporting high-quality policy and practice that maximises health, and recognises and manages risk appropriately. This will include: using established methods for assessing and managing risk; protecting health gains; placing policy options in the context of smoking

behaviour, health outcomes, and other activities, such as tobacco control measures; ensuring proposed measures are proportionate to risks and benefits; taking account of uncertainty and applying the precautionary principle[8] where appropriate; and taking account of existing regulatory and legal frameworks.

5. Facilitating the ongoing application of emerging evidence on e-cigarettes to policy and practice.
6. Being independent of tobacco and nicotine industry interests, consistent with the WHO Framework Convention on Tobacco Control.[9]

Results

Sources

The public health assessment framework drew upon the following frameworks and material, as no single framework covered all aspects required: health technology assessment;[10-13] health impact assessment;[14, 15] environmental health risk assessment;[16] evidence evaluation for healthcare recommendations;[17] requirements for consumer goods;[18, 19] medicine and chemical scheduling;[20, 21] tobacco product assessment;[22-24] recent major reviews of the evidence on e-cigarettes and health;[5, 6, 25-27] and the precautionary principle.[8]

Health technology assessments were relevant given that: (1) a widely promoted use of e-cigarettes is as a tobacco smoking cessation aid; (2) nicotine is a scheduled poison in many jurisdictions, including Australia; and (3) e-cigarette products that make therapeutic claims (eg, smoking cessation claims) are generally regulated as therapeutic goods. The following aspects of medicine benefit-risk assessments, medicine safety assessments, and medicine risk management were integrated into the framework:[10-13]

- Assessment of the benefits, risks and their balance in the context of: a specific indication and population; the alternative options available; the seriousness of the condition being

treated and the prognosis of the population without treatment.

- Consideration of the limitations and uncertainties of the evidence, and whether information required to characterise the benefits and risks is missing, and its anticipated consequences.
- Risk management, which aims to mitigate identified and potential risks through specific regulatory controls and activities that are proportionate.

Elements of two other risk assessment frameworks were incorporated as follows:

- Health impact assessment: the goal of maximising health benefits and minimising health risks following an assessment of predicted health impacts on a population prior to the implementation of a policy, programme or project; prioritisation of risks of high significance; and the utilisation of a hierarchy of controls to manage risks.[15, 14]
- Environmental health risk assessment: the general structure and processes of: issue identification; hazard identification and dose-response assessment; exposure assessment; and risk characterisation.[16]

Processes from the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) handbook[17] for developing healthcare recommendations were drawn upon, including:

- Framing of the healthcare question, specifically defining the populations of interest and intervention or exposure.
- Considering the relative importance of outcomes.
- Defining comparison group(s).
- Assessing the quality of evidence including considering: risk of bias, inconsistency, imprecision, indirectness, publication bias, magnitude of effect and dose-response gradient.

To guide the identification of suitable policy options, the following were drawn upon:

- Requirements for consumer goods, given that e-cigarettes are sold as consumer goods in

many jurisdictions.[28, 29] Mandatory safety standards are developed and applied to certain categories of consumer goods, legally requiring these products to meet specific safety criteria which can include performance, composition, contents, method of manufacture or processing, and packaging or labelling, before they can be sold.[19] Bans can also be placed on products if there is a risk that they may cause serious injury, illness or death.[18]

- Medicine and chemical scheduling: the principle of tailoring controls over access and availability of medicines and poisons to levels of harm in order to protect public health; and the factors considered when determining the appropriate schedule: substance toxicity, purpose of use, potential for abuse, safety in use and the need for the substance.[20, 21]
- Regulation of therapeutic goods: using a 'risk-based' approach in that regulation is applied only when needed to protect public health; the degree of scrutiny and level of regulation are proportionate to the risks posed; and the benefits of medicines and medical devices registered outweigh their risks to consumers.
- The precautionary principle: an established consideration in managing risk, requiring scientific evidence on harms and information on the uncertainty of such evidence.[8]

Published tobacco product assessment frameworks provided wide-ranging information, particularly on: characterisation of e-cigarette exposure; toxicology; summarising research information; non-clinical risk information and human health impact evaluation.[22-24]

The methods applied in Australian[1, 5, 25] and international reviews of the evidence on e-cigarettes and health were considered, including those from the 2018 reviews from US National Academies of Science, Engineering and Medicine (NASEM),[6] and Public Health England.[26, 27]

Assessment framework

Appropriate stakeholder engagement, transparency and public communication are recommended

throughout the assessment process.

1. Characterisation of e-cigarettes

The assessment starts with characterisation of contemporary e-cigarettes and their use. This includes the attributes of available devices and composition of e-liquids (figure 1).[27] Additional detailed advice on the characterisation of e-cigarette devices and e-liquids is given in the US Food and Drug Administration's (FDA) guidance on premarket tobacco product applications for Electronic Nicotine Delivery Systems and includes information on product formulation and design, flavours, e-liquid volume and nicotine concentration and propylene glycol/vegetable glycerine ratio.[22]

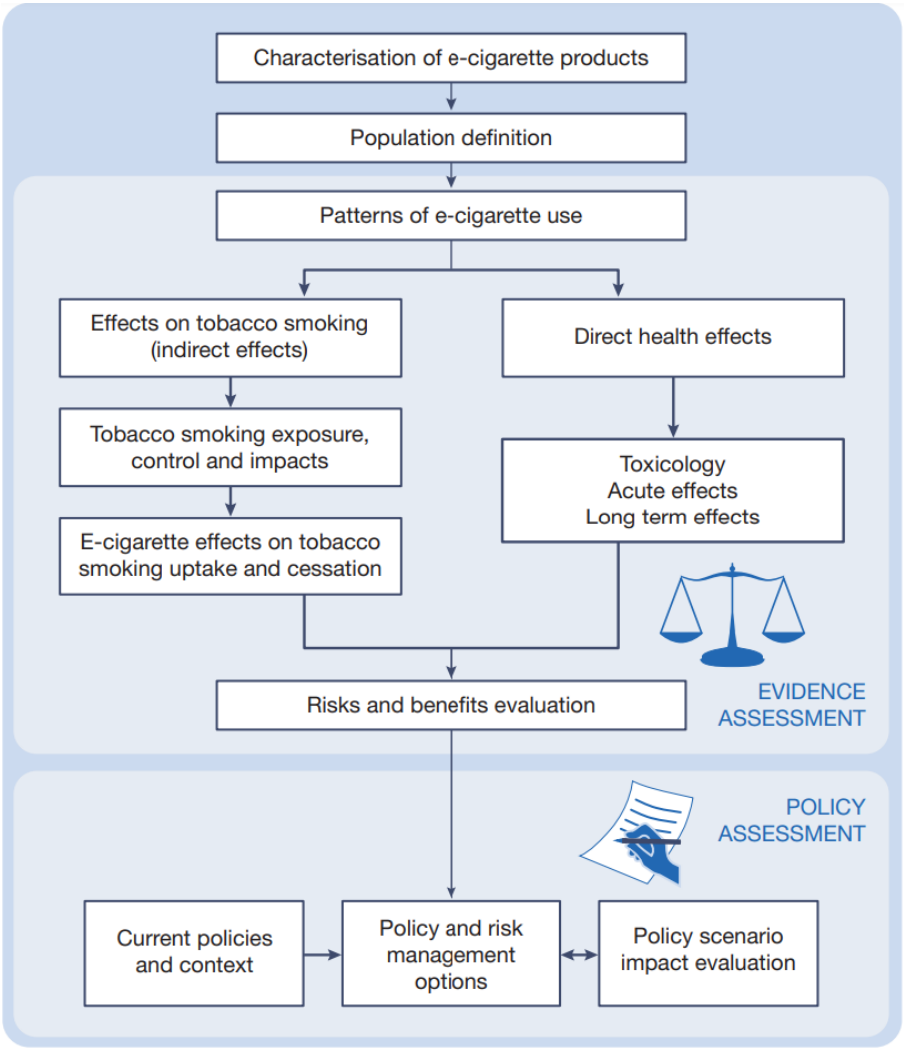

Figure 1
Overview of framework for public health assessment of electronic cigarettes.

2. Definition of the populations likely to be affected by e-cigarettes and by tobacco smoking

The target populations for the intervention and outcomes of interest should be defined, in keeping with the principle of maximising health overall and in priority groups, and avoiding interventions that improve health in one group at the expense of another. For an Australian assessment, target and priority populations were broadly defined by stakeholders as including: the general population; children and youth; Aboriginal and Torres Strait Islander peoples; past and never-smokers; and current smokers.

This section of the assessment focuses on technical definitions of the priority groups and identification of any others that may have been missed, ensuring that all elements of the assessment seek evidence and policy options relevant to these groups.

3. Characterisation of exposure to tobacco smoking and control measures, and tobacco impacts on health

The patterns of exposure to tobacco smoking, and their impact on health and wellbeing, have a significant bearing on the assessment of risks, benefits and safety, as well as the most appropriate policy options for e-cigarettes.[20] This section includes but is not limited to evidence on:

- The prevalence of and trends in tobacco smoking, including in populations of interest.
- The impact of tobacco smoking on health, including burden of disease.
- Current tobacco control measures.
- Available smoking cessation treatments.
- Current targets for tobacco control.

4. Characterisation of patterns of e-cigarette use, including dual use with tobacco smoking

Patterns of exposure to e-cigarettes provide important evidence relevant to likely effects on tobacco smoking and health outcomes. This section reviews evidence on the patterns of current and past e-

cigarette use, in populations relevant to the assessment, including use in combination with tobacco smoking.

5. Review of evidence on the relationship of exposure to e-cigarettes to outcomes of interest

This section reviews evidence on the relationship of e-cigarette use to health outcomes, including indirect effects through impacts on smoking behaviour and direct effects, considering published systematic reviews and primary studies and drawing on current best practice.

The following outcomes in relation to smoking behaviour are included:

- Efficacy of e-cigarettes for tobacco smoking cessation, as smoking cessation is the end goal for cessation aids and there is no safe level of tobacco smoking.[30, 31]
- Association between exposure to e-cigarettes and tobacco smoking uptake in never- or non-smokers and relapse to tobacco smoking in ex-smokers.

The Australian Department of Health also requested inclusion of evidence on the efficacy of e-cigarettes for nicotine cessation, since nicotine is an addictive substance that can result in poisoning and contribute to health outcomes such as cardiovascular disease.[6, 32]

The assessment of direct health effects should include a review of the toxicology of e-cigarette chemical constituents, which provides important in vitro and in vivo evidence on likely and potential adverse effects. Relevant information on the range of areas which can be covered is provided in the NASEM review and FDA guidance.[6, 22]

Health outcomes in human studies should include but not be limited to[6, 22]:

- Cardiovascular disease.
- Cancers.

- Respiratory disease.
- Oral diseases.
- Developmental and reproductive effects.
- Injuries and nicotine poisonings.
- Dependence (including nicotine dependence) and abuse liability.
- Mental health.

Environmental outcomes, including potential health impacts of waste, fire, loss of property and broader ecological consequences can also be examined.[33]

Evidence on health outcomes in relation to e-cigarette constituents, such as nicotine, from products other than e-cigarettes may also be informative.[6]

To examine the efficacy of e-cigarettes for cessation of tobacco smoking, and nicotine exposure, evidence from randomised controlled trials (RCTs) should be reviewed, given that this study design provides reliable evidence on the efficacy of interventions.[34] Observational data can be used to assess the association between e-cigarette exposure and tobacco smoking uptake in non-smokers and relapse in ex-smokers. Data from RCTs, observational studies and other appropriate sources should be reviewed for health outcomes. Meta-analyses of quantitative data should be conducted where appropriate.

The strength, relevance and uncertainty of the evidence should be assessed for each outcome and overall, consistent with the GRADE handbook, including:[17, 35, 36]

- Design and risk of bias of included studies.
- Consistency in relative effect sizes for an outcome across studies. If heterogeneity exists and it is unexplained, consideration will be given to its extent and whether it is important to confidence in the results.

- Direct relevance and likely generalisability, with respect to the population, intervention, and outcome measures in the evidence and whether these are applicable to the research questions. For the latter, consideration will be given to the timeliness of outcome data, the validity of surrogate measures, and the distance on the causal pathway between surrogate measures and community-important outcomes.
- Imprecision, or statistical uncertainty, introduced by matters such as sampling and limitations in statistical power, including that resulting from missing information.
- Publication bias, by considering the number of studies published, their size and direction of effect, and if appropriate, more formal methods for assessing publication bias.
- Magnitude of effect in the context of the study design and precision of the results. The clinical and public health significance of any observed effect will also be considered.

Potential competing interests should be noted, including whether or not the specific study under consideration, study authors and their organisations have received funding from the tobacco or nicotine industry. The extent to which results are influenced by the inclusion or exclusion of studies with potential competing interests should be explored, with emphasis on results independent of competing interests if results differ materially according to funding source.

Where applicable, the extent to which observed associations with e-cigarettes are likely to reflect causal relationships should be considered, drawing on relevant Bradford Hill criteria.[37-39]

The reporting of the reviews of evidence should be guided by other relevant guidelines, including the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement and checklist and the Meta-analyses of Observational Studies in Epidemiology (MOOSE) checklist.[40, 41]

6. Assessment of the likely risks, benefits and safety of e-cigarettes

This section of the assessment reviews and interprets the evidence from sections 1-5 above to address the questions listed below regarding the risks, benefits and safety of e-cigarettes. While data constraints mean that, currently, much of this will be based on narrative review, this assessment should be conducted using as much quantitative data as possible, drawing on meta-analyses for specific outcomes and, ideally, quantitatively summarising absolute risks and benefits.[42] This evidence, along with the answers to these questions, informs the conclusions that can be drawn regarding the likely impacts of e-cigarettes and identification of appropriate policy options.

1. *Benefits*. What is the evidence on the likely benefits of e-cigarettes, including their efficacy as a smoking cessation tool? What are the burden of disease and current trends in tobacco smoking in the absence of e-cigarettes? What is the quality, reliability and uncertainty of the evidence regarding likely benefits? Where possible, this assessment should include evidence on likely relative and absolute benefits and the nature of any observed benefit.[42]
2. *Risks*. What is the evidence on the likely risks of e-cigarettes? Are serious risks to human health, including those affecting present and future generations, scientifically plausible?[8] What is the quality, reliability and uncertainty of the evidence regarding risks? This assessment should include bringing together evidence on the nature of any observed risks and, where possible, their magnitude, in terms of relative and absolute risk.
3. *Safety*. The assessment will scope and consider which safety standards should be applied to e-cigarettes; for example, European Union guidance for assessing the clinical safety of medicines provides relevant information.[31, 43, 44] Applying the appropriate standards, what is the evidence of safety for e-cigarettes, with due consideration of the quality and uncertainty of that evidence? It is important to note that evidence on safety relates primarily to the adequacy of data to exclude harms and to manage risks.[36]
4. *Balance of benefits, risks and safety*. What can be concluded reliably about the likely balance

of risks, benefits, and safety of e-cigarettes, with due consideration of the quality and uncertainty of the evidence? What is this balance likely to be for e-cigarettes in priority populations, where evidence is available?

7. Identification and assessment of policy options to optimise health outcomes in relation to e-cigarettes

Policy options will be informed by integrated consideration of evidence from framework items 1-5 above, including evidence on the safety and efficacy of e-cigarettes and its uncertainty, as well as evidence on the target condition, populations likely to be affected and the availability of alternative ways of managing the target condition. The main components of this part of the assessment process include:

Scoping of the current local and international policy context relevant to e-cigarettes

This section considers how e-cigarettes are regulated locally and internationally including:

- Advertising, promotion and sponsorship.
- Use in public places, workplaces and other settings.
- Product availability and access.
- Pricing.
- Controls on manufacturing/quality, ingredients (eg, flavouring agents), and packaging and labelling.

Identifying suitable policy and risk management options for e-cigarettes

This process involves matching the attributes of the evidence on the intervention to the appropriate policy option(s) and includes consideration of:

- Appropriate policy and risk management framework(s). This element of the assessment of e-cigarettes will identify the most suitable policy and risk management framework(s) to

apply, noting that these may differ for the different target populations. Risks to health with high levels of uncertainty – including situations with important missing information – support application of the precautionary principle.[8] The ability to reliably quantify risks and benefits and establish the balance of safety and efficacy supports application of other risk management and policy frameworks. A favourable balance of benefits and risks further focuses the policy options. Transparency, stakeholder engagement and high-quality public communication are important elements of risk management, including the maximisation of benefits and mitigation of risks.

- The likely target population. Population-wide benefits, along with reliable evidence of safety, support policies enabling wide exposure to the intervention; while likely benefits restricted to specific groups support targeted exposure, such as policies underpinning the use of prescription medicines.[20]
- The need for e-cigarettes. The seriousness of the health impacts of tobacco smoking, the efficacy and safety of e-cigarettes and the efficacy and availability of existing tobacco control measures all inform assessment of the population need for the intervention.
- Other risk management considerations. A range of other policy considerations support the management of risk. These include that risk may be managed more effectively by incremental and potentially adaptable policy changes, with feedback on the effects of those changes, rather than by large and less reversible changes. Risk management measures should be proportionate to the likely risks and benefits of the intervention and should be actively reviewed as new information becomes available.
- The most appropriate categorisation of e-cigarettes within the identified policy and risk management frameworks. The evidence from the above sections of the assessment will be brought together to consider the most appropriate placement or placements of e-cigarettes within the range of policy options.

Consideration of the potential impact of different policy scenarios

The potential impacts of the identified policy options should then be considered by comparing a 'business as usual' scenario with scenarios where e-cigarettes are managed according to that policy option, for the different target populations. Both intended and unintended consequences of any policy option should be formally considered, including potential impacts on health equity. Depending on factors such as resources, time and evidence constraints, this can vary from broad general considerations of outcomes to detailed mathematical modelling, noting that such modelling relies on appropriate quantification of parameters. Costs and utility outcomes could also be considered in this element of the assessment.

The outcomes of the frameworks are evidence summaries under framework headings 1-5, which are then used to assess risks, benefits and safety and to consider policy options relevant to the context in which the framework is applied.

Discussion

This public health assessment framework provides a structured, formalised and evidence-based process for reviewing the available evidence on the public health impacts of e-cigarettes and applying this evidence to policy options, drawing on established methods known to safeguard the health of the population. The major focus of public health assessment is on the appropriate management of risk, through evaluation of evidence on health impact and identification of policy options suitable for managing identified risks and uncertainty. The framework is guided by a principle of supporting equity.

Internationally, approaches to e-cigarettes are diverse, including being regulated as consumer products, medicinal products (for those making therapeutic claims), tobacco products and combination products.[28, 29] We were not able to locate any published frameworks providing

practical guidance for regular and systematic assessment of current evidence on e-cigarettes and supporting its application to public health policy and practice in a wide range of regulatory contexts; this framework aims to fill this gap. Informative frameworks for assessment of e-cigarettes as novel tobacco products are available, including from the US FDA.[22-24] These frameworks relate to individual products rather than e-cigarettes in general, focusing on regulatory approval rather than broader public health considerations. Although they indicate the need for evidence on impacts on all populations, including never-smokers, other approved tobacco products are the primary comparator, emphasising potential 'harm reduction' impacts. Public health frameworks that support structured consideration of e-cigarette impacts on different population groups – giving greater prominence to never-smokers and youth – are important, as use of such products in never-smokers cannot generally be considered a harm reduction approach.[45]

For therapeutic products, the target population, reason for use of a product, and alternative treatment options influence the assessment of benefits and risks, as well as the application of risk-based policy options. For example, vaccines are administered to large populations of generally healthy infants and children, and consequently, there is a low tolerance for potential risks and adverse effects. There is higher tolerance of risks with chemotherapy for serious life-threatening conditions with limited alternative treatment options. Regulatory control of therapeutic goods increases with the level of risk posed by the product, considered in the context of their indications, target population and risks for other people who may come into contact with them, for example, children.[46-48] The level of risk posed by a therapeutic good informs the quantity and type of information required for assessment, the degree of scrutiny applied to the assessment, the level of ongoing safety monitoring, and how consumers can access the good.[46] Similarly, the Australian Standard for the Uniform Scheduling of Medicines and Poisons, which controls how medicines and poisons are made available to the public, has policy options across a risk-based spectrum. This spectrum ranges from medicines such as paracetamol – which are deemed to have a well-defined risk profile, be substantially safe for short-

term use and/or have low potential for harm from inappropriate use – to substances such as lead compounds that, under certain circumstances, are prohibited from sale, supply and use due to the high public health risk posed.[20, 21]

These risk-based approaches highlight the importance of considering separately population groups where risk/benefit balances are likely to differ. For example, around half to two-thirds of smokers are likely to die of smoking-related diseases if they do not quit.[49-51] The magnitude of this harm means that certain risks may be considered acceptable in smokers if an exposure, such as e-cigarette use, is found to support cessation. For people who have never smoked, the balance of risks and benefits is likely to differ from those of smokers, and some jurisdictions have chosen to ban or tightly limit access to e-cigarettes in order to minimise exposure to non-smokers.[29] Other jurisdictions have allowed widespread recreational use while introducing measures such as age limits, aiming to protect more vulnerable groups and limit use by never-smokers.[28]

The challenges inherent in assessing the public health impacts of e-cigarettes should be acknowledged. These include: difficulty quantifying the long-term effects of a newly-introduced product, including limited data on clinical outcomes; the huge diversity of products and users[52] and issues generalising evidence between these; lack of reliable information about the specific e-liquid constituents in many studies;[2, 3] and methodological issues with comparison groups and statistical power, including difficulties in reliably ascertaining e-cigarette health effects among current and past smokers, and limited disease events (eg, cancer, cardiovascular disease) among generally young never-smokers who use e-cigarettes and their age-matched peers. The situation will improve as evidence accrues, highlighting the need for continuing research.

The joint consideration of risks, benefits, safety and uncertainty provides critical information for risk management. High levels of uncertainty combined with scientifically plausible evidence of

serious risks to human health, especially those affecting future generations, supports the application of the precautionary principle.[8] This approach seeks to shift emphasis away from what is often seen as the traditional 'reactive' public health approach – removing hazards that have already been identified – to a strategy where action is taken to prevent harm even where some uncertainty remains about cause and effect relationships.[53] This situation is best addressed by minimising exposure to the intervention and continuing research to strengthen the evidence base. Where risks can be adequately characterised and managed, a risk management framework is more appropriate. As levels of uncertainty and evidence of harms and benefits are likely to vary according to the different population group under examination, it will be possible for the precautionary principle to be applied in one population and other risk management processes in another target group. For example, certain medications are restricted from use in pregnancy, due to uncertainty about their effects combined with potential for serious harm, while being made available in other groups where risks can be managed more effectively.

This framework is designed to be able to be applied to regularly update the assessment of e-cigarettes, as additional evidence becomes available. It is also potentially applicable to other exposures of public health importance.

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What this paper adds

What is known: Continuing evidence-based policy on electronic cigarettes requires the ongoing integration of current and emerging evidence and its interpretation and application, including consideration of risks and benefits, contextual factors and policy options. Pre-defined frameworks for public health assessments support high quality systematic evaluation of the effects of exposures on health outcomes as well as providing evidence suitable for policy.

Knowledge gaps: No framework suitable for consistent and comprehensive public health assessment of electronic cigarettes - including a structured approach to reviewing evidence on the health effects of electronic cigarettes and applying them to policy - was identified from searches of the published and grey literature using terms relating to human health risk assessment, human impact assessment, evaluating health impact and benefit-risk assessments, along with searches of reference lists of key articles, forward citation searches and expert advice. This means that public health policy on electronic cigarettes has been guided largely by periodic reviews of the evidence, regulatory assessments, consideration of individual pieces of emerging evidence and other factors, potentially compromising health outcomes.

What this study adds: This study drew upon multiple existing and established health assessment frameworks, as well as considerations relating to stakeholder requirements, medicines regulation and the precautionary principle, to arrive at one for electronic cigarettes that includes: (1) characterisation of products under consideration; (2) definition of populations of interest; (3) characterisation of exposure to tobacco smoking, control and impacts on health and wellbeing; (4) review of evidence on patterns of e-cigarette use; (5) review of evidence on the relationship of e-cigarette use to health outcomes; (6) assessment of likely risks, benefits and safety; and (7) Identification and assessment of policy options to optimise health outcomes.