

Vaping – Health harms: evidence briefing

Introduction

This briefing provides an overview of known health harms caused by vaping and existing research gaps on long-term effects of vaping and health risks for the youngest vapers.

Background

Over the past few years, vaping products have been evolving in design and content of e-liquids. While the addictive and harmful nature of nicotine is well-known, the presence of other ingredients (e.g. propylene glycol, glycerine and flavours) in the liquid solutions has raised safety concerns due to lack of research on the possible negative effects of their inhalation.

Methodology

This evidence briefing is based on a search and analysis of scholarly research on the health harms of vaping carried out between December 2022 and November 2023.

The search was conducted on a number of search engines: KandE (a Scottish Government resource covering several databases), Google Scholar, PubMed and ScienceDirect. It included the following terms: “ENDS”, “e-cigarettes”, “vapes”, “vaping”, “health harms”, “harm reduction”, “health risks”, “addiction”, “nicotine”, “biomarkers”, “dual use”, “young people”, “children”, “adolescents”, “teenagers”.

Twenty-four papers/reports were selected and reviewed (opinion pieces and editorials were excluded). Of these, eight were systematic reviews and/or meta-analyses, hence have been prioritised and represent the core sources used to write this briefing. No critical appraisal of the evidence they examined was undertaken.

In this briefing we make reference to “vaping products” to describe both nicotine and non-nicotine devices used to inhale an aerosol. The sources analysed here

adopt different terms and definitions. For accuracy and in order to preserve the original meaning, the terminology chosen by the authors of each review has been retained when summarising their findings.

Key findings

The systematic reviews and meta-analyses examined for this briefing highlight a number of known health harms associated with vaping. In particular, there is agreement in the sources that:

- vaping products cause **addiction** to nicotine;
- vaping causes health harms (e.g. due to addiction and/or exposure to toxicants) in **non-smokers** to which they would not otherwise have been exposed;
- vaping is **less harmful than smoking** when smokers completely switch to e-cigarettes.

The examined sources also identify developing fields of research requiring further investigation. In particular, there is agreement that:

- more research on **dual use** (i.e. use of conventional cigarettes in combination with vaping products) is needed, with data suggesting this might pose the same or higher health risks than smoking alone;
- there is insufficient data on a number of **clinical outcomes** (e.g. cardiovascular or respiratory disease, and cancer) caused by vaping and biomarkers of potential harms to health cutting across several diseases;
- there is insufficient evidence on the effects of vaping on **pregnant women**.

The assessment of health risks from vaping has been complicated by the ever-evolving nature of vaping products and the limited time they have been on the market which currently limit the ability to establish their long-term effects, and by the unfeasibility of experimental research on young people for ethical reasons.

Policy implications

Although evidence on the long-term harms of vaping and on the effects of vaping on young people is still emergent, a precautionary approach has been adopted by the Scottish Government, with the main objective being to protect public health and prevent nicotine addiction and other known potential health harms deriving from the use of vaping products, especially in children, young people and non-smokers.

The Scottish Government will continue to consider any new evidence encountered on this.

Annex – Analysis of the existing evidence

Known health risks of vaping

There is agreement in the reviews and meta-analyses examined for this briefing that vaping products cause **addiction** to nicotine:

- The [umbrella and systematic review of global evidence](#), conducted by the Australian National Centre for Epidemiology and Population Health and published in 2023, concluded that there is substantial evidence that nicotine e-cigarettes cause addiction in non-smokers and limited evidence that they cause addiction in smokers.
- The King's College London [Vaping in England evidence review](#), commissioned by the Office for Health Improvement and Disparities and published in 2022, concluded that there is substantial evidence from previous reports ([COT 2020](#), [PHE 2019](#) and [NASEM 2018](#)) that using vaping products can result in symptoms of nicotine dependency, but also moderate evidence that risk and severity of this dependency is lower than for cigarette smoking and vary by product characteristics. The pharmacokinetics studies analysed by the authors were consistent with these findings. Limitations of the evidence pertained to the lack of consensus on the optimal scale to assess nicotine dependency and of longer-term studies analysing the association between the use of e-liquids with different nicotine strength and dependency.

There is agreement in the examined reviews and meta-analyses that vaping causes health harms in **non-smokers**:

- The [Australian review \(2023\)](#) concluded that non-smokers are most vulnerable to e-cigarette adverse events, as they are disproportionately affected by risks such as addiction, toxicity from inhalation and increased smoking uptake, without the potential benefit associated with smoking cessation.
- The [Vaping in England evidence review](#) (2022) highlighted how vaping is not risk-free, particularly for people who have never smoked. The authors concluded that findings of higher absolute exposure to toxicants from vaping compared to non-use of nicotine products reinforce the need to discourage non-smoker from taking up vaping.
- The [Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment \(COT\) review](#) (2020) concluded that uptake of electronic non-nicotine delivery systems (E(N)NDS) by non-users of tobacco products is likely to be associated with some adverse health effects to which the user would not otherwise have been subject, including the risk of addiction.

There is agreement in the examined reviews and meta-analyses that vaping is **less harmful than smoking**:

- The [Australian review](#) (2023) concluded that, given the extreme harms of smoking, e-cigarettes may be beneficial for smokers who use them to completely and promptly cease smoking (i.e. there is no dual use).

- The [Vaping in England evidence review](#) (2022) concluded that vaping poses only a small fraction of the risks of smoking. The review found statistically significant and substantially reduced levels of exposure to nicotine and potential toxicants when using vaping products compared to conventional tobacco products. It also found conclusive evidence that acute and short to medium exposure to potential carcinogens and to most potential respiratory toxicants from vaping is significantly lower than smoking tobacco products.
- The [COT review](#) (2020) concluded that the use of E(N)NDS, produced according to appropriate manufacturing standards and used as recommended (as a replacement for conventional cigarette smoking), is likely to be associated with a reduction in overall risk of adverse health effects. The Committee reviewed data from biomonitoring studies which supported the conclusion that exposure to levels of tobacco-related toxicants associated with E(N)NDS is lower than from conventional cigarette smoking. Therefore, the Committee anticipated a considerable reduction in risk of lung cancer, although this would not necessarily be the case for all endpoints.
- The [Public Health Consequences of E-cigarettes report](#), published by the National Academies of Sciences, Engineering and Medicine (NASEM) in 2018, found that there is conclusive evidence that: completely substituting e-cigarettes for combustible tobacco cigarettes reduces users' exposure to numerous toxicants and carcinogens present in combustible tobacco cigarettes; and substantial evidence that completely switching to e-cigarettes results in reduced short-term adverse health outcomes in several organ systems. However, the authors concluded that there is limited evidence for reduction of chronic obstructive pulmonary disease (COPD) exacerbations among adult smokers with COPD who switch to e-cigarettes completely or in part (dual use).

Developing fields of research

There is agreement in the examined reviews that more research on **dual use** (of conventional cigarettes in combination with vaping products) is needed, with data suggesting this might pose higher health risks than smoking alone:

- The [Australian review](#) (2023) concluded that the direct health impact of dual use is unknown and that e-cigarettes may facilitate continued smoking, increasing risks.
- A [Danish systematic review](#), published in 2022, concluded that dual use is at least as, or probably even more, harmful than exclusive smoking of conventional cigarettes. However, the authors judged the overall certainty of the evidence as low.
- The [COT review](#) (2020) concluded that dual use of E(N)NDS and conventional cigarettes would not necessarily reduce the risk of adverse health effects associated with smoking and may even increase the overall risk, while also potentially leading to increased nicotine exposure.

- The [NASEM review](#) (2018) concluded that there is no evidence whether or not long-term e-cigarette use among smokers changes morbidity or mortality compared with those who only smoke combustible tobacco cigarettes, and insufficient evidence that e-cigarette use changes short-term adverse health outcomes in several organ systems in smokers who continue to smoke combustible tobacco cigarettes.

There is agreement in the reviews and meta-analyses examined in this briefing that there are insufficient data on a number of **clinical outcomes** caused by vaping (based both on biomarkers of potential harm and clinical conditions):

- An [American systematic review and meta-analysis](#), published in 2023, concluded that using e-cigarettes has a detrimental effect on cardiac health and that the risk of severe cardiac conditions increases with e-cigarette use. In particular, the authors state that e-cigarettes use should not be encouraged in patients with compromised cardiovascular systems.
- The [Australian review](#) (2023) concluded that there is no available evidence regarding the impacts of vaping on a range of important health and disease outcomes (e.g. those related to cardiovascular disease and cancer). The authors found conclusive evidence of seizures with use of nicotine e-cigarettes, and moderate evidence that e-cigarettes cause throat irritation, cough, dizziness, headache and nausea. They also found insufficient evidence in non-smokers and moderate evidence in smokers of some cardiovascular outcomes (e.g. arterial stiffness), and no evidence among non-smokers and insufficient evidence among smokers of some clinical respiratory outcomes (e.g. asthma and bronchitis). Less direct evidence indicates some adverse effects of e-cigarettes on cardiovascular health markers (including blood pressure and heart rate), lung function and adolescent brain development and function.
- The [Vaping in England evidence review](#) (2022) concluded that more research on biomarkers and the extent to which vaping presents a risk for various clinical outcomes is needed to establish both medium- and long-term risks of vaping. The authors found insufficient evidence that vaping induces oxidative stress, increased inflammation or platelet activation when compared to smoking or non-use of nicotine products, and limited evidence that acute vaping is associated with similar endothelial function effects as acute smoking (while short to medium term vaping is associated with improved endothelial function compared with short to medium term smoking). They also found some but insufficient evidence that vaping alters gene expression and DNA methylation. Evidence was deemed insufficient for any association of vaping with respiratory disease and any impact on lung function. The review highlighted how there is no available evidence of the association of vaping with longer-term changes to arterial stiffness, and clinical cardiovascular and other health outcomes compared to smoking.
- The [Cochrane review](#) on the use of electronic cigarettes for smoking cessation, published in 2022, concluded that there was no difference in adverse events when comparing use of nicotine and non-nicotine e-cigarettes, or nicotine e-cigarettes and NRT. However, confidence intervals were wide for

the most part of the data. The authors did not detect evidence of serious harm from nicotine e-cigarettes, but longest follow-up was two years and the number of studies were small.

- The [COT review](#) (2020) concluded that it is not currently possible to predict the adverse health effects that could be associated with use of E(N)NDS in the long term, and that data on possible toxicity by inhalation of a number of flavouring products in e-liquids are lacking.
- The [NASEM review](#) (2018) concluded that there is: no available evidence whether or not e-cigarette use is associated with certain clinical outcomes (e.g. cardiovascular or respiratory disease, and cancer); insufficient evidence that e-cigarette use is associated with long-term changes in blood pressure, heart rate, and cardiac geometry and function; and limited evidence that e-cigarette aerosol can be mutagenic or cause DNA damage in humans and human cells in culture, or is associated with a short-term increase in systolic blood pressure, changes in biomarkers of oxidative stress, increased endothelial dysfunction and arterial stiffness, and autonomic control. However, the reviewers found conclusive evidence that most e-cigarette products contain and emit numerous potentially toxic substances, whose number, quantity and characteristics are highly variable and depend on product characteristics and how the device is operated; and substantial evidence that e-cigarette aerosols can induce acute endothelial cell dysfunction and that components of e-cigarette aerosols can promote formation of reactive oxygen species/oxidative stress.

There is agreement in the reviews and meta-analyses examined in this briefing that there is insufficient evidence on the effects of vaping on **pregnant women**:

- The [Australian review](#) (2023) concluded that there is insufficient evidence as to how e-cigarette use among exclusive e-cigarette users and dual users relates to pregnancy and foetal outcomes, such as low birth weight, preterm birth, Apgar score and small-for-gestational-age birth.
- The [Vaping in England evidence review](#) (2022) concluded that the effects of vaping on foetal development and pregnancy outcomes remain in particular need of research, including the effects of switching from smoking to vaping in the perinatal phase. The review found that evidence on how vaping affects pregnancy outcomes compared to smoking or non-use of nicotine products is insufficient.
- A UK [systematic review of vaping in pregnancy](#), published in 2021, concluded that there are insufficient data on the effects of vaping in pregnancy, with the limited literature suggesting that vaping in pregnancy has little or no effect on birthweight.
- The [NASEM review](#) (2018) concluded that there is no available evidence on the effects of e-cigarettes on pregnancy outcomes, and insufficient evidence to establish whether maternal e-cigarette use affects foetal development.



© Crown copyright 2024

You may re-use this information (excluding logos and images) free of charge in any format or medium, under the terms of the Open Government Licence.

To view this licence, visit <http://www.nationalarchives.gov.uk/doc/open-government-licence/> or e-mail: psi@nationalarchives.gsi.gov.uk.

Where we have identified any third party copyright information you will need to obtain permission from the copyright holders concerned.

The views expressed in this report are those of the researcher and do not necessarily represent those of the Scottish Government or Scottish Ministers.

This report is available on the Scottish Government Publications Website (<http://www.gov.scot/Publications/Recent>)

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-83521-901-0

Published by the Scottish Government, January 2024