



**Superior
Health Council**



Electronic cigarette: flavour restrictions

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ADVISORY REPORT OF THE SUPERIOR HEALTH COUNCIL no. 9863

Electronic cigarette: flavour restrictions

In this scientific advisory report, which offers guidance to public health policy-makers, the Superior Health Council of Belgium provides recommendations for a drastic and urgent restriction on e-cigarette flavours, aiming to reduce their appeal—particularly among young people—without increasing the threshold for smokers who use e-cigarettes as a smoking cessation aid.

This version was validated by the Board on
05/11/2025¹

EXECUTIVE SUMMARY

In this scientific advisory report, the Superior Health Council (SHC) of Belgium provides a comprehensive assessment of the public health implications of flavoured e-cigarettes and formulates recommendations for regulatory action. The report addresses two primary concerns: the uncertain toxicological profile of flavouring substances when inhaled, and the increasing attractiveness of e-cigarettes to young people, in part because of the available variety of flavours. It also considers the potential role of flavoured e-cigarettes in smoking cessation among adult smokers. Conclusions and recommendations are based on a narrative review of the scientific literature, including toxicological, behavioural, epidemiological, and regulatory sources.

The number of available e-liquid flavours is exceptionally high. In 2017, nearly 20 000 e-liquids with 250 distinct flavour descriptors were identified on the Dutch market. Globally, > 7 000 unique e-liquid flavours are estimated to exist. These flavours are typically composed of complex and variable mixtures of numerous individual flavouring substances. For instance, a 2020 analysis of 129 e-liquids purchased on the Belgian market identified a total of 807 different flavouring compounds. Transparency regarding the composition of an e-liquid is further complicated by the use of herbal extracts that vary in composition, and by the fact that Commission Implementing Decision (EU) 2015/2183 allows ingredients used in quantities below 0.1 % of the final e-liquid composition to be considered confidential or a trade secret.

Many flavouring substances used in e-liquids —although authorised for oral consumption— have not been adequately assessed for inhalation toxicity. The most well-known example of

¹ The Council reserves the right to make minor typographical amendments to this document at any time. On the other hand, amendments that alter its content are automatically included in an erratum. In this case, a new version of the advisory report is issued.

flavourings that are safe for oral use but cause inhalation toxicity are the diketones diacetyl and acetylpropionyl. Experimental studies demonstrate that several flavourings induce oxidative stress and exhibit cytotoxic, genotoxic, and pro-inflammatory effects in, amongst others, human respiratory epithelial cells. For example, diacetyl, 2,3-pentanedione, ethylvanillin are known to induce the production of reactive oxygen species (ROS) and interleukin-8 (IL-8), leading to inflammation and a negative impact on lung function. Besides, diacetyl can cause *bronchiolitis obliterans* (popcorn lung). Menthol is associated with decreased lung function, while its antipruritic effect can lead to longer inhalation and retention of other cytotoxic substances. Besides, creamy flavours with cinnamaldehyde pose higher risks, impairing anti-pathogen immune responses, reducing mucociliary clearance (increasing the risk of respiratory infections), and enhance oxidative stress. For many other flavourings, little is known about their inhalation toxicity, while their cumulative “mixture” effects cannot be properly assessed either. The issue of toxicological uncertainty is further exacerbated because heating and chemical interactions during vaping can generate harmful by-products, including aldehydes (e.g. carcinogenic formaldehyde, acetaldehyde), furans, and aldehyde–propylene glycol acetals, whose toxicological properties remain largely unknown.

Multiple studies have shown that the use of e-cigarettes (with nicotine) worsens and increases the likelihood of certain respiratory complaints and diseases, from shortness of breath to bronchitis-like symptoms, asthma, Chronic Obstructive Pulmonary Disease (COPD), and Asthma-COPD-Overlap Syndrome (ACOS). Besides, pooled odds ratios in one study suggest that dual use of cigarettes and e-cigarettes is riskier than the use of cigarettes alone (cardiovascular disease, stroke, metabolic dysfunction, asthma, COPD, oral disease).

In silico, *in vitro*, and *in vivo* studies on different flavoured aerosols or specific flavourings have identified genotoxic effects in both animal and human cells (e.g. DNA damage, breaks and adduct formation, mutagenesis, induction of DNA repair enzymes). In summary, it is clear that flavourings of e-cigarettes can have genotoxic effects, but we do not know to what extent these effects may occur in e-cigarette users. While epidemiological studies remain inconclusive regarding the direct association between e-cigarette use and lung cancer, this should be further studied in the future, given the long latency time for the development of lung cancer and the association with biomarkers related to cancer risk, such as DNA damage and oxidative stress. However, in 2025, the Clinical Oncology Society of Australia made the following assessment after a qualitative risk assessment: *"Nicotine-based e-cigarettes are likely to be carcinogenic to humans who use them. E-cigarettes are likely to cause lung cancer and oral cancer"*.

The evaluation of flavours is a complex and time-consuming process that requires sophisticated chemical analysis, and toxicological evaluations with many uncertainties, multiple potential endpoints and research strategies. Risk assessment is currently complicated by uncertainties in exposure assessment, a lack of reliable cumulative risk assessment strategies, and because the chemical degradation of e-liquids due to heating is not taken into account. While it is still the responsibility of the manufacturers to assure the safety of the products before they place their products on the market, this logic is definitely not being followed in practice today by e-cigarettes on the market, where uncertainty about the toxicity and safety of the many substances remains high, and increasing scientific evidence points to health risks.

The growing prevalence of vaping among young people is alarming. According to the most recent VAD Flemish Pupil Survey (2023 - 2024²) among 12 - 18 year olds, 29 % have ever used e-cigarettes, 24 % have done so in the past year, and 9 % have done so at least once a week. The proportion of regular users is now more than four times higher than in 2018 - 2019. The effects of the recent Belgian ban on disposable vapes and display ban (both in 2025) are still unknown. While curiosity is the most important motivator for youth to start vaping, behavioural data from Belgium and other countries show that flavours are an important reason for the appeal of e-cigarettes among adolescents and young people. With the introduction of “trendy” and “cool” flavours such as popcorn, bubble gum and candyfloss, the tobacco and vape industry is specifically trying to reach young people with its addictive products. According to different Belgian and international surveys, youth are particularly attracted to fruity flavours, candy, beverage and dessert flavours, which may reduce harm perception and increase susceptibility to experimentation. At the same time, flavours might potentially increase the appeal of e-cigarettes as a potential tool for smoking cessation. High-certainty evidence exists that e-cigarettes with nicotine increase quit rates (8 - 10 of 100 people quit smoking) compared to, for example, nicotine replacement therapy (NRT) (6 of 100 people quit smoking). While people > 20 years also prefer fruit flavours, the biggest difference with 10 - 20 year olds is the higher appeal of tobacco and mint flavours among older vapers. Reliable data without industry funding are scarce on the preferences of ex-smokers who have successfully quit smoking by using e-cigarettes as a temporary smoking cessation tool. However, the scarce evidence is inconclusive and shows no clear association between the use of e-cigarette flavours and smoking cessation outcomes.

The Netherlands has banned all e-cigarette flavours with effect from 1 January 2024. Only tobacco flavour is still permitted, based on a positive list of 16 flavourings that have undergone a toxicological evaluation with risk assessment. These 16 flavourings can be used to create the tobacco flavour. The initial results from a cross-sectional survey conducted by the *Rijksinstituut voor Volksgezondheid en Milieu* (RIVM) nine months after the ban are encouraging, showing that 29.5 % of the respondents reduced vaping, and quitting among 22.4 %, without clear indications of substitution with cigarettes. However, enforcement and inspections remain essential because an illegal market continues to sell flavoured products. In contrast, restrictions on flavours in certain US states show a mixed picture, with a significant decline in vaping, but also indications of undesirable substitution among a minority of vapers who have returned to smoking. The Belgian legislator must therefore carefully consider the desired and undesired effects in order to be able to anticipate the latter with accompanying measures.

Recommendation: a drastic and urgent restriction of flavours

Considering all this evidence and taking into account the principles of physical-chemical environmental hygiene (see SHC 9404, 2019), **the Superior Health Council unanimously recommends an urgent and drastic reduction in the number of flavours available for e-cigarettes.** There are two positions within the Council:

² https://vad.be/content/uploads/2025/10/Syntheserapport-2023-2024_def_GL.pdf (accessed on 21 October 2025).

- 1) **From a toxicological and precautionary perspective, part of the working group prefers a flavour ban based on the Dutch model, whereby only tobacco flavour is permitted.** This tobacco flavour may only be composed on the basis of a positive list of 16 flavourings, for which there is currently insufficient information to demonstrate harmful effects.

Several studies recommend such a ban. An advantage of this approach is uniformity with the Netherlands, and possibly other European Member States in the future, which facilitates enforcement. If this option is opted for, the positive list must be regularly re-evaluated when new toxicological and other data become available.

- 2) **From a smoking cessation perspective, another part of the working group prefers to allow a few additional flavours besides tobacco flavour (generally ≤ 3).** They propose this option out of concern that e-cigarettes could lose their attractiveness as a potential tool to help certain smokers quit, and to prevent any return of some vapers to regular cigarettes, as seen in some US states after flavour restrictions. However, the current evidence is inconclusive and shows no clear association between the use of e-cigarette flavours and smoking cessation outcomes or longer-term use of e-cigarettes, although few studies are available.

If additional flavours are to be permitted, they should be selected based on a survey of (Belgian) ex-smokers who successfully quit smoking using e-cigarettes and subsequently ceased vaping. The selected flavours should be as unappealing as possible to young people. As such a study is currently unavailable, it would need to be conducted prior to selection. After flavour selection, a positive list of flavouring substances for flavour formulation should be established using a methodology comparable to that employed by the RIVM for tobacco flavour.

Both positions are scientifically substantiated but are constrained by gaps in the available data. The decision ultimately lies with the policymakers. **However, it is evident that individual adult preferences cannot trump population-level youth protection. The existing body of scientific evidence is sufficiently robust to justify immediate regulatory action.**

To ensure that strict flavour restrictions are effectively implemented, the SHC strongly recommends significantly intensifying enforcement efforts. Drawing on the experience of the *Nederlandse Voedsel- en Warenautoriteit* (NVWA) in the Netherlands, key challenges include combating illegal trade, proving non-compliant sales, and addressing the sale of flavoured accessories (e.g. aroma balls and mouthpieces). Inspections should target importers and retail points of sale, while online platforms and social media must be closely monitored for illegal sales and advertisements, with identified violations reported and removed. Besides, age verifications at points of sale should be further controlled by means of mystery shoppers.

Finally, the SHC also advocates diplomacy with neighbouring countries to coordinate policies, to prevent cross-border purchases.

Other recommendations:

- The SHC recommends to amend the existing national and/or European legislation, so that all new nicotine products that are not medically recognised are subject to the existing laws on tobacco products, or completely banned from market introduction. In this way, healthcare policymakers can stay ahead of the tobacco industry in order to prevent “new” problems in the future where the damage must be limited “*post hoc*”, as is the case with e-cigarettes.
- The SHC recommends closely monitoring and tracking the effects of a flavour ban or flavour restrictions after implementation, so that the policy can be further refined afterwards. The positive list of permitted flavourings must be evolutionary so that new information can be responded to quickly, in one direction or the other.
- The SHC recommends launching an information campaign for vapers around the start date of flavour restrictions to prevent them from returning to traditional cigarettes, as observed in some US states.
- The SHC agrees to prohibit the presence of synthetic cooling agents (e.g. WS-23) in e-liquids, under Article 7.6d of Directive 2014/40/EU and Article 4, § 4, 5° of the Royal Decree of 28/10/2016 (prohibiting additives that facilitate the inhalation or absorption of nicotine). Their presence may undermine the efficacy of flavour bans. These should be explicitly prohibited.
- The SHC recommends to prohibit all flavoured accessories such as aroma balls and mouthpieces, as their use may undermine the efficacy of flavour restrictions.
- The SHC recommends to ban Do-It-Yourself (DIY) e-liquids, as they are even less standardised and may therefore pose serious health risks. In DIY preparation, the vaper creates their own liquid by mixing concentrated flavourings, a nicotine booster, and a PG/VG base.
- The SHC recommends (already in advisory report no. 9549) the inclusion of a maximum period of use after opening on e-liquid bottles, taking into account the stability and durability of e-liquids (for example, the sensitivity of nicotine to light). The purpose is to minimise the formation of degradation products in e-liquids and to ensure that the declared nicotine concentration is maintained.
- The SHC recommends to standardise the packaging of e-cigarettes and e-liquids and to make the packaging as neutral as possible. These measures reduce the appeal to young people.
- The SHC recommends drastically stepping up the fight against the illegal trade and market in e-cigarettes, also online. This is essential in order to ensure that further measures are also implemented in practice.

- The SHC recommends setting up more prevention campaigns that highlight the dangers of tobacco and vapes, specifically targeting young people. Besides, also parents should be encouraged to quit smoking and vaping, to set a good example. Smoking and vaping behaviour in young people is strongly linked to their parents' smoking and vaping behaviour.
- The SHC recommends encouraging independent research to determine and quantify the real world, long-term impact of e-cigarettes (both health effects and impact on smoking cessation).
- The SHC recommends that the telephone number of the quitline "*Tabakstop*" should also be mandatory on the packaging of e-cigarettes (080011100).
- The SHC recommends that the word "nicotine", the accompanying warning message and the nicotine concentration should be stated more clearly and in larger print on the packaging of e-cigarettes and all other products containing nicotine. Besides, in addition to the warning message on the addictive nature of nicotine, another warning on the "hazardous" or "toxic" character should be added.
- The SHC recommends that, to protect the environment, policy should also focus on recycling and raising awareness about e-cigarettes and their components in litter.

Some specific recommendations are also made regarding traditional tobacco products:

- The SHC recommends to continue the promotion of other evidence-based smoking cessation aids. These should be made more accessible. It should therefore be investigated whether some of these aids can be reimbursed, either in full or in part, especially for socio-economically vulnerable populations.
- The e-cigarette is a cause for concern for the SHC, but that should not detract from the need to further step up the fight against smoking traditional tobacco products. Approximately 80 to 90 % of lung cancers and associated mortality are attributable to tobacco smoking, and smokers are 20 times more likely to develop lung cancer than non-smokers. The risks increase with the length of time (number of years) and amount smoked (number of cigarettes per day) and the younger the age at which smoking starts. The vast majority of lung cancers can therefore be avoided by not starting to smoke, but also by quitting smoking. Smoking cessation initiatives should therefore be further expanded and supported, and the availability and accessibility of conventional tobacco cigarettes should be further restricted.
- The SHC recommends to strongly restrict the points of sales for the classical cigarette and all other non-medical nicotine containing products (including the e-cigarette).
- The SHC recommends continuing to work at European level to ban cigarette filters.

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I INTRODUCTION AND ISSUE

On 6 December 2024, the Superior Health Council (SHC) received a request for advice on behalf of DG Animals, Plants and Food of the FPS Public Health, Food Chain Safety and Environment (FOD VVVL) on reducing the attractiveness of e-cigarettes, primarily on a possible reduction in permitted flavour(ing)s, and if a reduction is appropriate, how this can best be implemented.

This request for advice was reformulated on 17 June 2025 by the Minister of Social Affairs and Public Health, Frank Vandenbroucke. On the basis of the Law of 24 January 1977 *“betreffende de bescherming van de gezondheid van de verbruikers op het stuk van de voedingsmiddelen en andere produkten”*, the SHC's opinion is sought on the extent to which a flavour ban for e-cigarettes based on the Dutch model could contribute to the protection of public health, and more specifically the impact of these flavour restrictions on the (initiation of) use of nicotine products by young people. Since 1 January 2024, only tobacco flavour based on a positive list of 16 permitted flavourings has been allowed for e-cigarettes in the Netherlands. If the SHC concludes that the Dutch model is not the most suitable approach, the Minister has requested that a detailed alternative should be proposed. The advice was requested for 31 October 2025.

In the past, the SHC has addressed the issue of e-cigarettes on several occasions. However, the issue is becoming increasingly urgent. The growing prevalence of vaping among young people is alarming. According to the most recent VAD Flemish Pupil Survey (2023 - 2024)³ among 12 - 18 year olds, 29 % have ever used e-cigarettes, 24 % have done so in the past year, and 9 % have done so at least once a week. The proportion of regular users is now more than four times higher than in 2018 - 2019. The effects of the recent ban on disposable vapes and display ban (both in 2025) are still unknown. This advice is therefore complementary to previous reports (SHC 9549, 2022; SHC 9827, 2025) and recommends the introduction of drastic restrictions on the number of e-liquid flavours that are permitted. Additional measures are also proposed.

Prior to this report, the SHC emphasises the importance of further measures in the fight against smoking. The literature on smoking and vaping will need to be monitored closely in the coming years, given the rapid developments in this field of research.

³ https://vad.be/content/uploads/2025/10/Syntheserapport-2023-2024_def_GL.pdf (accessed on 21 October 2025).

II METHODOLOGY

After analysing the request, the Board and the Chairs of the Chemical Environmental Factors and Mental Health working groups identified the necessary fields of expertise. An *ad hoc* working group was then set up which included experts in analytical chemistry, toxicology, pulmonology, oncology, cancer prevention, cancer screening, carcinogenesis, pharmacy, general practice, addiction, psychiatry, psychology, tobacco prevention, smoking cessation, communication. The experts of this working group provided a general and an *ad hoc* declaration of interests and the Committee on Deontology assessed the potential risk of conflicts of interest.

This advisory report is based on a review of the scientific literature published in both scientific journals and reports from national and international organisations competent in this field (peer-reviewed), as well as on the opinion of the experts.

Once the advisory report was endorsed by the working group, it was ultimately validated by the Board.

Keywords and MeSH descriptor terms⁴

MeSH terms*	Keywords	Sleutelwoorden	Mots clés	Schlüsselwörter
Electronic Nicotine Delivery Systems	Electronic cigarette	<i>Electronische sigaret</i>	<i>Cigarette électronique</i>	<i>Zigarette elektronische</i>
Tobacco	Tobacco	<i>Tabak</i>	<i>Tabac</i>	<i>Tabak</i>
Behavior, addictive	Addiction	<i>Verslaving</i>	<i>Assuétude</i>	<i>Sucht</i>
Smoke	Smoke	<i>Roken</i>	<i>Fumer</i>	<i>Rauchen</i>
Nicotine	Nicotine	<i>Nicotine</i>	<i>Nicotine</i>	<i>Nikotin</i>
Cessation, smokeless tobacco	Smoking cessation	<i>Stoppen met roken Tabaksontwenning</i>	<i>Arrêt tabagisme</i>	<i>Raucherentwöhnung</i>
Cigarettes	Cigarette	<i>Sigaret</i>	<i>Cigarette</i>	<i>Zigarette</i>
	Vaping	<i>Vapen</i>	<i>Vapoter</i>	<i>Dampfen</i>

MeSH (Medical Subject Headings) is the NLM (National Library of Medicine) controlled vocabulary thesaurus used for indexing articles for PubMed: <http://www.ncbi.nlm.nih.gov/mesh>.

⁴ The Council wishes to clarify that the MeSH terms and keywords are used for referencing purposes as well as to provide an easy definition of the scope of the advisory report. For more information, see the section entitled "methodology".

List of abbreviations used

ACGIH	American Conference of Governmental Industrial Hygienists
ACOS	Asthma-COPD-Overlap Syndrome
ALARA	As Low As Reasonably Achievable
BMDL	Benchmark Dose Lower confidence limit
COPD	Chronic Obstructive Pulmonary Disease
CI	Confidence Interval
CBD	Cannabidiol
CLP	Classification, Labelling, Packaging
CMR	Carcinogenic, Mutagenic, Reprotoxic
CT	Computed Tomography
DG	Directorate-General
DIY	Do-It-Yourself
DNA	Deoxyribonucleic Acid
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
ENDS	Electronic Nicotine Delivery System
EPA	Environmental Protection Agency
EU	European Union
EU-CEG	European Union Common Entry Gate
FARES	<i>Fonds des affections respiratoires</i>
FCTC	WHO Framework Convention on Tobacco Control
FEMA	Federal Emergency Management Agency
FEV1/FVC	Forced Expiratory Volume in 1 second / Forced Vital Capacity
FOD VVVL	<i>Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu</i>
GC-MS	Gas Chromatography and Mass Spectrometry
GHS	Globally Harmonised System
HS GC-MS	Headspace Gas Chromatography – Mass Spectrometry
IARC	International Agency for Research on Cancer
IL-8	Interleukin-8
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LC	Liquid Chromatography
MRI	Magnetic Resonance Imaging
MoE	Margin of Exposure
NOAEC	No-Observed Adverse Effect Concentration
NOAEL	No-Observed Adverse Effect Level
NRT	Nicotine Replacement Therapy
NVWA	<i>Nederlandse Voedsel- en Warenautoriteit</i>
OR	Odds Ratio
PG	Propylene Glycol
PoD	Point of Departure
pOR	pooled Odds Ratio
pRR	pooled Relative Risk
(Q)SAR	(Quantitative) Structure-Activity Relationship
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RCT	Randomised Controlled Trial
RD	Royal Decree
ROS	Reactive Oxygen Species

RIVM	<i>Rijksinstituut voor Volksgezondheid en Milieu</i>
RR	Relative Risk
SCHEER	Scientific Committee on Health, Environmental and Emerging Risks
SHC	Superior Health Council
THC	Tetrahydrocannabinol
TTC	Threshold of Toxicological Concern
US	United States of America
VAD	<i>Vlaams Expertisecentrum Alcohol en andere Drugs</i>
VG	Vegetable Glycerine
VOC	Volatile Organic Compound
WHO	World Health Organization

III ELABORATION AND ARGUMENTATION

1 The e-cigarette and the Belgian Superior Health Council

An e-cigarette (Electronic Nicotine Delivery System, ENDS) consists of three basic components:

- a reservoir of e-liquid (cartridge);
- an element that brings the e-liquid into vapor phase by means of heating (atomiser);
- a battery.

A large variety of e-cigarette devices exists (see amongst others Schaap et al., 2023; Petrella et al., 2025).

The e-liquid is typically a mixture of propylene glycol (PG) and (vegetable) glycerin (VG), which act as carriers of nicotine and flavourings in aerosol formation. After heating the e-liquid, the vapour comes into contact with cold air, which the user inhales through the device, and condenses into a visible white aerosol. Small amounts of water or organic solvents such as ethanol are sometimes added, as well as a whole range of possible flavouring chemicals. The range of flavours is very extensive (see e.g. Havermans et al., 2021) and often involves mixtures of different flavourings. In order to classify e-liquid flavours with a shared vocabulary, Krüsemann et al. (2019) distinguished 13 main categories (tobacco, menthol/mint, nuts, spices, coffee/tea, alcohol, other beverages, fruit, dessert, candy, other sweets, and unflavoured), and 90 subcategories (Figure 1).

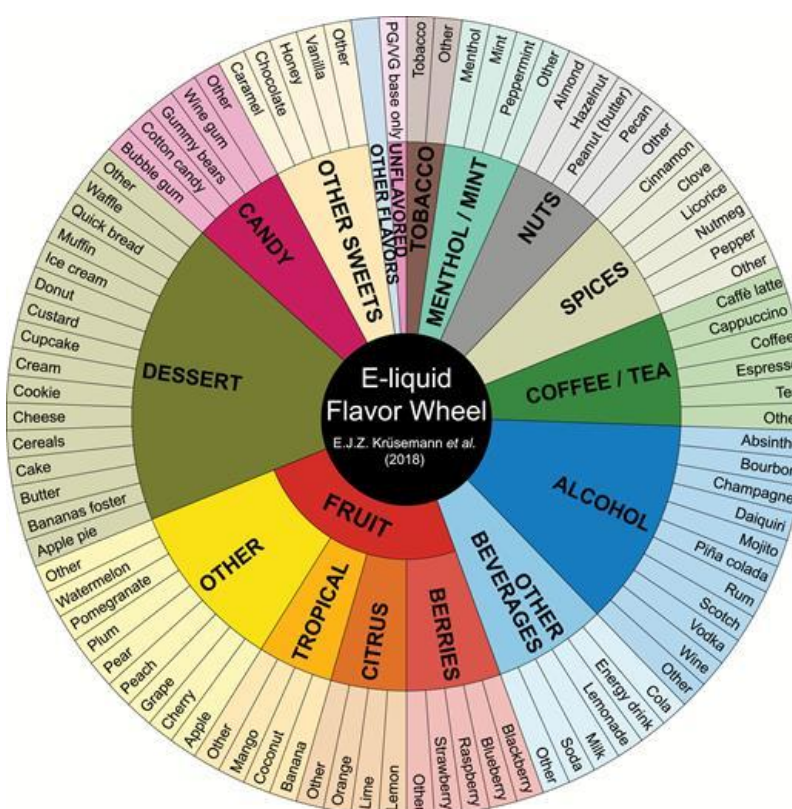


Figure 1. Flavour wheel, proposed by Krüsemann et al. (2019: fig. 2) for the classification of e-liquid flavours. Copyright Nicotine & Tobacco Research.

Given the increase of vaping prevalence, especially among youth and young adults, the SHC has provided recommendations on this topic in the past. An extensive advisory report was published in 2022 SHC (9549, 2022). Recently, in 2025, a brief literature overview based on SHC 9549 was updated, and warning messages were developed for inserts that need to be included in the e-cigarette packaging (SHC 9827, 2025).

The general position of the SHC on e-cigarettes, formed after a balanced discussion with experts from various disciplines, can be summarised in the first three warning messages for the package insert:

- A health life = no smoking, no vaping.
- E-cigarettes are strongly discouraged for non-smokers, especially young people and young adults (< 25 years) and pregnant women.
- E-cigarettes can be used as a possible aid for adult smokers to quit smoking, preferably under the supervision of a health professional.

However, the working group is well aware that there are many different products available on the internet. In this advice, we focus specifically on those products on the legal market that are under the control of the legislator and for which further measures can be taken. Appropriate control and enforcement must be stepped up for illegal sales. Especially since illegal e-cigarettes with tetrahydrocannabinol (THC) and even synthetic cannabinoids are also circulating among teenagers in our country⁵.

2 E-cigarette flavours: regulation

The composition of e-cigarettes and e-liquids is specifically regulated by the Royal Decree of 28/10/2016 “*betreffende het fabriceren en het in de handel brengen van e-sigaretten*”, which transposes Article 20 of Directive 2014/40/EU.

The liquid does not contain any of the following additives:

- vitamins or other additives that give the impression that an e-cigarette offers health benefits or poses fewer health risks. The interpretation of this provision means that the presence of CBD and vitamin E acetate, for example, is prohibited (exclusively in liquids containing nicotine);
- caffeine or taurine or other additives and stimulating chemical compounds associated with energy and vitality;
- additives that color emissions;
- additives that have CMR characteristics in unburned form.
- additives that facilitate the inhalation or absorption of nicotine

Commission Implementing Decision (EU) 2015/2183 stipulates that ingredients used in quantities exceeding 0.1 % of the final composition of the e-liquid shall not be considered confidential or a trade secret.

⁵ <https://www.vrt.be/vrtnws/nl/2025/04/22/drugs-vapes-synthetische-cannabis-pano-onderzoek-belgie-tieners/> (accessed on 21 October 2025).

3 E-cigarette flavours: toxicity and health effects

Note: This chapter has been partially reproduced and updated from Chapter 2 of SHC (9781, 2025). For the toxicity and effects of nicotine, we refer to this report.

The flavours used in e-cigarettes are usually made of synthetic flavouring chemicals that are allowed in food. Overall, there is not much qualitative research on the clinical effects of inhalation of flavourings via vaping and more studies are needed (Royal College of Physicians, 2024). The largest review on the possible risks of flavours concluded that flavourings may lead to health risks for the user, but that the available evidence for this remains limited for the time being. However, current data on the toxic effects of flavours in particular are mainly from *in vitro* research with limited *in vivo* experiments being performed (Livingstone-Banks et al., 2025). For most of the flavouring chemicals, evaluations are available as food flavourings via EFSA in the EU (Barhdadi et al., 2021) or FEMA in the US (Jabba & Jordt, 2019). However, this does not take into account the inhalation toxicity of these flavourings. In addition, it is not known which potential reaction products can be formed after heating and whether interaction products are formed in the mixture. The effects of all the potentially generated products are also unknown. The evaluations by the official institutions do provide the necessary information on potential CMR properties (carcinogenic, mutagenic, or toxic for reproduction) of the flavourings, as these properties are independent of the route of exposure.

Higher cytotoxic effects have been observed at higher concentrations of aromas (Hua et al., 2019; Omaiye et al., 2020). In addition, it has been found that sweet flavours in particular contain more flavouring chemicals than tobacco and menthol flavours (Czoli et al., 2019) and that creamy flavours and flavours with cinnamaldehyde in particular would pose higher risks (McNeill et al., 2022; Royal College of Physicians, 2024). According to Leigh et al. (2016), flavourings significantly affect inhalation toxicity of aerosol generated from ENDS. In this study, a strawberry-flavoured product appeared to be the most cytotoxic (followed by menthol and coffee flavours), decreasing cell viability, metabolic activity and release of cytokines in H292 human bronchial epithelial cells (Leigh et al., 2016). Flavouring chemicals such as diacetyl, 2,3-pentanedione, ethylvanillin are known to induce the production of ROS and interleukin-8 (IL-8), leading to inflammatory reactions and a negative impact on lung function (Petrella et al., 2025). Free radical formation by dipentene (racemic limonene), ethyl maltol, citral, linalool, and piperonal showed a dose-response relationship in the study by Bitzer et al. (2018), while ethylvanillin inhibited radical formation. The antipruritic effect of the flavouring menthol can lead to longer inhalation of aerosols, which can increase the retention of cytotoxic substances (Petrella et al., 2025).

In addition, attention should also be paid to the heating products of aromas (Royal College of Physicians, 2024). When studying the heating products of flavoured e-cigarettes, Khlystov & Samburova (2016) found a correlation between the formation of toxic aldehydes and the amount of flavouring compounds in e-liquids. The results of these experiments have not been confirmed since then (see e.g. Klager et al., 2017). However, the flavoured formulations tested by Gillman et al. (2020) resulted in an increase of 150 % - 200 % in acetaldehyde. Such studies should be carried out more often in order to gain more insight into the type of flavourings to which this applies. The heating of sucrose and glucose-containing liquids would also lead to the formation of the toxic furans: 5-hydroxymethylfurfural and furfural. In addition to heating products, interaction products are also possible as a result of reaction between the different

chemicals in a mixture (Soussy et al., 2016). Erythropel et al. (2019) described the formation of aldehyde-propylene glycol acetal adducts formed in an e-liquid matrix with flavouring chemicals such as benzaldehyde, cinnamaldehyde, citral, ethylvanillin and vanillin. The toxicological properties of these newly formed products should also be evaluated.

3.1 Genotoxicity/Carcinogenicity

All substances with CMR properties are prohibited in e-liquids, regardless of whether or not they are present in the aerosols. Several evaluations are already available for genotoxicity and carcinogenicity of the different flavourings, in particular the EFSA opinions. Studies show that e-liquids can contain genotoxic components such as: safrole, estragole, furylmethyl ketone, dimethylhydroxyfuranone, and pulegone (Jabba & Jordt, 2019; Barhdadi et al., 2021). For some flavourings, there are indications that they would have CMR properties or there are insufficient data to rule out genotoxicity. These should be further evaluated *a priori* (Liu et al., 2017; Barhdadi et al., 2021b; Kang et al., 2020). It should be noted that there are several weights of evidence for the data used to evaluate whether a chemical can be considered CMR. There is the (harmonized) CLP labelling (classification, labelling and packaging), IARC classification, individual experimental results, etc.

The literature on genotoxic properties of the e-cigarette liquids is rather limited. The study by Tommassi et al. (2017) found no significant increase in the number of mutations in mouse or human cells *in vitro* after exposure to e-cigarette vapour. The increased expression of enzymes activating procarcinogens to carcinogens was observed in human keratinocytes *in vitro* by Sun et al. (2019) and *in vivo* in rats by Canistro et al. (2017). DNA adduct formation by flavouring chemicals was predicted by *in silico* research by Kang et al. (2020). Oxidative stress after exposure to e-cigarette aerosols was observed in mice and is reported in cells of the head, neck, and mouth in humans (Platel et al., 2022; Wilson et al., 2022). Induction of DNA repair enzymes was observed in mice *in vivo* and in human cells *in vitro* (Lee et al., 2018). DNA breaks or other forms of DNA damage were detected on mammalian and human cells *in vitro* (Holliday et al., 2016; Lee et al., 2018) and *in vivo* in animals by Canistro et al. (2017), Platel et al. (2022) and Espinoza-Derout et al. (2022) and in Human Mouth Cells by Cheng et al. (2022). Mutations were observed in mice *in vivo* by Espinoza-Derout et al. (2022) and Platel et al. (2022) and *in vivo* in rats by Canistro et al. (2017). An increase in the number of micronuclei was observed in rats *in vivo* (Canistro et al., 2017). Tommassi et al. (2023) demonstrated a dose-dependent formation of DNA Damage in oral cells from vapers who had never smoked tobacco cigarettes. Moreover, users of sweet-, mint or menthol-, and fruit-flavoured e-liquids showed the highest levels of DNA damage, compared to nonusers. In summary, it is clear that compounds of e-cigarettes can have genotoxic effects, but we do not know to what extent these effects may occur in e-cigarette users.

To date, most studies have not shown a significant association between e-cigarette use and lung cancer (Petrella et al., 2025; Kundu et al., 2025). However, there is substantial evidence that exposure to the e-cigarette is associated with biomarkers related to cancer risk, such as DNA damage and oxidative stress (Allbright et al., 2024; Kundu et al., 2025). The *Scientific Committee on Health, Environmental and Emerging Risks* (SCHEER, 2021) assessed the evidence for carcinogenic effects in the respiratory tract from long-term, cumulative exposure to nitrosamines, acetaldehyde and formaldehyde as weak to moderate. However, in 2025, after a qualitative risk assessment, the Clinical Oncology Society of Australia made the

following assessment: "*Nicotine-based e-cigarettes are likely to be carcinogenic to humans who use them. E-cigarettes are likely to cause lung cancer and oral cancer.*" (Stewart, 2025). Given that many experimental studies have shown oxidative stress, inflammation and genotoxicity (see above) and given the long latency time for the development of lung cancer (often longer than the time in which the e-cigarette has been used to date), this should be further followed up in the future in qualitative, longitudinal epidemiological research. At the moment, preliminary reports from a Korean cohort study found a significant association between smokers who switched to the e-cigarette and a higher risk of lung cancer and associated mortality. This effect was more pronounced in high-risk individuals for whom it is likely recommended to participate in low-dose CT screenings) (Kim et al., 2024). Besides, several preclinical studies have reported that acute exposure to vaping may accelerate the progression of some cancers (e.g., brain tumors, bladder cancer, oral squamous cell carcinoma) (Petrella et al., 2025).

3.2 Inhalation toxicity

Special attention should be paid to the toxicity of flavourings by inhalation and especially to their toxicity on the lung epithelium. It should be noted that exposure limits of different substances set for e.g. occupational exposure should not be directly compared with the inhalation of chemicals through the use of the e-cigarette, as the exposure pattern is different (Hubbs et al., 2015), and heating takes place.

The most well-known example of flavourings that are safe for oral use but cause inhalation toxicity are the diketones: diacetyl and acetylpropionyl. Diacetyl is known to cause bronchiolitis obliterans or "*popcorn lung*" when inhaled (Cao et al., 2020). Furthermore, dose-dependent *in vitro* neurotoxic effects have been observed with both compounds (Das & Smid, 2019). E-cigarette menthol flavouring is associated with decreased lung function (reduced FEV1 % predicted and FEV1/FVC independent of age, gender, race, pack-years of smoking, and use of nicotine or cannabis-containing vaping products) in combustion cigarette smokers (Chandra et al., 2023). Another much-discussed flavouring is cinnamaldehyde. This flavouring chemical was found to be cytotoxic in several *in vitro* experiments. In addition, it would suppress the ciliary motility of the bronchial epithelial cells and therefore increase the risk of respiratory infections (Clapp et al., 2017, 2019). Other examples described in the literature are benzyl alcohol, benzylaldehyde, vanillin, banana oil, 3-hexen-1-ol acetate, 4-methyl-2-phenyl-1,3-dioxolane, 5-heptyldihydro-2(3H)-furanone, 2-propenyl ester hexanoic acid and benzaldehyde propylene glycol acetal (Czoli et al., 2019; Girvalaki et al., 2018). These flavouring substances were also found in e-liquids and contain an indication that inhalation of these aromas would be toxic. The inhalation toxicity was indicated by, in the best case, a harmonised GHS classification (Globally Harmonised System) or, in doubtful cases, by self-notified GHS classification.

In addition to irritation in the upper respiratory tract (see e.g. SCHEER, 2021), vaping has been shown to worsen or increase the likelihood of certain respiratory diseases. Passive exposure to nicotine-containing vape aerosols with different flavouring chemicals is not harmless. In young adults, it is associated with an increased risk of bronchitis-like symptoms and shortness of breath (Islam et al., 2022). Vaping is associated with an increased risk of COPD. A short-term study found that mice exposed to nicotine-containing e-cigarette aerosols were more likely to experience symptoms associated with the onset of COPD than mice that

were not exposed (Garcia-Arcos et al., 2016). A large cross-sectional study in 2019 found that e-cigarette use in humans was associated with an odds ratio (OR) of 1.75 (95 % CI: 1,25 - 2,45) on chronic bronchitis, emphysema or COPD (all three) compared to people who had never used e-cigarettes. The OR even increased to 2.64 (95 % CI: 1,43 - 4,89) among daily e-cigarette users (Osei et al., 2020). Another study showed similar results: compared to people who never use e-cigarettes, e-cigarette users had a significantly increased OR of asthma-COPD-overlap syndrome (ACOS), asthma and COPD (ORs 2.27, 1.26, 1.44, respectively) (Bircan et al., 2021). In 2025, two more meta-analyses were published showing that e-cigarette users have a higher risk of developing COPD, compared to people who do not smoke or vape. The stratified analyses by Song et al. (2025) of cross-sectional studies only (pOR = 1.55, 95 % CI: 1.26 - 1.84) and of prospective cohort studies only (pRR = 1.52, 95 % CI: 0.98 - 2.06) showed that e-cigarette users are significantly more likely to develop COPD. The meta-analysis by Malvi et al. (2025) distinguished between patterns of use over time. The pooled OR for current users of nicotine-containing e-cigarettes and COPD risk was 1.488 (95 % CI: 1.363 - 1.623), 1.839 for former users (95 % CI: 1.513 - 2.234) and 1.787 (95 % CI: 1.421 - 2.247) for people who have ever used an e-cigarette. Given the corrections made for tobacco use in the various selected studies, these results underline that nicotine-containing vapes contribute to the risk of COPD, regardless of tobacco use. Unfortunately, specific studies for vapes without nicotine seem to be lacking. Compared to the risk of COPD when smoking cigarettes, the risk of COPD with the e-cigarette is lower. In addition, dual use seems to be even riskier: in the study of Glantz et al. (2024), pooled odds ratios for dual use versus cigarettes were increased for all outcomes (range 1.20 to 1.41 for cardiovascular disease, stroke, metabolic dysfunction, asthma, COPD, oral disease).

For more information on the pulmonary effects of vaping (pulmonary cytotoxicity, lung inflammation, anti-pathogen immune response, mucociliary function, oxidative stress and DNA damage, matrix remodeling and emphysema, airway hyperresponsiveness, other lung diseases), we refer the reader to the extensive review by Allbright et al. (2024). Concerning flavours, it was concluded by these authors that cinnamon, tobacco, and mint/menthol flavourings enhance cytotoxicity and induce lung inflammation compared with other flavourings and the absence of flavourings (Allbright et al., 2024):

- Cinnamon flavourings (especially cinnamaldehyde) impair anti-pathogen immune responses, reduce mucociliary clearance, and enhance oxidative stress.
- (Some) tobacco flavourings induce oxidative stress, airway hyperresponsiveness, and DNA damage.
- Mint/menthol flavourings have been associated with increased DNA damage.

3.3 (Cardio)vascular effects

While (cardio)vascular effects linked to nicotine in cigarettes and e-cigarettes are well known (see e.g. Whitehead et al., 2021; McNeill et al., 2022; SCHEER, 2022), there are far fewer studies available on the effects of the flavourings in the e-cigarette itself. An experimental study with MRI images showed acute, adverse effects on endothelial function in healthy non-smokers after inhaling the aerosol of nicotine-free e-cigarettes (Caporale et al., 2019). However, further studies are needed on possible long-term effects (Caporale et al., 2019; McNeill et al., 2022).

3.4 Respiratory sensitisation

"Respiratory sensitisation" is a toxicological endpoint that is currently not being given much attention in e-cigarette research. Nevertheless, cases of allergic reactions were reported after using the e-cigarette (Clapp et al., 2017, 2019). Skin sensitisation, also known as type IV delayed cell-mediated hypersensitivity, would also play a role in exposure to flavours in e-cigarettes. There is already a series of well-known fragrances, used in cosmetics, which are known for their allergenic properties. It is being investigated whether these substances can also induce a sensitisation process through inhalation. A study by the Dutch National Institute for Public Health and the Environment (RIVM) has shown that iso-eugenol can indeed lead to negative effects in the respiratory system via inhalation (Ter Burg et al., 2014). However, it is unclear whether this applies to all allergenic fragrances (Basketter & Kimber, 2015). In addition to allergenic fragrances, there are other chemicals that have been found in e-liquids with a GHS classification for respiratory sensitisers (H334) such as methyl cyclopentalone and α -ionone (Girvalaki et al., 2018).

4 The evaluation of flavours: difficulties

4.1 Should we evaluate flavours or the flavouring chemicals used to create flavours?

E-cigarette consumers choose the flavours they prefer. The number of flavours is particularly large: nearly 20 000 e-liquids with 250 unique flavour descriptions were identified on the Dutch market in 2017 (Havermans et al., 2021), while more than 7 000 e-liquid flavours exist (Zhu et al., 2014). In general, e-liquid flavours can be divided into 13 main categories and 90 subcategories (Krüseemann et al., 2019) (Figure 1). Therefore, national legislators may want to intervene at this "macro" level. However, the toxicity of a certain flavour is the result of the toxicity of the various chemical flavouring substances in the e-liquid mixture, both individually and cumulatively (where additivity, synergism, or antagonism may occur).

Another disadvantage of regulations on "flavour level" is that the chemical composition of different brands is not necessarily consistent for a particular flavour. Both the mixture of flavouring substances can vary, as well as their respective concentrations. The fact that ingredients present in quantities below 0.1 % can be kept confidential or considered trade secrets (following Commission Implementing Decision (EU) 2015/2183) makes their characterisation and risk assessment increasingly complex. Substances with such low concentrations can still pose risks, depending on their toxicological profile, exposure type, and potential reactions after heating. Furthermore, when herbal extracts are used, their composition is by definition uneven and variable over time.

The chemical analysis of e-cigarette exposure is complex: aerosol analysis uses techniques like headspace static extraction and gas chromatography coupled with mass spectrometry (GC-MS), and liquid analysis uses liquid-liquid extraction techniques and liquid chromatography (LC) systems (Toledo et al., 2025). Using a headspace gas chromatography-mass spectrometry method (HS GC-MS), Barhdadi (2020) identified 807 flavouring substances in 129 liquids purchased on the Belgian market.

It can be deduced from this that the national legislator may act in two phases. On the macro level of the flavours, the decision on whether or not to allow a flavour (e.g. tobacco in the Netherlands) can be based on figures relating to attractiveness, addiction risk, importance for

potential smoking cessation and, if applicable, general toxicological assessments. Subsequently, on the micro level of the individual flavouring substances, a positive list of permitted flavourings can be compiled to “create” the permitted flavour. In the Netherlands, the RIVM has outlined a strategy for this purpose (Pennings et al., 2024).

An alternative regulatory approach would be the option for national legislators to prohibit individual substances with a negative list, a mechanism that is particularly effective when new toxicological evidence becomes available. Research initiatives examining the chemical composition of e-liquids and identifying hazardous constituents are of substantial scientific value and may yield important public health benefits. However, the present regulatory framework—whereby the inhalation toxicity of many substances currently on the market has not been adequately characterised—does not align with the principles applied in comparable chemical legislation. By way of comparison, under the European REACH regulation, manufacturers producing chemical substances in quantities exceeding one tonne per year are required to submit a comprehensive dossier, supported by high-quality scientific evidence, demonstrating that the substance satisfies safety requirements for both human health and the environment under its intended conditions of use, prior to market entry. This logic is definitely not being followed in practice today by e-cigarettes on the market, where uncertainty about the toxicity and safety of the many substances remains high, and increasing scientific evidence points to health risks (see Chapter 3).

4.2 Toxicological evaluations: a time consuming process with multiple potential endpoints and research strategies

The toxicological evaluation of e-liquid flavours and different flavouring chemicals in these flavours is a time consuming process, combining *in vivo*, *in vitro*, and *in silico* data. The results are often not binary and open to interpretation. For example, there are many different *in vitro* tests available for genotoxicity of chemical substances (e.g. Ames, comet, micronucleus), and not every substance reacts positively in each test. Given the significant amount of flavours on the market (> 7000), Barhdadi et al. (2021) developed a prioritisation strategy to identify potentially genotoxic flavourings:

- 1) Identification of the chemical substances present in the e-liquids via GC-MS screening.
 - 2) Prediction of the genotoxic potential of the substances using two complementary (quantitative) structure-activity relationship (or (Q)SAR) *in silico* models.
 - 3) Collection of existing *in vitro* and *in vivo* genotoxicity data from public literature sources (harmonized CLP classification, opinions by EFSA via the OpenFoodTox database and by the Scientific Committee on Consumer Safety, ECHA).
 - 4) *In vitro* genotoxicity testing on a selection of commercially available flavourings.
- ⇒ Based on all collected information, flavourings of high concern were identified.

The study of Barhdadi et al. (2021) shows that a full evaluation of flavourings is a complex, time consuming process that requires the use multiple techniques and the integration of a lot of scientific data. In addition, besides genotoxicity, there are numerous other health endpoints that can be evaluated, from the cellular level to the highest levels: e.g. cytotoxicity, ROS formation, irritation, pulmonary inflammation, lung function, endocrine disruption, immune responses. For the legislator, the question then arises: which endpoints (apart from CMR properties, which must lead to exclusion in any case) should be used to classify substances

for a ban in e-liquids, and how much evidence is needed to justify legislative action? The precautionary principle is essential here, especially if insufficient toxicological data is available to demonstrate safety.

4.3 Hazard, exposure and risk assessment in the context of e-cigarettes

Every chemical substance has its intrinsic hazards. However, the risk formed by a substance is the product of its hazard and the degree of exposure within a given period. To perform a risk assessment, the exposure can be evaluated with existing health-based exposure limit values for inhalation, derived by (inter)national scientific institutes and health authorities. There is a double difficulty in performing risk assessments of e-cigarettes: sufficient knowledge on hazard and exposure is not available for every substance to establish a consolidated limit value, while exposure cannot be simulated unambiguously due to factors such as variation between individuals (different puffing patterns; safety/uncertainty factors are applied for this purpose), devices and e-liquids.

Klager et al. (2017) studied aldehydes in the aerosols of 24 e-cigarette flavours. Exposure was simulated by connecting the e-cigarettes to a pump drawing air for 2 second puffs with 30 second intervals between each puff. For formaldehyde, a known IARC Group 1 carcinogen, the median concentration (626 $\mu\text{g}/\text{m}^3$) in the e-cigarette vapour exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) maximum concentration for workers (370 $\mu\text{g}/\text{m}^3$). Hence, health risks could not be excluded.

Three years later, Barhdadi (2020) performed a risk assessment for the inhalation of diacetyl. For local inhalation toxicity, the concentration in the aerosol was estimated to calculate the maximum alveolar concentration to which the respiratory tract is exposed after inhalation. A point of departure (PoD) was determined based on the NOAEC. The risk was calculated by the Margin of Exposure (MoE), which must be higher or equal than the default value 100 (assessment factor 10 for intra-species differences, and another 10 for inter-species extrapolation). The MoE is the ratio between the dose or concentration obtained from animal studies at which no harmful effect was observed (NOAEL/NOAEC, BMDL) and the estimated exposure level for humans (calculated using the exposure scenarios). It was concluded that a risk for local lung toxicity, being lung tissue lesions associated with chronic pulmonary bronchiolitis obliterans, could not be excluded in case of repeated exposure to diacetyl through e-cigarette use. Besides, a similar MoE-based assessment showed no risk for systemic toxicity related to diacetyl vapours.

The Dutch RIVM evaluated the safety of 23 of flavouring chemicals that can be used in e-liquids to make them taste like tobacco (RIVM, 2022; Pennings et al., 2024). For substances where a point of departure (PoD) could be determined, the risk assessment calculated a Margin of Exposure (MoE), with 4 different exposure scenarios. If not sufficient information was available to determine a PoD, the threshold of toxicological concern approach was used (TTC). Chemicals were removed from the list (1) if a substance has CMR toxic properties or properties that did not allow determination of a safe level of exposure; (2) if the calculated MoE for a substance was lower for one or more exposure scenarios than the minimum MoE that was considered; and (3) if the TTC approach resulted in a possible concern for a substance (RIVM, 2022; Pennings et al., 2024). A total of 7 chemicals was excluded, resulting in a “positive list” of 16 substances.

A drawback in the current risk assessment process, is that it generally focuses on one single substance, which ignores the actual combined exposure to different substances at once. Certain chemicals may interact, potentially resulting in antagonistic, additive and synergistic effects. This is particularly relevant for substances with a similar mode of action. Unfortunately, the latter is often insufficiently known for each substance in a mixture. Reliable and reproduceable Cumulative Risk Assessments are therefore highly needed, but are not currently available for e-cigarettes (and many other situations). In addition, the SHC also aware of the issue of low-dose effects (SHC 8915, 2013; SHC 9404, 2019). The significance of this for the diversity of e-liquids and flavourings is currently unknown, but cannot be ruled out *a priori*. Another major drawback is that the risk assessment process does not account for chemical degradation of the e-liquid substances due to heating.

5 Flavour attractiveness and e-cigarette addiction among young persons

The most important motivators for youth to start vaping are curiosity, the desire for social acceptance, a predisposition for taking risks, peer influence and sibling modelling (Petrella et al., 2025). In the most recent Flemish Pupil Survey (VAD-Vlaamse Leerlingenbevraging, 2023 - 2024⁶), curiosity was (one of) the reason(s) for starting to use e-cigarettes among 80.9 % of the pupils who have ever vaped. Flavours attract both young persons and adults to use e-cigarettes, but their appeal is especially relevant for young people. They may increase the product appeal, willingness to use e-cigarettes, susceptibility to use and initiation, and may decrease the harm perception on vaping products (Meernik et al., 2019; Petrella et al., 2025; Livingstone-Banks et al., 2025).

With the introduction of “trendy” and “cool” flavours such as popcorn, bubble gum and candyfloss, the tobacco and vape industry is specifically trying to reach young people with its addictive products. According to the systematic review of Meernik et al. (2019), banning non-menthol flavours in e-cigarettes may reduce e-cigarette use among young persons. It was stated that youth prefer non-tobacco-flavoured e-cigarette flavours, especially sweet flavours like fruit and candy, which was also described by Harrell et al. (2016) in Texas. Concerning fruit and candy flavours, Romijnders et al. (2018) concluded that these specific flavours are considered less harmful than other (tobacco) flavours among both youth and adult scenarios.

Among 1 549 young people (13 - 18 years) in the US who ever tried ENDS, Groom et al. (2020) found that flavour is one of the primary reasons for experimentation with ENDS among youth, while fruit flavour is strongly associated with the use of ENDS as the first tobacco product. These authors recommended to stop the sale of all e-cigarette flavours other than tobacco, a similar recommendation was made in a Dutch study by Krüsemann et al. (2021). In the latter study, it was found that that sweet- and minty-flavoured e-liquids are liked equally by young nonsmokers and adult smokers, and more than tobacco flavours.

In a consumption study among vaping youth in Canada, England, New Zealand and the USA, young people who use fruit flavours reported the highest e-liquid consumption, while some evidence exists of higher consumption levels for sweet/drinks/other flavours (Gomes et al., 2025). Also in a recent study on 598 e-cigarettes confiscated from public and private high

⁶ https://vad.be/content/uploads/2025/10/Syntheserapport-2023-2024_def_GL.pdf (accessed on 21 October 2025).

schools in Australia, it was found that students prefer fruity flavours with high concentrations of nicotine. Worryingly, most of them contained the coolant WS-23, which was potentially added to reduce throat irritation from nicotine and other chemicals (Jenkins et al., 2025).

In a 2023 study by the Belgian Cancer Foundation (*Stichting tegen Kanker*)⁷ on vaping among Belgian youth, both 15- to 20-year-olds (n=682), teaching staff (n=258) and parents of 12- to 20-year-old children (n=1097) were surveyed. The results showed that 38 % of 15- to 20-year-olds had used an e-cigarette at least once, and 16 % said they currently used them. Young people also had a different attitude towards e-cigarettes than older people: 33 % of 15- to 20-year-olds who smoke said they had used an e-cigarette at least once, compared to only 4 % of older respondents. For those over 20, vaping was a way to quit smoking for almost 9 out of 10 (88 %). Among young people aged 15 to 20, this was only 1 in 5 (20 %), indicating that vaping is a practice in itself for the youngest generation. Among the 15- to 20-year-olds and vapers, the pleasant taste, together with stress relief and relaxation, are the most important reasons to use e-cigarettes, compared to older people and persons who do not vape. 38 % of the 15- to 20-year-old vapers indicated that they had started vaping out of curiosity about new flavours (compared to 32 % of the respondents), while 26 % indicated that they might stop vaping if their favourite flavour were no longer available. The fact that there are always new flavours to discover is also a significantly more important reason for young people and vapers to use than for older people and those who do not vape. In addition, peer pressure (*"my friends do it too"*) and the feeling that using together creates a bond are also more important in the youngest age category, compared to older vapers. The fact that products are easy to obtain is also more of a reason for 15- to 20-year-olds compared to older people. According to the 2023 survey, fruit flavours are the most popular, but this is even more pronounced among people aged 15 - 20 (Figures 2 - 3). Berry flavours (59 %), tropical fruit flavours (36 %) and other fruit flavours (38 %; with watermelon being the most popular) are particularly popular among 15 - 20-year-olds. Candy flavours are also preferred by 16 %.

A recent study by *"Kom op tegen Kanker"*⁸ in 2024 among 12 - 26 years olds states that curiosity is the main motivator to try smoking (61 %, n=894) or vaping (58 %, n=1294). When thinking back to the first moment of use, *"It seemed tasty"* scored noticeably higher with e-cigarettes than with traditional tobacco products (35 % versus 16 %). This is not surprising, because while traditional tobacco products only have tobacco flavour, vapes offer an almost endless range of flavours. *"I was curious about the different flavours"* was answered by 36 % of respondents. Just like with smoking, destressing (43 %) and calming down (43 %) are important motivators to continue vaping. The pleasant taste (42 %) and the variety of flavours (28 %) were additional reasons for young people to use e-cigarettes (n=656). One in three also regarded vaping as a moment for themselves (31 %), a habit (27 %), and something that friends also do (28 %).

In 2024, the *Fonds des Affections Respiratoires* (FARES) conducted its second survey⁹ on vaping among 293 young people aged 11 to 24. The results show growing popularity: 92 % of the young people surveyed said they were familiar with vaping, which is a clear increase from the 65 % recorded in the first survey in 2022. This growing popularity is also reflected in an

⁷ https://cancer.be/wp-content/uploads/2024/01/stichting_tegen_kanker_-_rapport_jongeren_en_vapen_2023_-_nl_voor_publicatie.pdf (accessed on 21 October 2025).

⁸ https://www.komoptegenkanker.be/sites/default/files/media/2024-07/Rapport%20%20jongeren_en_vapen_juli_2024.pdf (accessed on 21 October 2025).

⁹ <https://www.aideauxfumeurs.be/la-puff-une-cigarette-electronique-qui-seduit-toujours-les-jeunes/> (accessed on 21 October 2025).

increase in use, with 39 % of young people saying they used e-cigarettes in 2024, compared to 24 % in 2022. The main motivations for consumption are varied tastes (75 %), followed by nicotine (10 %) and the feeling of relaxation (9 %). 49.2 % of young people said they used it primarily because of the flavours. As for the most popular flavours, 61 % said they preferred fruity flavours, 10 % candy flavours, 9 % menthol flavours, and 8 % flavours associated with beverages (cola, lemonade, energy drinks, etc.).

Overall, it can be concluded that flavours are an important reason for the appeal of e-cigarettes among adolescents and young people.

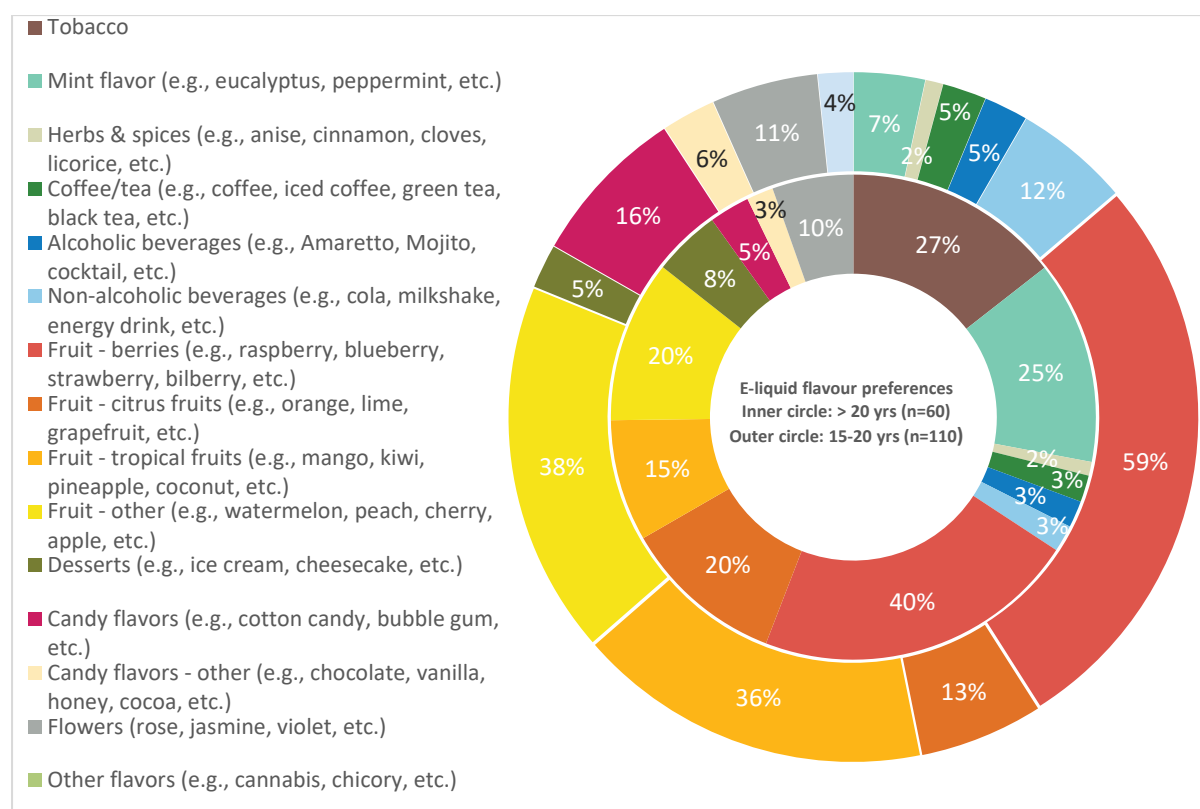


Figure 2. Preferences for e-liquid flavours among people aged 15 – 20 (outer circle) and those aged over 20 (inner circle). Based on the question: “Which three flavours do you prefer to use in your e-cigarette?”. Source: Stichting tegen Kanker, Indiville survey (2023)¹⁰.

¹⁰ https://cancer.be/wp-content/uploads/2024/01/stichting_tegen_kanker_-_rapport_jongeren_en_vapen_2023_-_nl_voor_publicatie.pdf (accessed on 21 October 2025).

According to the systematic review of Meernik et al. (2019), non-menthol flavours increase appeal, enjoyment and are the main reason many adults want to use e-cigarettes. The evidence on whether non-menthol-flavoured e-cigarettes promote or disrupt cessation among adult smokers remained unclear (Meernik et al., 2019). According to the RIVM factsheet (RIVM, 2021), smokers are particularly interested in trying e-cigarettes with a tobacco or menthol/mint flavour. People who have never smoked or vaped before mainly prefer sweet and menthol/mint flavours. Smoking adults find e-liquids with sweet flavours and e-liquids with menthol/mint flavours just as tasty as non-smoking young people (up to 18 years old) and young adults (20 - 15 years old). They also all find these sweet and minty flavours much tastier than tobacco flavours. In the 2023 survey of *Stichting tegen Kanker*, berry flavours are also the most popular (40 %) among vapers aged > 20, followed by tobacco flavour (27 %) and mint/menthol flavours (25 %) (Figures 2 - 3). The biggest difference with the 15 - 20 year olds who were surveyed is the proportion of tobacco and mint flavours among the older group.

It can be noted that the results from the 2023 *Stichting tegen Kanker* survey do not necessarily say anything about the flavours used by people who have successfully quit smoking by using e-cigarettes as temporary smoking cessation tool. Reliable data on this subject appears to be scarce in the scientific literature, and the available behavioural studies are often industry funded. A study by Russell et al. (2019), funded by an e-cigarette company, found that users of non-tobacco flavours were 30 % more likely to report smoking abstinence during the past 30 days compared to users of tobacco flavour. In the largest cross-sectional survey ever performed on patterns of flavoured e-cigarette use among adult vapers in the US (n=69,233), fruit and dessert/pastry/bakery flavours were considered particularly important among those who formerly smoked in their effort to quit smoking and to prevent relapse to smoking (Farsalinos et al., 2023). Tobacco flavours were only used by a minority of the study participants. Unfortunately, also in this study, some authors declared competing interests, including industry funding for behavioural research during the past three years. As a result, the evidence remains unreliable.

A systematic review by Lindson et al. (2023) concluded that there does not appear to be a clear association between e-cigarette flavours and smoking cessation or longer-term e-cigarette use, possibly due to a paucity of data. However, evidence exists that people using e-cigarettes to quit smoking switch between e-cigarette flavours. Similar findings were reported in the systematic review of Liber et al. (2023). These authors state that the evidence about the role of different flavored ENDS use and smoking cessation outcomes is inconclusive, reflecting highly heterogeneous study definitions and methodological limitations (Liber et al., 2023). The review by Lindson et al. (2023) was updated in 2024: Lindson et al. (2025b) concluded that smokers using e-cigarettes to quit smoking generally prefer sweet flavours, but preferences depend on the context. Based on intervention studies, no clear association was found between the use of e-cigarette flavours and smoking cessation or longer-term use of e-cigarettes (Lindson et al., 2025b). In an overview of systematic reviews, Livingstone-Banks et al. (2025) concluded that the impacts of e-cigarette flavours on e-cigarette and cigarette use are inconclusive.

7 The Dutch model

7.1 Outline

Based on scientific research into e-cigarettes and the factors that contribute to their appeal, the Dutch government has concluded that regulating e-cigarette flavours could reduce the appeal of e-cigarettes to young people. Therefore, the Netherlands banned selling e-liquids or vapes with flavours other than tobacco flavour on 1 January 2024. One year later, the packaging of vapes or e-liquids may no longer contain any reference to flavour, including the word “tobacco”.

In order to implement the flavour ban, a positive “limitative” list was created with flavouring substances necessary to compose e-liquids with tobacco flavour. The methodology followed by the RIVM to create this positive list is outlined by Pennings et al. (2024). E-liquid ingredient data was extracted from the European Common Entry Gate (EU-CEG) System, a database in which manufacturers/importers need to provide information about the composition and properties of tobacco and related products marketed in the EU. Only the set of flavourings used in tobacco flavours was selected (n=503). A restrictive list was compiled based on five selection criteria:

- 1) The flavouring must be prevalent in more than 0.5 % of all tobacco-flavoured e-liquids.
- 2) The flavouring must be used more frequently (higher %) in e-liquids with tobacco flavour compared with all e-liquids.
- 3) Flavourings that are mixtures defined as a distillation or extraction product from plant material are excluded, given the inconsistent composition of such mixtures, rendering monitoring difficult.
- 4) Flavourings associated with tobacco flavour were selected.
 - A. Flavourings with a flavour description containing the word “tobacco” or related terms like “roll-your-own” were added to the proposed list, based on the descriptions in the Leffingwell database.
 - B. Flavourings (not added in A.) with a flavour description with one of the following words were excluded: “sweet”, “honey”, “vanilla”, “caramel”, “chocolate”, “fruit(y)”, “butter(y)”, “popcorn”. Also derived words or fruit types were excluded.
 - C. For the flavourings not added in A. or excluded in B., it was determined if their flavour is part of tobacco aroma or whether they are present in tobacco or smoke. All remaining flavourings were excluded.
- 5) Health Risk Assessment. Flavourings with health hazards known from public databases (IARC, ECHA, US EPA, JECFA) were excluded.
 - A. Exposure: four exposure scenarios were defined from low to high exposure, for the median and maximum concentrations found for the 23 selected flavourings. For a person of 70 kg, the systemic dose was calculated, assuming that 70 % of the inhaled dose reaches the alveoli, and is totally absorbed there.
 - B. Hazard: substances with CMR properties were excluded. For non-CMR substances, dose-response information was collected (preferentially from inhalation studies) to determine a PoD, after which a MoE was derived. For substances with insufficient information to determine a PoD, the threshold of toxicological concern (TTC) approach was used.

➤ C. Risk Assessment: Exposure was compared with hazard.

This finally resulted in a restrictive list of 16 substances (Pennings et al., 2024; Table 1).

Table 1. The Dutch positive list of allowed flavourings for tobacco-flavoured e-liquids, compiled by the RIVM (Pennings et al., 2024: table 2).

CAS No	Flavouring name	Flavour description	Association with tobacco
35044-68-9	beta-Damascone	Complex odour of blackcurrant, plum, rose, honey and tobacco	Tobacco-like flavour
23726-91-2	(E)-beta-Damascone	Complex odour of blackcurrant, plum, rose, honey and tobacco	Tobacco-like flavour
23726-92-3	(Z)-beta-Damascone	Complex odour of blackcurrant, plum, rose, honey and tobacco	Tobacco-like flavour
23696-85-7	Damascenone	Fruity floral with apple-plum-raisin-prune, tea, rose, tobacco notes	Tobacco-like flavour
23726-93-4	(E)-beta-Damascenone	Fruity floral with apple-plum-raisin-prune, tea, rose, tobacco notes	Tobacco-like flavour
1125-21-9	Ketoisophorone	Tobacco-like , hay straw, tea notes, honey	Tobacco-like flavour
4883-60-7	2-Hydroxy-3,5,5-trimethyl-2-cyclohexenone	Sweet, musty tea, caramellic odour; musty, tea, nutty, tobacco taste	Tobacco-like flavour
536-78-7	3-Ethylpyridine	Strong tobacco , roasted, nutty, smoky notes odour; tobacco-like flavour	Tobacco-like flavour
350-03-8	3-Acetylpyridine	Strong, burnt roasted, nutty, cigar tobacco-like	Tobacco-like flavour
91-10-1	2,6-Dimethoxyphenol	Phenolic- woody -medicinal, smoky odour; a tarry, spicy, smoky (bacon) taste	Attribute of tobacco aroma
67-47-0	5-(Hydroxymethyl)-2-furfural	Herbaceous winey hay-like odour, sweet herbaceous hay and tobacco-like taste	Tobacco-like flavour
591-12-8	alpha-Angelica lactone	Sweet, bread, molasses, coumarin, tobacco odour ; nut-like taste	Tobacco-like flavour
503-74-2	Isovaleric acid	Very sour, 'sweaty', cheesy , odour; fruity on dilution	Attribute of tobacco aroma
1139-30-6	(-)-Caryophyllene oxide	Dry, woody, faint cedar, tobacco-like notes	Tobacco-like flavour
3738-00-9	Ambroxide	Intense velvety ambergris notes	Present in tobacco smoke
564-20-5	(3aR)-(+)-Sclareolide	Cedary; impact compound of certain tobaccos ; fish and berry flavour improver	Tobacco-like flavour

Terms associated with tobacco or tobacco smoke are indicated in bold.

7.2 Effects and perspectives

In a first press communication on the effects of the flavour ban (19/03/2025), a survey by the Dutch RIVM¹² among ca. 500 adolescents and young adults and 450 adults about their e-cigarette use showed 40 % of the respondents reduced their e-cigarette use, while 22 % indicated that they had completely stopped vaping. Daily use of vapes in these groups dropped from 29 to 18 %. Weekly use dropped from 30 to 14 % and monthly use from 42 to 16 %. The unintended side effects of the flavour ban were also investigated by the RIVM: purchase of flavours through the illegal market or people switching to other harmful products. Most consumers who quit because of the ban did not switch to a substitute.

More scientific details on this survey were provided in by the researchers from the RIVM and Wageningen University in an abstract for the World Conference on Tobacco Control 2025 (Hellmich et al., 2025)¹³. Nine months (September 2024) after the implementation of the Dutch flavour ban, a retrospective cross-sectional survey was performed among 548 adolescents and young adults (aged 13 - 24 years) and 457 adults (aged > 25 years), all of whom used e-cigarettes at least monthly before the flavour ban. The following results were reported (quotation):

“As a result of the ban, 39.5 % ± 1.7 % of respondents reported reduced vaping, and 22.4 % ± 1.4 % reported quitting. These outcomes did not differ between the two age groups ($p = 0.48$ and $p = 0.06$, respectively). The use of flavorless e-cigarettes among younger users increased (from 1.9 % to 3.7 %, $p = 0.01$), but there was no shift to tobacco flavors. The use of now-banned flavors declined from 91.4 % ± 0.9 % before the ban to 47.0 % ± 1.6 % after ($p < 0.01$). Among those continuing to use banned flavors, the majority (35.6 % ± 2.2 %) purchased them abroad. The use of related products (e.g., nicotine

¹² <https://www.rivm.nl/en/news/two-in-five-reduced-use-of-e-cigarettes-after-introduction-of-flavour-ban> (accessed on 21 October 2025).

¹³ <https://www.tobaccoinduceddiseases.org/A-comprehensive-evaluation-of-an-e-cigarette-flavor-ban-on-consumer-behavior-and-206322.0.2.html> (accessed on 21 October 2025).

pouches/snus) remained stable pre to post-ban, while the use of other products (e.g., cigarettes) decreased, suggesting no major substitution of e-cigarettes with alternative products.” (Hellmich et al., 2025).

Based on these data, the authors concluded that the Dutch flavour ban effectively reduced the e-cigarette use, potentially benefiting public health. However, they recommended that similar bans should be adopted on the international level, to attain maximum effectiveness (Hellmich et al., 2025).

Enforcement remains essential to uphold this ban. Since the introduction of the flavour ban on 1 January 2024, the Dutch Food and Consumer Product Safety Authority (NVWA) has removed millions of sweet-flavoured products from the Dutch market, including 1.7 million vapes with a market value of 12 million euros¹⁴. In January 2025, the NVWA seized nearly 66 000 illegal vapes and e-liquids, found at seven locations in Amsterdam, Rotterdam, Almere, and Eindhoven. The sellers were fined, and have to pay the costs of destroying the vapes and other prohibited products¹⁵. According to Van Mourik et al. (2025), NVWA inspections at importers blocked 3.5 million flavoured products and led to the recall of 800 000 more in 2024. Over 1 200 inspections were conducted, in 17 % of the cases a violation of the flavour ban was found. These authors concluded that stronger and consistent legislation is needed at the European level, to close gaps in enforcement and prevent cross-border trade in flavoured products.

8 Effects of flavour restrictions in US states

Flavour restriction policies have different and mixed outcomes, which are also affected by other accompanying measures. While the preliminary results of the Dutch flavour ban show favourable trends (after nine months, 29.5 % reduced vaping, 22.4 % reported quitting) without indications of substitution towards cigarettes (Hellmich et al., 2025), other observations were described from the US, where a mixed picture is seen, sometimes with undesirable substitution:

- Tam et al. (2023): An online, national survey of young adults aged 18 - 34 in the US was conducted in 2021 (n=1 523). Mixed responses to e-cigarette flavour bans were registered. Most young adults would continue vaping following flavour restrictions (80.9 %), while 7.8 % of those who exclusively vaped responded to switch completely to combustible tobacco, highlighting a potential negative implication of flavour restrictions.
- Friedman et al. (2024a): In the US, balanced panel analyses of 242 154 individuals (18 - 29 years) consistently found that results in states with flavour restrictions were associated with statistically significant reductions in daily vaping (-3.6 %, 95 % CI: -5.0 to -2.1), but increases in daily cigarette smoking (+2.2 %, 95 % 1.0 to 3.4), compared to changes in states without these restrictions.
- Friedman et al. (2024b): By matching new flavour policy data in 7 US states to retail sales data, these authors concluded that any public health benefits of reducing ENDS

¹⁴ <https://www.nvwa.nl/nieuws-en-media/nieuws/2024/04/23/nvwa-weert-miljoenen-vapes-met-smaakjes-van-nederlandse-markt> (accessed on 21 October 2025).

¹⁵ <https://www.nvwa.nl/nieuws-en-media/nieuws/2025/02/04/nvwa-neemt-in-maand-tijd-tienduizenden-vapes-in-beslag> (accessed on 21 October 2025).

sales via flavour restrictions may be offset by public health costs from the increased sales of cigarettes.

- Cheng et al. (2025): Flavour restrictions in 7 US states were associated with reduced e-cigarette use, but also with unintended increases in traditional cigarette use.
- Buckell et al. (2025): US state cigarette and e-cigarette flavour bans were associated with reduced vaping among those who dual use. In Massachusetts, a higher proportion of quitting all tobacco products was observed, because smokers in this state could not substitute with flavoured e-cigarettes which had been banned.
- Cotti et al. (2025): Using data from a variety of US surveys (Youth Risk Behavior Surveys, Behavioral Risk Factor Surveillance Survey, and Population Assessment of Tobacco and Health), robust evidence was found that the adoption of an ENDS flavour restriction reduced short-term frequent and everyday ENDS use among youths by ca. 2 - 3 %. However, substitution from flavoured ENDS to unflavoured ENDS and traditional cigarettes was observed among adolescents and young adults. For adults aged 31-and-older, little support exists for the hypothesis that ENDS flavour restrictions increase cigarette smoking.
- Saffer et al. (2025): Based on four national US data sets, evidence was found that young adults (18 - 24 year olds) decreased e-cigarette use by about 2.5 % after the flavour bans, while increasing cigarette participation by 3.5 % (probably an even swap, based on the standard errors of these estimates). For youth, the evidence is less clear. No effect on e-cigarette and smoking participation was found in people aged > 25.

9 Position of the Belgian Superior Health Council

9.1 Earlier position (SHC 9543, 2022)

In the Advisory report SHC (9543, 2022: p. 31 - 35), a first evaluation was made of possible policy measures to tackle the flavour issue:

“- Geen wijziging aan de huidige regelgeving. Dit voorstel werd door de experten niet aanvaardbaar bevonden.

- Totaal of drastisch verbod op aroma's in e-vloeistoffen. Sommige parlementsleden hebben wetsvoorstellen ingediend waarin wordt gepleit voor een totaal verbod op aroma's of voor een drastische vermindering van het aantal aroma's. Zo'n totaal of drastisch verbod is volgens de experten niet de oplossing. Deze optie dreigt niet verenigbaar te zijn met de noden van de gebruikers en zou daarom bij hen kunnen leiden tot frustratie; het risico bestaat dan dat zij stoppen met de e-sigaret en weer klassiek gaan roken. Men mag ook niet uit het oog verliezen dat er een aanzienlijke markt is voor aroma's (meer bepaald toegelaten aroma's voor voedingswaren), die men kan kopen en aan e-vloeistoffen toevoegen.

- Verbod op kenmerkende aroma's zoals dit in de richtlijn wordt voorgesteld voor tabaksproducten. Dit concept is evenwel moeilijk toe te passen op e-sigaretten: hoe bepaalt men of een product een kenmerkend aroma bevat, welk product moet worden toegestaan of verboden? Sommige landen (Hongarije, Finland; Nederland overweegt het) hebben het geprobeerd, maar stuiten op diverse problemen. Deze optie blijft dus niet overeind, deels omdat zij geen controle van de markt mogelijk maakt en in de praktijk de keuze van de ingrediënten overlaat aan de producenten in de landen die deze optie hebben toegepast.

- Opstellen van een negatieve lijst van additieven die verboden zijn omdat ze toxicologisch gezien een onaanvaardbaar risico inhouden versus het opstellen van een positieve lijst van additieven die toegestaan zijn omdat ze toxicologisch gezien een aanvaardbaar risico inhouden.

Zoals in het hoofdstuk V over aroma's wordt vermeld, is het onderzoek naar de toxiciteit ervan momenteel beperkt tot bepaalde aroma's. Studies naar de interacties tussen verschillende smaakstoffen en de vorming van toxische verhittingsproducten zijn schaars.

Een negatieve lijst zou dan ook beperkt blijven tot producten waarvan men over gegevens beschikt, maar zou geen enkele garantie bieden wat het aanvaardbare risico van e-sigaretmengsels op de markt betreft.

De experts zijn van mening dat een (beperkte) positieve lijst van onschadelijke stoffen moet opgesteld worden waarvan de aanwezigheid als additieven toegelaten kan worden in e-sigaretten, dit in de plaats van de meer dan 1 800 stoffen die op dit ogenblik toegelaten zijn. De toxicologische eigenschappen van de overgrote meerderheid van deze stoffen is onvoldoende gekend. Het gaat vooral om smaakstoffen of aroma's. Enkel deze additieven mogen toegelaten worden waarvan redelijkerwijze vaststaat dat ze onschadelijk zijn voor de gezondheid. Hierbij kan in de eerste plaats gekeken worden naar een beperkt aantal toxicologische eindpunten zoals genotoxische, hormoonverstorende of kankerverwekkende werking. Echter willen de experts benadrukken dat een correcte positieve lijst enkel kan opgesteld worden op basis van een volledige risicobeoordeling op wetenschappelijke basis. Verschillende noodzakelijke gegevens zijn hier echter niet beschikbaar zoals blootstellingsgegevens (intensiteit van het vaperen, gehalte aan additieven, enz.) en toxicologische referentiewaarden. Bovendien moeten om het toxicologisch aanvaardbare risiconiveau te evalueren de toelaatbare doseringen/concentraties en eventueel de mogelijke wisselwerkingen tussen ingrediënten worden bepaald.

...

Het samenstellen van een dergelijke lijst zou evenwel, net als een klassieke positieve of negatieve lijst, de consument de indruk kunnen geven dat de gezondheidsautoriteiten verzekeren dat de verschillende additieven op de markt risicoloos zijn en dat dit ook geldt voor de consumptie van e-sigaretten. Dat zal uiteraard niet het geval zijn en daarom zal bijzondere aandacht moeten gaan naar de overheidscommunicatie daaromtrent."

It should be noted that the SHC's 2022 recommendation for a limited positive list is therefore very similar to the Dutch approach by the RIVM (Pennings et al., 2024), that has since been implemented.

9.2 Objective and possible negative impact of measures

The Belgian legislator must therefore carefully consider the desired and undesired effects in order to be able to anticipate the latter with accompanying measures. With measures restricting the use of flavourings in e-cigarettes, the following favourable outcomes are aimed:

- Objective 1: Reduce the overall (sensory) appeal of e-cigarettes.
- Objective 2: Protect young people from the design and appeal of e-cigarettes targeted at this age group.
- Objective 3: Reduce the number of non-smoking persons who start vaping.
- Objective 4: Reduce the number of (long-term) dual users.

On the other hand, negative side effects may emerge, and should be taken into account when developing new policies:

- Negative side effect 1: Decreasing the appeal of vaping as a possible smoking cessation aid, causing smoking persons to return to traditional tobacco products.
- Negative side effect 2: The increase in illegal sales on the black market and the internet.
- Negative side effect 3: The purchase of prohibited flavours abroad where they are still permitted.
- Negative side effect 4: People may add inappropriate flavourings to e-liquids themselves, with potentially serious (acute) toxic effects.

9.3 Physical-Chemical Environmental Hygiene and the precautionary principle

While acknowledging that chemistry and technical progress have greatly improved life expectancy and living conditions, the Superior Health Council expressed serious concerns in its advisory report SHC (9402; 2019) about the ever-increasing complex exposure of people to chemicals throughout their lives, and the emergence of civilisation diseases. Real life exposures do not occur to single agents but instead involve complex mixtures of many chemicals and other hazards, with possible interactions between them explaining adverse effects. Sufficient mechanistic insights and molecular-epidemiological data are available indicating that a series of chemical substances contribute importantly to many diseases of civilisation, even if definite epidemiological proof is not yet available. Mutagenic agents, endocrine disruptors, substances binding to hormone receptors, and substances binding to nuclear receptors functioning as transcription factors (which thus can affect gene expression and/or have epigenetic effects) are important, especially with relation to cancer, and contribute also to the risk of other diseases of civilization. Exposures early in life can interfere with an optimal development and can result in disease later in life. An important aspect of the problem is the huge number of chemical substances, among which probably a few percent have mutagenic, carcinogenic, endocrine disrupting or receptor binding properties. Assessing the toxicological properties for humans of a chemical is time consuming and costly, only a very small minority of the chemicals have been adequately studied so far. Therefore a holistic approach involving avoidance or reduction of exposure to many different agents is desirable along the precautionary principle. Hence, the SHC proposed a particular form of hygiene, “physical chemical environmental hygiene” (SHC, 9404; 2019 and Bourguignon et al., 2018). This strategy should act at both the regulatory level (restricting exposure and authorisation of

substances if their safety cannot be sufficiently demonstrated, and extending the ALARA principle: exposures should not only be as low as possible, but also as late in life as possible, as short as possible and as few as possible) and at the individual level (international scientific panels should develop preventive measures for target groups, especially pregnant women and children, followed up with human biomonitoring and longitudinal evaluation of health endpoints in the offspring).

The matter of e-cigarette flavourings exemplifies this concern. Individuals may be variably exposed to a myriad of flavourings, many of which have undergone toxicological evaluation solely for oral ingestion rather than inhalation, with substantial uncertainties regarding long-term health effects, potential chemical interactions, low-dose and mixture effects. This unsafe and uncertain exposure is unacceptable to the SHC and justifies an urgent restriction based on the precautionary principle. The pronounced, specific appeal of the extensive range of flavours to young people further augments the urgency of intervention (see Belgian survey data by *Stichting tegen Kanker, Kom op tegen Kanker, Fonds des Affections Respiratoires* between 2023 and 2024; Meernik et al., 2019; Petrella et al., 2025). The growing prevalence of vaping among young people is alarming. According to the most recent Flemish Pupil Survey (VAD - *Vlaamse Leerlingenbevraging*, 2023 - 2024¹⁶) among 7 522 pupils between 12 - 18 years, 29 % have ever used e-cigarettes, 24 % have done so in the past year, and 9 % have done so at least once a week. The proportion of regular users is now more than four times higher than in 2018 - 2019.

9.4 Recommendation: a drastic restriction of flavours

Considering all scientific arguments, including:

- The increasing prevalence of vaping among young people, who are particularly vulnerable to chemical exposure.
- The specific appeal of the many flavours to young people, including flavours specifically targeted at young people (e.g. chewing gum, popcorn, etc.).
- The uncertainty surrounding the toxicological profile and health effects of thousands of flavourings in complex mixtures.
- The growing evidence of adverse health effects due to flavoured e-cigarettes, observed in both *in vitro*, *in vivo* and epidemiological studies (Short-term: increased risk of, among others, irritation of the throat, eyes, and respiratory tract; respiratory symptoms including coughing and conditions resembling pneumonia; asthma attacks and exacerbation of existing asthma; certain cardiovascular effects. Long-term: damage to the respiratory tract, increased risk of serious pulmonary diseases such as COPD; genotoxicity that may contribute to the development of cancers; adverse effects on foetal development and birth outcomes; and other still unknown effects. See SHC 9827, 2025; SHC 9549, 2022; Albright et al., 2024 and Petrella et al., 2025).
- Favourable preliminary results (after nine months) of the Dutch flavour ban, showing a reduction of vaping among 29.5 % of the respondents, and quitting among 22.4 %, without clear indications of substitution towards cigarettes (Hellmich et al., 2025).
- The principles of physical-chemical environmental hygiene (see SHC 9404, 2019).

¹⁶ https://vad.be/content/uploads/2025/10/Syntheserapport-2023-2024_def_GL.pdf (accessed on 21 October 2025).

The Superior Health Council unanimously recommends an urgent and drastic reduction in the number of flavours available for e-cigarettes. There are two positions within the Council:

- 1) **From a toxicological and precautionary perspective, part of the working group prefers a flavour ban based on the Dutch model, whereby only tobacco flavour is permitted.** This tobacco flavour may only be composed on the basis of a positive list of 16 flavourings, for which there is currently insufficient information to demonstrate harmful effects (Pennings et al., 2024).

Several studies recommend such a ban (e.g. Groom et al., 2020; Krüsemann et al., 2021). An advantage of this approach is uniformity with the Netherlands, and possibly other European Member States in the future, which facilitates enforcement (see Van Mourik et al., 2025). If this option is opted for, the positive list must be regularly re-evaluated when new toxicological and other data become available.

- 2) **From a smoking cessation perspective, another part of the working group prefers to allow a few additional flavours besides tobacco flavour (generally ≤ 3).** They propose this option out of concern that e-cigarettes could lose their attractiveness as a potential tool to help certain smokers quit (Lindson et al., 2025a), and to prevent any return of some vapers to regular cigarettes, as seen in some US states after flavour restrictions (Tam et al., 2023; Friedman et al., 2024a, 2024b; Cheng et al., 2025; Cotti et al., 2025, Saffer et al., 2025). However, the current evidence is inconclusive and shows no clear association between the use of e-cigarette flavours and smoking cessation outcomes or longer-term use of e-cigarettes, although few studies are available (Liber et al., 2023; Lindson et al., 2023, 2025b; Livingstone-Banks et al., 2025).

If additional flavours are to be permitted, they should be selected based on a survey of (Belgian) ex-smokers who successfully quit smoking using e-cigarettes and subsequently ceased vaping. The selected flavours should be as unappealing as possible to young people. As such a study is currently unavailable, it would need to be conducted prior to selection. After flavour selection, a positive list of flavouring substances for flavour formulation should be established using a methodology comparable to that employed by the RIVM for tobacco flavour (Pennings et al., 2024).

For some flavours, it is already clear that they are not eligible. For example, watermelon is the most popular flavour among youths aged between 15 and 20, according to the 2023 survey by *Stichting tegen Kanker*. While not popular among adolescents, mint/menthol flavour cannot be allowed anymore under Article 7.6d of Directive 2014/40/EU and Article 4, § 4, 5° of the Royal Decree of 28/10/2016 (prohibiting additives that facilitate the inhalation or absorption of nicotine). The anti-irritant effect of the flavouring menthol can lead to longer inhalation of aerosols, which can increase the retention of cytotoxic substances (Petrella et al., 2025). A recent randomised crossover clinical trial showed that menthol-flavoured e-cigarettes enhanced e-cigarette use experience compared with tobacco flavour (Chowdhury et al., 2025). This study suggests that menthol in e-cigarettes poses a risk to nicotine-naïve youth to initiate e-cigarette use and keep those young people currently using,

addicted (Chowdhury et al., 2025). In a study by Leigh et al. (2016), menthol, coffee and strawberry-flavored aerosol significantly reduced both cell viability and metabolic activity. Besides, multiple studies indicate that creamy flavours and flavours with cinnamaldehyde in particular pose higher risks (McNeill et al., 2022; Royal College of Physicians, 2024). Cinnamon flavourings can impair anti-pathogen immune responses, reduce mucociliary clearance, and enhance oxidative stress (Allbright et al., 2024).

Both positions are scientifically substantiated but are constrained by gaps in the available data. The decision ultimately lies with the policymakers. **However, it is evident that individual adult preferences cannot trump population-level youth protection. The existing body of scientific evidence is sufficiently robust to justify immediate regulatory action.**

To ensure that strict flavour restrictions are effectively implemented, the SHC strongly recommends significantly intensifying enforcement efforts. Drawing on the experience of the *Nederlandse Voedsel- en Warenautoriteit* (NVWA) in the Netherlands (Van Mourik et al., 2025), key challenges include combating illegal trade, proving non-compliant sales, and addressing the sale of flavoured accessories (e.g. aroma balls and mouthpieces). Inspections should target importers and retail points of sale, while online platforms and social media must be closely monitored for illegal sales and advertisements, with identified violations reported and removed (Van Mourik et al., 2025). Besides, age verifications at points of sale should be further controlled by means of mystery shoppers.

Finally, the SHC also advocates diplomacy with neighbouring countries to coordinate policies, to prevent cross-border purchases.

9.5 Other recommendations

- The SHC recommends to amend the existing national and/or European legislation, so that all new nicotine products that are not medically recognised are subject to the existing laws on tobacco products, or completely banned from market introduction. In this way, healthcare policymakers can stay ahead of the tobacco industry in order to prevent “new” problems in the future where the damage must be limited “*post hoc*”, as is the case with e-cigarettes.
- The SHC recommends closely monitoring and tracking the effects of a flavour ban or flavour restrictions after implementation, so that the policy can be further refined afterwards. The positive list of permitted flavourings must be evolutionary so that new information can be responded to quickly, in one direction or the other.
- The SHC recommends launching an information campaign for vapers around the start date of flavour restrictions to prevent them from returning to traditional cigarettes, as observed in some US states.
- The SHC agrees to prohibit the presence of synthetic cooling agents (e.g. WS-23) in e-liquids, under Article 7.6d of Directive 2014/40/EU and Article 4, § 4, 5° of the Royal Decree of 28/10/2016 (prohibiting additives that facilitate the inhalation or absorption

of nicotine). Their presence may undermine the efficacy of flavour bans (Jenkins et al., 2025, Minetti et al., 2025). These should be explicitly prohibited.

- The SHC recommends to prohibit all flavoured accessories such as aroma balls and mouthpieces, as their use may undermine the efficacy of flavour restrictions.
- The SHC recommends to ban Do-It-Yourself (DIY) e-liquids, as they are even less standardised and may therefore pose serious health risks. In DIY preparation, the vaper creates their own liquid by mixing concentrated flavourings, a nicotine booster, and a PG/VG base.
- The SHC recommends (already in advisory report no. 9549) the inclusion of a maximum period of use after opening on e-liquid bottles, taking into account the stability and durability of e-liquids (for example, the sensitivity of nicotine to light). The purpose is to minimise the formation of degradation products in e-liquids and to ensure that the declared nicotine concentration is maintained.
- The SHC recommends to standardise the packaging of e-cigarettes and e-liquids and to make the packaging as neutral as possible. These measures reduce the appeal to young people (see e.g. Taylor et al., 2025).
- The SHC recommends drastically stepping up the fight against the illegal trade and market in e-cigarettes, also online. This is essential in order to ensure that further measures are also implemented in practice.
- The SHC recommends setting up more prevention campaigns that highlight the dangers of tobacco and vapes, specifically targeting young people. Besides, also parents should be encouraged to quit smoking and vaping, to set a good example. Smoking and vaping behaviour in young people is strongly linked to their parents' smoking and vaping behaviour.
- The SHC recommends encouraging independent research to determine and quantify the real world, long-term impact of e-cigarettes (both health effects and impact on smoking cessation).
- The SHC recommends that the telephone number of the quitline “*Tabakstop*” should also be mandatory on the packaging of e-cigarettes (080011100).
- The SHC recommends that the word “nicotine”, the accompanying warning message and the nicotine concentration should be stated more clearly and in larger print on the packaging of e-cigarettes and all other products containing nicotine. Besides, in addition to the warning message on the addictive nature of nicotine, another warning on the “hazardous” or “toxic” character should be added.
- The SHC recommends that, to protect the environment, policy should also focus on recycling and raising awareness about e-cigarettes and their components in litter.

Some specific recommendations are also made regarding traditional tobacco products:

- The SHC recommends to continue the promotion of other evidence-based smoking cessation aids. These should be made more accessible. It should therefore be investigated whether some of these aids can be reimbursed, either in full or in part, especially for socio-economically vulnerable populations.
- The e-cigarette is a cause for concern for the SHC, but that should not detract from the need to further step up the fight against smoking traditional tobacco products. Approximately 80 to 90 % of lung cancers and associated mortality are attributable to tobacco smoking, and smokers are 20 times more likely to develop lung cancer than non-smokers (Boyle & Maisonneuve, 1995; Cislighi & Nimis, 1997; IARC, 2004; Jemal et al, 2008; Wood et al, 2018; Surgeon General, 2004; All.Can Belgium, 2024). The risks increase with the length of time (number of years) and amount smoked (number of cigarettes per day) and the younger the age at which smoking starts. The vast majority of lung cancers can therefore be avoided by not starting to smoke, but also by quitting smoking. Smoking cessation initiatives should therefore be further expanded and supported, and the availability and accessibility of conventional tobacco cigarettes should be further restricted.
- The SHC recommends to strongly restrict the points of sales for the classical cigarette and all other non-medical nicotine containing products (including the e-cigarette).
- The SHC recommends continuing to work at European level to ban cigarette filters (SHC 9726, 2023; Everaert et al., 2023).

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V COMPOSITION OF THE WORKING GROUP

The composition of the Committee and that of the Board as well as the list of experts appointed by Royal Decree are available on the following website: [About us](#).

All experts joined the working group *in a private capacity*. Their general declarations of interests as well as those of the members of the Committee and the Board can be viewed on the SHC website (site: [conflicts of interest](#)).

The following experts were involved in drawing up and endorsing this advisory report. The working group was chaired by **Filip LARDON** and **Frieda MATTHYS**; the scientific secretary was **Stijn EVERAERT**.

BARHDADI Sophia	Pharmacy, e-cigarettes, analytical chemistry	Sciensano
CATALDO Didier	Pulmonology, molecular biology	<i>ULiège</i> , BeRS
CRUNELLE Cléo	Neuroscience, addiction	VUB, <i>UZ Brussel</i>
DECONINCK Eric	Analytical chemistry, additives, contaminants	Sciensano
EGER Katrien	Pulmonology	UZA, BeRS
FRAEYMAN Norbert	Pharmacy, toxicology	<i>UGent</i>
GABRIELS Suzanne	Tobacco prevention, smoking cessation, psychology	<i>Stichting tegen Kanker</i>
GODDERIS Lode	Occupational medicine, prevention, toxicology	<i>KU Leuven</i> , IDEWE
GOEMINNE Pieter	Pulmonology	VITAZ, BeRS
HAFID Imane	General practice	SSMG
JANSSENS Annelies	Thoracic oncology	UZA
LARDON Filip	Oncology, medical physiology	<i>UAntwerpen</i>
MATTHYS Frieda	Psychiatry	VUB
MAES Veerle	Cancer prevention	<i>Kom op tegen Kanker</i>
MEUNIER Adrien	Smoking cessation	<i>Hôpital de la Citadelle</i>
MICHEL Olivier	Pulmonology	ULB
POCHET Sophie	Marketing, communication	<i>Haute École Galilée</i>
SCHOETERS Greet	Environmental health, toxicology	<i>UAntwerpen</i>
VAN HAL Guido	Tobacco prevention, medical sociology, cancer screening	<i>UAntwerpen</i>
VAN LAREBEKE Nicolas	Carcinogenesis, cancer prevention	<i>UGent</i> , VUB
VERHEYEN Marc	Tobacco prevention, training and professional development	VRGT
WILLAME Elise	Tobacco prevention	FARES

The following expert was heard but did not take part in endorsing the advisory report:

HENDRICKX Stefaan	Tobacco prevention, smoking cessation, health inequality	<i>Vlaams Instituut Gezond Leven</i>
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About the Superior Health Council (SHC)

The Superior Health Council is a federal advisory body. Its secretariat is provided by the Federal Public Service Health, Food Chain Safety and Environment. It was founded in 1849 and provides scientific advisory reports on public health issues to the Ministers of Public Health and the Environment, their administration, and a few agencies. These advisory reports are drawn up on request or on the SHC's own initiative. The SHC aims at giving guidance to political decision-makers on public health matters. It does this on the basis of the most recent scientific knowledge.

Apart from its 25-member internal secretariat, the Council draws upon a vast network of over 500 experts (university professors, staff members of scientific institutions, stakeholders in the field, etc.), 300 of whom are appointed experts of the Council by Royal Decree. These experts meet in multidisciplinary working groups in order to write the advisory reports.

As an official body, the Superior Health Council takes the view that it is of key importance to guarantee that the scientific advisory reports it issues are neutral and impartial. In order to do so, it has provided itself with a structure, rules and procedures with which these requirements can be met efficiently at each stage of the coming into being of the advisory reports. The key stages in the latter process are: 1) the preliminary analysis of the request, 2) the appointing of the experts within the working groups, 3) the implementation of the procedures for managing potential conflicts of interest (based on the declaration of interest, the analysis of possible conflicts of interest, and a Committee on Professional Conduct) as well as the final endorsement of the advisory reports by the Board (ultimate decision-making body of the SHC, which consists of 30 members from the pool of appointed experts). This coherent set of procedures aims at allowing the SHC to issue advisory reports that are based on the highest level of scientific expertise available whilst maintaining all possible impartiality.

Once they have been endorsed by the Board, the advisory reports are sent to those who requested them as well as to the Minister of Public Health and are subsequently published on the SHC website (www.hgr-css.be). Some of them are also communicated to the press and to specific target groups (healthcare professionals, universities, politicians, consumer organisations, etc.).

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