

# Current knowledge about electronic cigarettes

As electronic cigarette usage becomes more common, practice nurses need to fully understand the health implications of e-cigs before they can advise their patients, writes **Dr Graham Cope**

## ABSTRACT

The emergence and growth of electronic cigarette (e-cig) usage has been one of the most significant changes to public health in recent times. The public are increasingly aware of the harmful effects of smoking and as a consequence many are looking to alternative, 'healthier' forms of nicotine delivery, either to maintain their addiction or, in some cases, to stop their smoking habit. The evidence suggests that e-cigs are a 'healthier' form of nicotine delivery than conventional cigarettes, but there are chemicals produced by these devices, including nicotine that have significant effects on health, especially if used long-term.

**Key words** | COPD | Electronic cigarette | Nicotine | Smoking cessation | TPD

**T**obacco smoking is a well-established risk factor for cancer and chronic inflammation of the lung leading to COPD, cardiovascular disease and several other conditions, affecting every organ system in the body (Cope, 2016). Smoking-related diseases are a significant burden on the NHS infrastructure, being responsible for estimated costs of more than £5bn a year (Allender, 2009). This includes the expenditure for hospital admissions, GP consultations and prescriptions, but the cost to the UK society as a whole is much higher, estimated at over £13bn, by including the loss in productivity and increased absenteeism (Nash and Featherstone, 2010).

Since their introduction in 2004, there has been rapid growth in sales of e-cigs, with an estimated 2.8 million regular users in the UK (ASH, 2016a). During this time e-cigs have been largely unregulated, being freely available, with the growth of specialist outlets and sales in supermarkets. Meanwhile, they have been

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heavily advertised on TV, in cinemas and on then internet (Bauld et al, 2014).

## Electronic cigarettes

Electronic cigarettes contain an atomiser usually charged by a re-chargeable lithium battery that produces a vapour by heating a solution of nicotine usually in propylene glycol or glycerine, sometimes up to 350°C (Britton and Bogdanovica, 2014). The reported concentrations of nicotine vary from zero to 24 mg/mL, but there are many uncertainties about the nicotine delivery and the advertised amounts (Buettner-Schmidt et al, 2016). There are also wide variations in the solvents and the flavourings used in the e-cig liquids or 'juice', many of which are chosen to be attractive to younger users (Oncken et al, 2015).

Electronic cigarettes are generally considered by smokers to be a safer way of inhaling nicotine (*Box 1*) and perceived as a more appealing way of quitting smoking than nicotine replacement therapy (NRT), being more akin to smoking a cigarette, providing the feel and sensory experience the smokers need (West, 2015); with a consequence that the 'over-the-counter' (OTC) sales of NRT have fallen, and there's been a decline in the number of people attending stop smoking services (HSCIC, 2015).

One major concern about the surge in e-cig usage is the take up by adolescents and if it could lead to them to adopting combustible cigarettes, thus acting as a 'gateway' to the harmful effects of tobacco. Initially the evidence was that the vast majority of e-cig users were ex- or current users of tobacco (McNeill et al, 2015), but more recent evidence from the USA shows a high proportion of young e-cig users, particularly college students who had never smoked cigarettes were either current users of e-cigs (Kenne et al, 2016) or there was a strong intention to use normal cigarettes in the future (Barrington-Trimis et al, 2016).

## Toxicology

E-cigs have been proposed by manufacturers and supporters as a useful tool for harm reduction and as an effective aid to quit (Brown, Beard et al, 2014). However a recent review concluded that e-cigs are no more efficient at helping people quit than OTC NRT and that regular users were 28% less likely to quit smoking than non-users (Kalkhoran and Glantz, 2016).

**Box 1: Benefits of e-cigs over combustible cigarettes**

- Vastly reduced particulate matter in the vapour
- No 'tar' and fewer carcinogens
- No carbon monoxide
- Significantly less secondhand emissions

**Box 2: Identified toxicants in e-cig vapour**

- Nicotine – deleterious to the nervous system and to many non-neurological cells types, including the immune system
- Heavy metals including chromium, cadmium, mercury, and aluminium
- Tobacco-specific nitrosamines being emitted from some devices
- DNA-damaging free radicals
- Formaldehyde and acetaldehyde, especially when the heating element is operated at high voltage

**Solvent and flavours**

It is clear that e-cigs are much less harmful to human health than combustible cigarettes. They are devoid of, or contain much less of the most damaging toxins in tobacco, such as the carcinogenic nitrosamines, tissue damaging free radicals and oxygen depriving carbon monoxide. However, recent analysis has shown that e-cigs do produce various toxins in their vapour, mainly derived from the solvents or flavourings including heavy metals, potential carcinogens, formaldehyde and acrolein (Box 2) (Pisinger and Døssing, 2014).

Traces of heavy metals, such as chromium, cadmium and mercury have been found in some e-cig emissions, which are damaging to soft mucosal tissues, while nicotine-derived nitrosamines have also been detected, albeit at much lower concentrations than found in tobacco smoke. Also, DNA-

damaging free radicals have also been detected (Goel, 2015), along with toxic levels of formaldehyde, acetaldehyde and acrolein (Pisinger and Døssing, 2014).

Some e-cigs solutions also contain harmful flavourings including diacetyl and acetyl propionyl, which are used to add a buttery taste to the e-cig vapour and are known to cause bronchiolitis obliterans, a debilitating inflammatory lung disease (Farsalinos et al, 2013).

**Nicotine**

The vapour from e-cigs provide a relatively high concentration of nicotine, and plasma levels have been shown to be similar to that when using conventional cigarettes (Marsot and Simon, 2016). Although nicotine from NRT and e-cigs is considered by many to be relatively safe (McNeill et al, 2015), there is recent evidence that nicotine is deleterious to parts of the nervous system, especially during neonatal development, with concerns about the use of e-cigs during pregnancy (Suter et al, 2015). It also has harmful effects on many non-neurological cells, including those in the respiratory tract, immune system and the blood vasculature (Cope, 2016). Stimulation of nicotine receptors in the blood vessels increases the formation of atheroma and causes inflammation (Santanam et al, 2012) and in other organs ranging from the eye, to the gastrointestinal tract and the reproductive organ, it causes the cells to malfunction and diseases to ensue (Cope, 2016). Nicotine is also responsible for the impaired immune response post-surgery, leading to increased risk of infection and poor wound healing. Consequently, the use of e-cigs is not recommended before or after surgery (Davies and Ismail, 2016).

**Unexpected problems**

As well as potential harm to the users, nicotine is also a poison and there has been reports of accidental ingestion of nicotine solutions by children, some of which have been fatal (Gupta et al, 2014) and there has been reports of intentional intake of the fluids during suicide attempts (Schipper et al, 2014). Other problems arise from substandard and unregulated manufacture, leading to injuries and fatalities (Brown and Cheng, 2014) and fires due to exploding battery chargers (BBC, 2014).

Earlier this year new regulations brought the sale of e-cigs under the EU Tobacco Products Directive (TPD). This should largely prevent explosions and poisonings, but there will be sometime before these problems can be eradicated as there is a transition period which allows



Figure 1: E-cigs might be healthier, but they still produce various toxins

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**Box 3: EU Tobacco Products Directive (TPD) regulation (from May 2016)**

- Child resistant / tamper evident packaging is required for liquids and devices
- The device must be protected against breakage and leakage and capable of being refilled without leakage
- Devices must deliver a consistent dose of nicotine under normal conditions
- Tank and cartridge sizes must be no more than 2 ml in volume and nicotine strengths of liquids must be no more than 20 mg/ml

retailers to sell off their existing stock and thereafter adhere to the new regulations. This means e-cigs or refill containers which are not compliant can be sold until 20 November 2016 and from May 2017 all products sold to consumers must be fully compliant with the TPD (ASH, 2016b) (Box 3).

**Attitudes of health-care professionals**

While the public sees e-cigs as a safer alternative to smoking and a potential means of quitting, the opinion of many primary health-care professionals about the safety and efficacy of the devices as smoking cessation aids appear to be negative or ambivalent.

One recent study carried out in the Netherlands found 70% of GPs and smoking cessation advisors believed that e-cigs are harmful to long-term users, and about half to two thirds believed that e-cigs are carcinogenic, increase cardiovascular risk, and enhance the risk of chronic lung disease (van Gucht and Baeyens, 2016).

Another study from the USA found nearly 70% of smoking cessation counsellors believed that e-cigs are not effective quitting aids, with most believing that they are addictive and that secondhand exposure to vapour is harmful. Therefore, most counsellors in the survey believed e-cigs should be regulated like combustible cigarettes in terms of advertising, taxation, access by minors, and use in public places (Cummins et al, 2016).

**Advice to patients**

Taking these findings into account, the prevailing attitude is that pharmacotherapy such as NRT, bupropion, varenicline with behavioural support should be recommended for most smokers trying to quit; with the use of different NRT formulae in combination, usually with slow-release

type (patch) used with rapid release, such as nicotine gum, lozenge, inhaler, or nasal spray when needed, being the first choice (Stead et al, 2012).

However, many patients are disillusioned with pharmacotherapy, with a high non-adherence rate to the treatment (Yingst et al, 2015). They are increasingly aware of e-cigs and because of their free availability, advertising and anecdotal evidence, many people have used the devices either as a replacement for combustible cigarettes when they

cannot smoke, but still continue to use normal cigarettes, albeit in smaller numbers; while others have used them as a smoking cessation tool.

But considering the effects of nicotine on the cardiovascular and immune systems e-cigs potentially pose a significant danger to those ‘at risk’ (Morris et al, 2015). Therefore, all patients need to be asked about their use as part of routine history taking (Table 1). This can be problematic because as with normal cigarettes there may be a significant degree of denial or under-reporting (Park et al, 2015). For accurate determination point-of-care cotinine testing can be used (Cope et al, 2012). This is the only simple approach as carbon monoxide (CO) is not generated by e-cigs. If this is not possible, then it is important to integrate into

**Table 1. Summary of Current Recommendations for Clinical Guidance (Adapted from Bhatnagar et al, 2014)**

E-cigs use should be included in tobacco screening questions that are part of every health examination
Clinicians should know about e-cigs and be prepared to counsel their patients as part of a comprehensive tobacco cessation strategy
Tobacco users who are willing to quit should receive intervention to help them quit
Tobacco product users unwilling to quit at the time should receive interventions to increase their motivation to quit
Those who recently quit using tobacco products should be provided with relapse prevention treatment
There is insufficient evidence for clinicians to counsel their patients who smoke to use e-cigarettes as a primary cessation aid
If a patient has failed initial treatment, has been intolerant to or refuses to use conventional smoking cessation medication, and wishes to use e-cigarettes to aid quitting, it is reasonable to support the attempt as long as this is for a finite time
Patients should be informed that although e-cigarette ‘smoke’ is much less toxic than cigarette smoking, the products are unregulated, may contain low levels of toxic chemicals
It is appropriate to advise the patient to consider setting a quit date for their e-cigarette use and not to plan to use it indefinitely
It is also important to stress that patients should quit smoking cigarettes entirely as soon as possible



**KEY POINTS**

- Electronic cigarette use is increasing, particularly among the young
- Electronic cigarettes generate an aqueous vapour containing nicotine
- There is no carbon monoxide and other toxins are reduced
- Nicotine may cause detrimental effects
- Safety of e-cigarettes yet to be established
- Role as a smoking cessation aid needs further investigation

routine consultation questions about the frequency of e-cig use, along with enquiries about tobacco use (Bhatnagar et al, 2014). Smoking cessation counselling should rely on tried and tested methods with pharmacotherapy combined with the usual “5 A” counselling and follow up (Dino et al, 2011). If the patient expresses a desire to use an e-cig to quit smoking then health professionals, including nurses should tell their patients about the possible dangers of e-cig use and that they should be used for a limited time and not merely as a substitute for conventional cigarettes and that a quit date should be chosen and adhered to.

A special case may be patients with serious mental illness (SMI), a very high percentage of which are regular and frequently heavy smokers, and consequently are at increased risk of serious illness and premature death from smoking-related diseases (Cope, 2016). Patients with SMI may be a suitable group to encourage the use of e-cigs. A trial showed self-reported use of combustible tobacco declined when provided with e-cigs with a good rating of satisfaction and enjoyment (Pratt et al, 2016).

**Conclusion**

Assistance with smoking cessation is a fundamental element of the prevention and management of smoking-related diseases. Healthcare professionals are obliged to assist with the initiation of cessation treatment, and can play an important role in achieving a smoke-free future (Prochaska and Benowitz, 2016). The role of e-cigs as a smoking cessation tool remains controversial, with some advocating their use as a safer alternative to conventional cigarettes (Gostin, 2015), while others believe the devices should not be normalised and ‘should be seen as a part of the armoury of devices intended to wean smokers away from cigarettes, and nothing more (Watson and Forshaw, 2015).

The new TPD regulations will soon regulate the amount of nicotine available and improve safety of the liquid containers. Certainly more research is required to determine the benefits of these devices as smoking cessation aids and also the potential toxic effects of long-term nicotine and the other chemicals produced. **PN**

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