Comparing identity, attitudes, and indicators of effectiveness in people who smoke, vape or use heated tobacco products: A cross-sectional study

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ABSTRACT

Background: There is limited long-term and independent research on heated tobacco products (HTPs). We compared people who used HTPs with those who used nicotine vaping products (NVP) or cigarettes on smoker identity, indicators of effectiveness and, among NVP/HTP users, perceptions of these products.
Methods: Adults exclusive cigarette smokers (N = 45) and ex-smokers with medium/long-term (>3months) NVP (N = 46) or HTP use (N = 45) were recruited in London, UK. Participants completed a questionnaire assessing socio-demographics, smoking characteristics, smoker identity, dependence, intention to stop and attitudes towards HTP/NVP.
Results: In adjusted analysis, people who used cigarettes (Mean Difference (MD) = 1.4, 95%Confidence Intervals (CI) 0.7,2.0) and HTPs (MD = 0.8, 95%CI 0.1, 1.5) reported stronger smoker identities than those who used NVPs. Compared with smokers, HTP/NVP users had lower cravings for cigarettes (MD = 3.0, 95%CI 1.6, 4.3; MD = 3.1, 95%CI 1.9, 4.3, respectively), and higher intention to stop product use (MD = −0.8, 95%CI −1.7,-0.01; MD = −1.2, 95%CI −2.0, -0.3, respectively). People using HTPs or NVPs reported similar perceived product satisfaction (HTP:M = 3.4, 95%CI 2.8, 3.9; NVP:M = 3.0, 95%CI 2.5, 3.5), efficacy for smoking cessation (HTP:M = 4.5, 95%CI 4.2, 4.9; NVP:M = 4.6, 95%CI 4.3, 4.9) and safety (HTP:M = 2.1, 95%CI 2.0, 2.2; NVP:M = 2.0, 95%CI 1.8, 2.1). HTP users reported greater perceived addictiveness than NVPs (MD = 0.3, 95%CI 0.2, 0.6).
Conclusions: HTP and NVP users perceived products to be similarly acceptable and effective suggesting that HTPs, like NVPs, may support smoking cessation. However, since HTP use appears to maintain a stronger smoker identity and perceived addiction, this may suggest a more limited role of HTP for a permanent transition away from cigarettes.

1. Introduction

Smoking cessation is the modifiable health behaviour that has the greatest impact on mortality (Pirie et al., 2013). Many smokers attempt to quit, though most quit attempts result in relapse to smoking. Both short- (Piasecki, 2006) and long-term relapse following abstinence is common (Ferguson et al., 2005), with approximately 75% of quit attempts not maintained beyond four weeks and most smokers experiencing multiple relapses before they are able to remain abstinent for good (Chaiton et al., 2016). Research aimed at tackling this problem has found that behavioural support in combination with pharmacotherapy

(e.g., Nicotine Replacement Therapy; NRT) is more effective in helping people to achieve prolonged smoking abstinence than attempting to quit without help (Stead et al., 2016). However, approximately half of smokers - at least in high income countries (e.g., US, UK) - make an independent, unassisted quit attempt every year, with less than 5% of such attempts being maintained a year later (Edwards et al., 2014). For this reason, methods to help smokers remain abstinent from combustible cigarettes (thereafter cigarettes), which are not only effective but also popular, are urgently needed.

1.1. Novel nicotine products

During the last decade, new products such as nicotine vaping products (NVPs; also known as e-cigarettes) and heated tobacco products (HTPs) have been introduced as alternatives to cigarettes. NVPs and HTPs are available in UK and most other European countries, and USA. NVPs are banned in Asian countries such as Japan, North Korea and both products are banned without prescription in Australia (Glantz, 2021; Global Tobacco Control, 2023; Gomez, 2022). Both products are available in England and currently the adult NVP and HTP use prevalence in England is 12.3% and 0.4% respectively (West et al., 2023).

1.2. Nicotine vaping products

NVPs are battery operated aerosolizing devices using liquids that most commonly contain a mixture of glycerol and propylene glycol, flavours, and nicotine. NVPs are a less harmful alternative to cigarettes because no combustion occurs, and thus produce much lower quantities of toxicants known to cause smoking related disease (Hartmann-Boyce et al., 2020; McNeill et al., 2022). Epidemiological data also suggest that there have been reductions in incidents of cardiovascular diseases in exclusive NVP users relative to cigarette smokers (Hirschtick et al., 2023).

Evidence from randomised controlled trials (Hajek et al., 2019; Hartmann-Boyce et al., 2022; Walker et al., 2020) and observational studies (Beard et al., 2019; Jackson et al., 2019) suggests that NVPs increase the likelihood that people will succeed in their attempts to stop smoking cigarettes compared with NRT, nicotine-free electronic cigarettes, behavioural support or no support. NVPs have also become the most popular aid to quitting smoking, with around a third of adult smokers in England reporting having used an NVP in their most recent quit attempt (West et al., 2022), and are perceived as more helpful than NRT, for example, in controlling withdrawal symptoms (Hajek et al., 2019; Nelson et al., 2015). The longer-term use of NVPs after smoking cessation, though, remains controversial as the long-term health effects of vaping are unknown and may not be clearly established for many years. Although studies have suggested that the medium-term health impact of exclusive switching to vaping may be comparable to NRT use (Shahab et al., 2017), there are concerns that vaping may renormalise smoking behaviours and encourage more people to smoke or those who have quit to relapse (Sæbø & Scheffels, 2017).

1.3. Heated tobacco products

HTPs are battery-powered devices designed to heat processed tobacco without combustion to produce a nicotine-containing aerosol that is inhaled. Similar to NVPs, HTPs are considered less harmful alternatives to cigarettes based on research by the tobacco industry (i.e., Haziza et al., 2016; Martin et al., 2016). Though emerging evidence suggest that HTPs are likely more harmful than NVPs, with some estimates ranging from 1.5 to 2 times more harmful than NVPs (Farsalinos et al., 2018; McNeill et al., 2022). There is currently little evidence on the effectiveness of HTPs in replacing cigarette smoking in any country McNeill et al., 2022; Simonavicius et al., 2019; Tattan-Birch et al., 2022), apart from Japan (Stoklosa et al., 2020) and Italy (Caponnetto et al., 2023). In Japan one observational study suggests that the introduction of HTPs led to a reduction in cigarette sales (Pesola et al., 2023; Stoklosa et al., 2020), while in Italy a randomised control trial comparing the effectiveness of HTPs and NVPs on cigarette substitution found that switching to HTPs elicited a reduction in cigarette consumption which was comparable to NVPs (Caponnetto et al., 2023).

1.4. Psychosocial factors that contribute to quit success

In investigating the potential of NVPs and HTPs for smoking cessation, it is important to study the proximal outcomes (i.e., mood and physical symptoms, cravings) of the main psychosocial factors (i.e., social and environmental cues, smoker identity) that contribute to a successful quit attempt or relapse to cigarette smoking. These include mood and physical symptoms, cravings, behavioural, social and environmental cues to smoke (Buczkowski et al., 2014; Caraballo et al., 2014; Piasecki, 2006; West et al., 1989), and concepts that cut across psychological and social domains, such as smoker identity (Notley, 2016; Tombor et al., 2013). Identity encompasses an individual's mental representation of the self in addition to feelings attached to such representations (Cheek, 1989). It has been demonstrated that having a smoker or non-smoker identity plays an important role in maintaining or stopping smoking (Tombor et al., 2013) and establishing a strong non-smoker identity is an important factor protecting against the momentary want or need to smoke that could lead to late relapse (Vangeli et al., 2010).

Current smokers exhibit a stronger smoker identity than ex-smokers (Tombor et al., 2013), including those who use NVPs (Nelson et al., 2015). This suggests that NVPs may not undermine self-identification as an ex- or non-smoker, which may help maintain abstinence from cigarettes (Nelson et al., 2015). Additionally, NVP compared with NRT use is associated with less severe cravings for cigarettes and mood and physical symptoms, higher perceived helpfulness of the product and lower intentions to stop using the product (Hajek et al., 2019; Nelson et al., 2015). There is only limited research related to HTPs, and what research exists is mainly tobacco-industry funded (i.e., Goldenson et al., 2022), and from Japan (i.e., Xu et al., 2020), where these products are popular and NVPs are not available (Tabuchi et al., 2016).

1.5. The current study

Since evidence suggests that NVPs are effective for smoking cessation and have a specific impact on psychopharmacological outcomes (i.e., smoker identity, indicators of dependence), and since research on HTP is limited, the present study seeks to evaluate the psychopharmacological impact of medium-to long-term use of HTP compared with medium-to long-term use of NVP, and also cigarette smoking. We compare NVP use and HTP use as it can be assumed that if HTPs perform similarly to NVPs (i.e., in alleviating cigarette cravings) they may also be effective in helping smokers to quit cigarettes and, if not, this may suggest they are less effective. Ideally, all factors that are likely to influence the product-contingent effects would be assessed prospectively and with random allocation. However, given the length of time needed to evaluate the use of NVP and HTP for harm reduction appropriately, this study used a pragmatic approach, purposively selecting participants who were smokers, had stopped smoking and switched to NVP or HTP for at least three months. Additionally, the present study includes users of the three products from the same location (Greater London, UK), where all three products are available.

1.6. Aim

The aim of the present study is to evaluate the association of exclusive cigarette, NVP or HTP use with psychopharmacological outcomes. Specifically, this study assesses the association of exclusive cigarette smoking, medium-to long-term NVP or HTP use with smoker identity, effectiveness, intention to stop product use and, among NVP and HTP users only, perceptions of these products.

2. Methods

2.1. Study design

This cross-sectional analysis forms part of a wider study assessing the possible health effects of using novel nicotine and tobacco-containing products compared with smoking cigarettes and not smoking at all (please see supplementary material regarding the methodology used in

the larger study). This cross-sectional analysis focuses on baseline psychopharmacological assessments measured with a questionnaire at a single laboratory visit at University College London, lasting approximately 1 h. Participants were asked to avoid using the toilet and to refrain from alcohol, eating and product use one hour before the visit, but we did not assess the exact time since last product use. The wider study also involved the collection of biological samples, not reported here. For this cross-sectional analysis, smokers, and ex-smokers using NVP or HTP (thereafter NVP or HTP users) regularly for at least three months before their visit were purposively recruited. Participants were reimbursed for time and travel. The study received ethical approval from the University College London Ethics Committee (Project ID 12621/001).

2.2. Study sample and recruitment

Participants were recruited in the Greater London (UK) area between March 2018 and February 2022, with a pause between March 2020 and September 2021 due to the Covid-19 pandemic. Various recruitment methods were used to access a diverse sample in terms of key socio-demographic characteristics (age and sex). These included adverts in newspapers, social media, online NVP forums, approaching users on the street, email mailouts, as well as use of marketing companies.

Participants were screened for eligibility via an online questionnaire. Inclusion criteria required >3 months of regular exclusive NVP or HTP use to control for a noted learning curve in effective NVP and HTP use (e.g., Bullen et al., 2013). Ex-smokers with NVP or HTP use had also to have stopped smoking cigarettes for at least three months. Smokers had to smoke an average of five or more cigarettes per day for at least six months and not have regularly used NVP or HTP. Current smoking status was verified using a breathalyser to assess expired air carbon-monoxide (CO). Due to collection of biological samples for the wider study (not reported here), participants were excluded if they were younger than 18 years old, had a history of heart or lung disease, were pregnant, or had bleeding gums, illness, or infection within 24 h of their scheduled appointment.

Forty-five participants were recruited into each of the three groups (an additional NVP user was recruited due to a scheduling error). Data for all participants (N = 136) are provided in Table 1. This sample provides >95% power, with alpha = 0.05 in two-sided analysis to detect large differences (d = 1) observed in a previous study (Nelson et al, 2015) in smoker identity and effectiveness between current smokers, NVP or HTP users.

3. Measures

3.1. Outcome measures

Smoker identity: Based on work establishing the validity of simple measure of smoker identity (e.g., Tombor et al., 2013), the present study used an established item to determine smoker identity strength (Shadel & Mermelstein, 1996): participants were asked to rank their agreement with the statement, 'Smoking is a part of me' on a 5-point Likert scale (1 = 'not at all' to 5 = 'complete agree').

Effectiveness: Withdrawal symptoms related to cigarettes were assessed in all three groups. We used the Mood and Physical Symptoms Scale (MPSS, West & Hajek, 2004; West et al., 2006) which assesses cravings in the past 24 h using two items; cigarette craving strength and frequency; range 0–5 per item, from 'no urges'/'not at all' to 'extremely strong'/'all the time'. We also assessed product-specific cravings using the same two items related to specific product use, and other general mood and symptoms related to withdrawal symptoms specific to each product (seven items; being irritable, restless, depressed, hungry, anxious, subjected to poor sleep, poor concentration; range 1–5 per item; 1 = 'not at all' to 5 = 'extremely).

Intention to stop product use: Intention to stop product use was

Table 1
Socio-demographic, smoking and product use characteristics.

	Total (N = 136)	Smokers (N = 45)	NVP users (N = 46)	HTP users (N = 45)
Socio-demographics				
Mean age (SD)	37.1 (13.9)	35.7 (15.0) [a]	42.7 (14.2) [b]	32.8 (10.1) [a]
% Male (N)	66.2 (90)	60.0 (27)	60.9 (28)	77.8 (35)
% White (N)	77.2 (105)	66.7 (30)	80.4 (37)	84.4 (38)
% Married/Cohabiting (N)	26.5 (36)	15.6 (7) [a]	43.5 (20) [b]	20.0 (9) [a]
% Post-16 qualifications (N)	65.4 (89)	57.8 (26)	65.2 (30)	73.3 (33)
Smoking characteristics				
Mean length of smoking, years (SD)	16.7 (12.7)	15.7 (13.4) [a]	22.1 (13.7) [b]	12.2 (8.4) [a]
Mean cigarettes per day (SD)	14.3 (8.7)	12.1 (9.1) [a]	17.2 (9.1) [b]	13.7 (7.1) [a]
Mean age of starting smoking, years (SD)	18.4 (6.0)	19.7 (6.2)	17.4 (7.3)	18.1 (3.8)
Mean CO level in ppm (SD)	4.2 (5.2)	9.1 (0.6) [a]	1.0 (0.7) [b]	2.2 (0.8) [b]
Mean length stopped smoking, months (SD)			32.2 (26.1) [a]	17.6 (13.1) [a]
Product use characteristics				
Mean length of product use, months (SD)			35.0 (25.1) [a]	17.6 (12.9) [a]
Mean product use, nicotine mg/day (SD)			45.0 (43.0)	53.9 (30.4)
Mean product use, HEETS/day (SD)				14.56 (8.21)
% Product use within 1 h of waking (N)	69.1 (94)	44.4 (20) [a]	87.0 (40) [b]	75.6 (34) [b]
Mean MTTS (SD)	5.0 (1.6)	4.5 (1.6) [a]	5.5 (1.4) [b]	5.0 (1.6)

SD = Standard difference, N = number of participants, MTTS = Motivation to stop scale for each product use (scores 1–7 with higher score presenting higher motivation to stop product use).

[a,b] Different letters indicate significant differences between groups.

measured using a modified version of the motivation to stop scale (MTTS, Kotz et al., 2013), replacing the term 'cigarette' with 'NVP' or 'HTP', with higher values indicating greater motivation to stop use (seven response options; ranging from 'I don't want to stop' to 'I really want to stop and intend to in the next month').

Perceptions of NVPs/HTPs: Using 5-point Likert scales, NVP and HTP users only were asked whether they found the product helpful in enabling them to refrain from smoking ('not at all helpful' to 'extremely helpful'), whether they would recommend the product to a friend who wanted to stop smoking ('definitely not' to 'definitely'), whether they would use the product outdoors ('definitely not' to 'definitely'), indoors at home ('definitely not' to 'definitely'), indoors at work/public spaces ('definitely not' to 'definitely'), how pleasant they found the product to use ('not at all pleasant' to 'extremely pleasant'), and how embarrassing they found the product to use in the company of others ('not at all' to 'extremely'). Finally, NVP and HTP users were asked whether - compared with cigarettes - they found their product safer for their health ('yes absolutely safe', 'no but they are safer than cigarettes', 'no they are as dangerous as cigarettes', 'no they are more dangerous than cigarettes'), whether they thought the NVPs/HTPs are addictive ('no, absolutely not', 'yes but they are less addictive than cigarettes', 'yes, they are as addictive as cigarettes', 'yes, they are more addictive than cigarettes'), and how satisfying the NVP/HTP was compared with cigarettes ('much less than usual', 'a little less than usual', 'the same as usual', 'a little more than usual', 'much more than usual'). All these measures have been used in previous research (Nelson et al., 2015).

3.2. Covariates

Socio-demographics included age (continuous), sex (male vs other), ethnicity (white vs other), education (post-16 qualification/education after the age of 16 years old vs not), and marital status (married/cohabiting vs other).

Smoking-related characteristics included length of current/past cigarette smoking (in years), current/past number of cigarettes smoked per day, age started smoking regularly, cigarette dependence (measured with time to first cigarette (Fagerstrom, 2012). Similarly, equivalent product-related use characteristics were assessed for HTP and NVP. Participants were asked to indicate the length of use (in months), and — as an indicator of dependence — latency to use the product after waking. Consumption was assessed by asking NVP users about the type of product they used; those using first generation NVP and those using second or third generation NVP (refillable or advanced personal vaporisers) were asked to indicate, respectively, either the nicotine content of the cartridge/pod or the concentration of the e-liquid used as well as the quantity used per day. HTP users were also asked the type and the number of tobacco sticks (HEETS) they used per day. Based on previous research, we calculated that each HEET contains approximately 3.7 mg/stick nicotine (Begić et al., 2023). All participants were also asked to report time of last product use.

3.3. Statistical analysis

Descriptive statistics were calculated to characterise the overall sample and for each of the three study groups of different product users. Differences between study groups and socio-demographic variables, smoking-related characteristics and product use characteristics were assessed with one-way ANOVAs or independent t-tests.

Linear regressions were used to compare people who used the different products (cigarette (referent category) with NVP and HTP, and NVP (referent category) with HTP) on smoker identity, effectiveness, intention to stop product use, and attitudes towards the product, adjusting for relevant covariates (sociodemographic and smoking-related characteristics; and time of last product use only for the analyses related to effectiveness) and method of recruitment (marketing companies vs all other). Based on recommendation by Montgomery et al. (2018) on the bias introduced by adjusting for post-treatment variables, the present analyses were not adjusted for product-related characteristics. We ran each model twice, first with cigarette smokers as the referent category and then with NVP users, to obtain estimates of difference between each of the three groups.

Analyses were conducted with SPSS version 27.

4. Results

Table 1 displays socio-demographic, smoking and product use characteristics by study group. The mean age of the sample was 37.1 years (Standard deviation (SD) = 13.9), with more men than women included in the sample. Almost two thirds of participants had post-16 qualifications, one third were married/cohabiting and just over two thirds were of white ethnicity. On average participants started smoking at age 18 and had smoked 14 cigarettes per day for almost 17 years. NVP and HTP users had stopped cigarette smoking 32 and 18 months ago, having used their products for an average of 35 months and 18 months, respectively, consuming an estimated average 45 and 54 mg/day nicotine. Consistent with cessation of cigarette smoking, they had much lower levels of CO than current cigarette smokers. The three groups differed in age and marital status, with NVP users being older and more likely to be married/cohabiting than cigarette smokers and HTP users. Regarding differences in smoking and product-specific characteristics, NVP users recalled smoking for longer and consuming more cigarettes per day before quitting than HTP users or cigarette smokers. NVP and HTP users were more likely to use their product in the first hour of

waking than cigarette smokers.

4.1. Smoker identity

Cigarette smokers and HTP users reported a stronger smoker identity than NVP users (Mean Difference (MD) = 1.4, 95%Confidence Intervals (CI) 0.7, 2.0; MD = 0.8, 95%CI 0.1, 1.5, respectively, Table 2).

4.2. Effectiveness

The three groups did not differ notably in mood and physical symptoms and product-specific cravings (Table 2). Though cigarette-specific cravings were higher for cigarette smokers than HTP or NVP users (MD = 3.0, 95%CI 1.6, 4.3; MD = 3.1, 95%CI 1.9, 4.3, respectively), with little difference between the latter two groups (MD = -0.1, 95%CI −1.2, 0.9).

4.3. Intention to stop product use

HTP users reported similar level of intention to stop product use to NVP users, which for both was significantly higher than for cigarette smokers (Table 2; MD = −0.8, 95%CI −1.7, −0.01; MD = −1.2, 95%CI −2.0, −0.3, respectively).

4.4. Attitudes towards NVPs/HTPs

Table 3 shows NVP and HTP users' attitudes towards their products. After adjustment, NVP and HTP users had similar attitudes regarding recommending their product to a friend who wanted to stop smoking (MD = 0.3, 95%CI −0.1, 0.6), using the products outdoors (MD = 0.2, 95%CI −0.1, 0.4), and indoors at home (MD = 0.2, 95%CI −0.2, 0.5). However, HTP users were more likely to use their product at work or in public spaces than NVP users (MD = −0.8, 95%CI −1.5, −0.2). NVP and HTP users reported similar levels of perceived pleasantness or embarrassment of product use (MD = 0.3, 95%CI −0.1, 0.7; MD = 0.8, 95%CI −0.4,0.6, respectively). Compared with cigarette smoking, NVP and HTP users reported similar levels of perceived product satisfaction (MD = −0.4, 95%CI −1.0, 0.3), efficacy for smoking cessation (MD = 0.01, 95%CI −0.4, 0.4) and safety (MD = −0.1, 95%CI −0.3, 0.01) for their product. However, using cigarette addictiveness as a reference point, HTP users reported higher levels of perceived addictiveness of their product than NVP users (MD = −0.3, 95%CI −0.6, −0.2).

5. Discussion

In this cross-sectional study of London-based adults, we assessed the association of exclusive cigarette smoking and of ex-smokers' medium-to long-term exclusive use of NVP or HTP with smoker identity, effectiveness and intention to stop product use. HTP and NVP users exhibited low levels of cigarette-specific cravings, and these were much lower than for cigarette smokers. The three groups reported similar average levels of product-specific dependence and mood and physical symptoms. HTP and NVP users also reported high levels of intention to stop their product use, which were higher than for cigarette smokers. Cigarette smoking and HTP use was associated with greater smoker identity than NVP use. Among NVP and HTP users, most attitudes towards their products were similar, though HTP users were more likely to use their product at work or in public spaces, and they rated their product higher in addictiveness relative to cigarettes than NVP users.

Consistent with previous findings demonstrating reliable nicotine delivery using NVPs and HTPs, our results indicated that people reported both products were effective in reducing cravings from cigarettes and producing withdrawal relief. Since our study suggested that HTPs and NVPs performed similarly on cigarette-related withdrawal relief, and the wider literature indicates that NVPs are effective for cigarette smoking reduction and cessation (Hajek et al., 2019; Hartmann-Boyce

Table 2

Comparisons between all three groups in smoker identity, indicators of dependence and intention to stop product use.

	Smokers M (95%CI)	NVP users M (95%CI)	HTP users M (95%CI)	Smokers vs NVP users MD (95%CI)	Smokers vs HTP users MD (95%CI)	NVP vs HTP users MD (95%CI)
Smoker identity* (range 1–5)	3.4 (2.9, 3.9) [a]	2.0 (1.6, 2.4) [b]	2.8 (2.3, 3.3) [a]	1.4 (0.7, 2.0)	0.6 (−0.1, 1.2)	−0.8 (−1.5, −0.1)
MPPS craving product-specific** (range 1–10)	5.1 (4.3, 5.9)	5.6 (4.9, 6.3)	5.0 (4.3, 5.8)	−0.6 (−1.7, 0.4)	0.1 (−0.9, 1.0)	0.6 (−0.5, 1.8)
MPPS mood and physical symptoms** (range 7–35)	12.6 (10.7, 14.6)	14.1 (12.4, 15.8)	14.0 (12.3, 15.8)	−1.5 (−4.1, 1.2)	−1.4 (−4.2, 1.4)	0.1 (−2.2, 2.4)
MPPS craving cigarette-specific** (range 1–10)	5.3 (4.4, 6.2) [a]	2.2 (1.4, 3.0) [b]	2.3 (1.5, 3.2) [b]	3.1 (1.9, 4.3)	3.0 (1.6, 4.3)	−0.1 (−1.2, 0.9)
Intention to stop using product* (range 1–7)	4.2 (3.5, 4.8) [a]	5.4 (4.8, 5.9) [b]	5.0 (4.4, 5.5) [b]	−1.2 (−2.0, −0.3)	−0.8 (−1.7, −0.01)	0.4 (−0.3, 1.1)

M = mean, MD = Mean Difference, CI = Confidence Interval, MPPS = Mood and Physical Symptoms Scale *Estimated marginal means and mean differences are adjusted for age, gender, ethnicity, marital status, education, method of recruitment, product use, number of cigarettes smoked per day, age started smoking.
**Estimated marginal means and mean differences are adjusted for age, gender, ethnicity, marital status, education, method of recruitment, product use, number of cigarettes smoked per day, age started smoking, time of last product use.
[a,b] Different letters indicate significant differences between groups.

Table 3

Comparisons between NVP and HTP users in attitudes towards their products.

	NVP users M (95% CI)	HTP users M (95% CI)	NVP vs HTP users MD (95%CI)
Recommend product to a friend who wants to stop cigarette smoking (range 1–5)	4.7 (4.4, 5.0)	4.4 (4.1, 4.7)	0.3 (−0.1, 0.6)
Product use outdoors (range 1–5)	5.0 (4.8, 5.2)	4.8 (4.6, 5.0)	0.2 (−0.1, 0.4)
Product use indoors at home (range 1–5)	4.7 (4.4, 5.1)	4.6 (4.2, 4.9)	0.2 (−0.2, 0.5)
Product use indoors at work/public places (range 1–5)	2.0(1.5, 2.5)*	2.8 (2.3, 3.4)*	−0.8 (−1.5, −0.2)
Pleasantness of product use (range 1–5)	4.0 (3.7, 4.4)	3.7 (3.3, 4.1)	0.3 (−0.1, 0.7)
Embarrassment of product use (range 1–5)	1.6 (1.2, 2.0)	1.5 (1.1, 2.0)	0.8 (−0.4, 0.6)
Product efficacy for cigarette smoking cessation (range 1–5)	4.6 (4.3, 4.9)	4.5 (4.2, 4.9)	0.01 (−0.4, 0.4)
Product addictiveness compared with cigarettes (range 1–4)	2.3 (2.0, 2.5)*	2.6 (2.3, 2.8)*	−0.3 (−0.6, −0.2)
Product satisfaction compared with cigarettes (range 1–4)	3.0 (2.5, 3.5)	3.4 (2.8, 3.9)	−0.4 (−1.0, 0.3)
Product safety compared with cigarette smoking (range 1–4)	2.0 (1.8, 2.1)	2.1 (2.0, 2.2)	−0.1 (−0.3, 0.01)

M = Mean, MD = Mean Difference, CI = Confidence Intervals.
Estimated marginal means and mean differences are adjusted for age, gender, ethnicity, marital status, education, method of recruitment, product use, number of cigarettes smoked per day, age started smoking.
For product addictiveness, satisfaction and safety compared with cigarette, lower values indicate that the products are less addictive, less satisfactory, and less harmful than cigarettes.
*Indicate significant differences between the two groups.

et al., 2022; Jackson et al., 2019), then it may be that HTPs and NVPs are similarly effective for smoking cessation. Additionally, in our sample, HTP and NVP users reported high levels of intention to stop their product use, and this was significantly higher than for cigarette smokers, who reported a residual intention to stop cigarette smoking (scores just over midpoint of the scale). It has been documented that many ex-smoker NVP users are interested in eventually quitting product use, since NVP use is often initiated to quit cigarettes (Ma et al., 2018; Palmer et al., 2021). Our results show that this appears similarly true for ex-smokers who use HTPs.

Smoking identity can impact smoking abstinence and identity change is thought to be critical to sustained smoking cessation that might be resistant to environmental cues to smoke (Tombor et al., 2013; Vangeli et al., 2010). Retaining a sense of oneself as a smoker despite quitting may be an explanatory factor underpinning smoking relapse

(Vangeli et al., 2010). Our results suggest that ex-smokers HTP users appear were more likely to report a residual smoker identity (scores around mid-point of the scale) similar to cigarette smokers, while ex-smokers NVP users viewed themselves as not having a strong smoker identity (scores below mid-point of the scale). Such findings may further suggest that there is a greater chance of relapse to smoking and/or concurrent use of cigarettes among HTP users. Indeed, emerging evidence from 2018 International Tobacco Control survey in Japan suggests that only one quarter of HTP user had completely transitioned from cigarette smoking to HTP use (Gravely et al., 2023). Our findings also support previous research demonstrating that ex-smoker NVP users embrace a unique identity, which is culturally and socially acceptable and distinct from smoker identity (Notley et al., 2018). On the other hand, consistent with our findings, HTP users still keep a fluidity between HTP user and smoker identity (East et al., 2023).

Our examination of attitudes towards NVPs and HTPs, suggests that HTPs are perceived as more similar to cigarettes in terms of addictiveness, which may mean longer maintained product use and greater difficulty stopping compared with NVPs. For both NVPs and HTPs to become a viable quitting aid or long-term substitute for smokers, they need to be perceived as effective in managing withdrawal symptoms, as well as being enjoyable, socially acceptable, and safe. Indeed, our findings indicate that in our sample of ex-smokers, both NVP and HTP use resulted in similarly high perceived acceptability, satisfaction and perceived effectiveness.

All results obtained should be seen in the light of the following limitations. First, the results and their interpretations are based on a small convenience sample of London-based adults. Although diverse recruitment methods were used, the sample was purposively selected on smoking status and thus findings may not generalise to the general population. Additionally, smokers included in the present study had comparatively low CO levels (normally this would be above 10 ppm, e. g., Maga et al., 2017) and started smoking relatively late around 19 years of age (most UK smokers report taking up smoking before the age of 18; Department of Health and Social Care, 2017). Additionally, participants especially NVP and HTP users were predominantly of white ethnicity. Future studies with more racially/ethnically samples are needed. Second, although smoking status was verified and validated, a number of other self-report measures were used; these may not be able to capture fully complex concepts such as smoker identity. We also used a single question to measure smoker identity, which may not be as reliable and valid as other scales with more items(i.e., 6-item Smoker Identity Scale by Dupont et al.,2015), though the item used in the current study is an established item to determine smoker identity strength (Shadel & Mermelstein, 1996) and previous research has established the validity of a simple measure of smoker identity (e.g., Tombor et al., 2013). Third, due to the cross-sectional design, it is not possible to

determine the direction of the association between product use and outcome variables as these may be due to self-selection. While a longitudinal study would be preferable, given the relatively novelty of HTPs and the associated lack on data on this topic, we chose this pragmatic design to assess associations with long-term use now which can be further investigated in future longitudinal studies.

To conclude, HTP and NVP users reported comparable product dependence and nicotine intake, that their product use was similarly effective in controlling cigarette cravings and withdrawal symptoms, and that they perceived their respective products as similarly safe, satisfying and helpful for smoking cessation. These findings suggest that HTPs may support smoking cessation, though the extent to which this is the case would need to be established using appropriate experimental studies. Finally, compared with NVP use, HTP use was associated with maintenance of a stronger smoker identity and perceived addiction, which may suggest a more limited role of HTP for a permanent transition away from cigarettes.

6. Availability of data

The dataset used and analysed during the current study are available from the corresponding author on reasonable request.

7. Registration

The analysis plan was pre-registered, and it is available at https://osf.io/snh46.

8. Governance and ethics

The study has been approved by UCL Research Ethics Committee (Project ID Number: 12621/001). All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all subjects.

9. Role of funding source

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10. Contributors

LS conceived and designed the study. DK analysed the data and wrote the first draft. All authors provided critical revisions. All authors read and approved the submitted manuscript.

11. Authors' contributions

LS conceived and designed the study. DK analysed the data and wrote the first draft. All authors provided critical revisions. All authors read and approved the submitted manuscript.

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CRediT authorship contribution statement

Dimitra Kale: . **Jamie Brown:** . **Lynne Dawkins:** Writing – review & editing. **Maciej L. Goniewicz:** . **Corinna Leppin:** . **Harry Tattan-Birch:** Writing – review & editing. **Lion Shahab:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2023.107933.

References

Beard, E., West, R., Michie, S., & Brown, J. (2019). Association of prevalence of electronic cigarette use with smoking cessation and cigarette consumption in England: A time–series analysis between 2007 and 2017. *Addiction.* https://doi.org/10.1111/add.14851

Begić, E., Aziri, B., Omeragić, E., Medjedović, E., Iglica, A., Stanetić, B., Kovačević-Preradović, T., Živanović, Ž., Begić, A., Janković, S., Mlačo, N., Mladenović, Z., Badnjević, A. (2023). Heat-not-burn tobacco products and cardiovascular risk reduction: A systematic review of randomized controlled trials. Technol Health Care. 10.3233/THC-220677. Epub ahead of print. PMID: 36641697.

Buczkowski, K., Marcinowicz, L., Czachowski, S., & Piszczek, E. (2014). Motivations toward smoking cessation, reasons for relapse, and modes of quitting: results from a qualitative study among former and current smokers. *Patient Preference and Adherence, 8,* 1353–1363.

Bullen, C., Howe, C., Laugesen, M., McRobbie, H., Parag, V., Williman, J., & Walker, N. (2013). Electronic cigarettes for smoking cessation: a randomised controlled trial. *Lancet, 382,* 1629–1637.

Caponnetto, P., Campagna, D., Maglia, M., Benfatto, F., Emma, R., Caruso, M., Caci, G., Busà, B., Pennisi, A., Ceracchi, M., Migliore, M., & Signorelli, M. (2023). Comparing the Effectiveness, Tolerability, and Acceptability of Heated Tobacco Products and Refillable Electronic Cigarettes for Cigarette Substitution (CEASEFIRE): Randomized controlled trial. *JMIR Public Health Surveillance, 9.*

Chaiton, M., Diemert, L., Cohen, J. E., Bondy, S. J., Selby, P., Philipneri, A., & Schwartz, R. (2016). Estimating the number of quit attempts it takes to quit smoking successfully in a longitudinal cohort of smokers. *BMJ Open, 6*(6).

Cheek, J. M. (1989). Identity Orientations and Self-Interpretation. *Personality Psychology. Springer,* 275–285.

Department of Health and Social Care. (2017). Towards a smoke-free generation: a tobacco control plan for England Accessed July 2023 https://www.gov.uk/government/publications/towards-a-smoke-free-generation-tobacco-control-plan-for-england.

Dupont, P., Tack, V., Blecha, L., Reynaud, M., Benyamina, A., Amirouche, A., & Aubin, H. J. (2015). Smoker's identity scale: Measuring identity in tobacco dependence and its relationship with confidence in quitting. *The American Journal on Addictions, 24*(7), 607–612. https://doi.org/10.1111/ajad.12272

East, K. A., Miller, C. R., Hitchman, S. C., McNeill, A., & Tompkins, C. N. E. (2023). 'It's not what you'd term normal smoking': A qualitative exploration of language used to describe heated tobacco product use and associated user identity. *Addiction, 118*(3), 533–538. https://doi.org/10.1111/add.16051

Edwards, S. A., Bondy, S. J., Callaghan, R. C., & Mann, R. E. (2014). Prevalence of unassisted quit attempts in population-based studies: A systematic review of the literature. *Addictive Behaviors, 39,* 512–519.

Fagerstrom, K. (2012). Determinants of tobacco use and renaming the FTND to the Fagerstrom test for cigarette dependence. *Nicotine & Tobacco Research, 14,* 75–78.

Farsalinos, K. E., Yannovits, N., Sarri, T., Voudris, V., Poulas, K., & Leischow, S. J. (2018). Carbonyl emissions from a novel heated tobacco product (IQOS): Comparison with an e-cigarette and a tobacco cigarette. *Addiction, 113,* 2099–2106.

Ferguson, J., Bauld, L., Chesterman, J., & Judge, K. (2005). The English smoking treatment services: One-year outcomes. *Addiction, 100*(Suppl 2), 59–69.

Glantz, S. (2021). 47 countries have banned e-cigarettes. <https://profglantz.com/2021/11/03/47-countries-have-banned-e-cigarettes/"https://profglantz.com/2021/11/03/47-countries-have-banned-e-cigarettes/>. Accessed November 2023.

Global Tobacco Control (2023). Heated Tobacco. <https://www.globaltobaccocontrol.org/en/policy-scan/heated-tobacco>. Accessed November 2023.

Goldenson, N. I., Augustson, E. M., Chen, J., & Shiffman, S. (2022). Pharmacokinetic and subjective assessment of prototype JUUL2 electronic nicotine delivery system in two nicotine concentrations, JUUL system, IQOS, and combustible cigarette. *Psychopharmacology (Berl)., 239*(3), 977–988.

Gomez, L.G. (2022). Australia: Heated tobacco regulation, December 2022. <https://tobaccointelligence.com/australia-heated-tobacco-regulation-december-2022/>. Accessed November 2023.

Gravely, S., Meng, G., Xu, S.S., Boudreau, C., Thompson, M.E., Tabuchi, T., Katanoda, K., Yoshimi, I., Cunnings, K.M., Hyland, A., Fong, G.T. (2023). An examination of Philip Morris International's estimate of IQOS users who have 'completely transitioned' from cigarettes: Findings from the 2018 ITC Japan survey. *SRNT conference presentation.*

Hajek, P., Phillips-Waller, A., Przulj, D., Pesola, F., Myers Smith, K., Bisal, N., Li, J., Parrott, S., Sasieni, P., Dawkins, L., Ross, L., Goniewicz, M., Wu, Q., & McRobbie, H. J. (2019). A randomized trial of E-cigarettes versus nicotine-replacement therapy. *The New England Journal of Medicine 14, 380*(7), 629–637. https://doi.org/10.1056/NEJMoa1808779

Hartmann-Boyce, J., Lindson, N., Butler, A. R., McRobbie, H., Bullen, C., Begh, R., Theodoulou, A., Notley, C., Rigotti, N. A., Turner, T., Fanshawe, T. R., & Hajek, P. (2022). Electronic cigarettes for smoking cessation. Issue 11. Art. No.: CD010216 *Cochrane Database of Systematic Reviews.* https://doi.org/10.1002/14651858.CD010216.pub7.

Haziza, C., de La Bourdonnaye, G., Merlet, S., Benzimra, M., Ancerewicz, J., Donelli, A., Baker, G., Picavet, P., & Lüdicke, F. (2016). Assessment of the reduction in levels of exposure to harmful and potentially harmful constituents in Japanese subjects using a novel tobacco heating system compared with conventional cigarettes and smoking abstinence: A randomized controlled study in confinement. *Regulatory Toxicology and Pharmacology, 81*, 489–499.

Hirschtick, J. L., Cook, S., Patel, A., Barnes, G. D., Arenberg, D., Bondarenko, I., Levy, D. T., Jeon, J., Jimenez Mendoza, E., Meza, R., & Fleischer, N. L. (2023). Longitudinal associations between exclusive and dual use of electronic nicotine delivery systems and cigarettes and self-reported incident diagnosed cardiovascular disease among adults. *Nicotine & Tobacco Research, 25*(3), 386–394. https://doi.org/10.1093/ntr/ntac182

Jackson, S. E., Kotz, D., West, R., & Brown, J. (2019). Moderators of real-world effectiveness of smoking cessation aids: A population study. *Addiction, 114*, 1521–1720. https://doi.org/10.1111/add.14656

Kotz, D., Brown, J., & West, R. (2013). Predictive validity of the Motivation To Stop Scale (MTSS): A single-item measure of motivation to stop smoking. *Drug and Alcohol Dependence, 128*, 15–19.

Ma, B. H., Yong, H. H., Borland, R., McNeill, A., & Hitchman, S. C. (2018). Factors associated with future intentions to use personal vaporisers among those with some experience of vaping. *Drug and Alcohol Review, 37*(2), 216–225. https://doi.org/10.1111/dar.12574

Maga, M., Janik, M. K., Wachsmann, A., Chrząstek-Janik, O., Koziej, M., Bajkowski, M., Maga, P., Tyrak, K., Wójcik, K., Gregorczyk-Maga, I., et al. (2017). Influence of air pollution on exhaled carbon monoxide levels in smokers and non-smokers. A prospective cross-sectional study. *Environmental Research, 152*, 496–502. https://doi.org/10.1016/j.envres.2016.09.004

Martin, F., Talikka, M., Ivanov, N.V., Haziza, C., Hoeng, J., Peitsch, M.C. (2016). Evaluation of the tobacco heating system 2.2. Part 9: application of systems pharmacology to identify exposure response markers in peripheral blood of smokers switching to THS2.2. *Regulatory Toxicology and Pharmacology* 6, 81 Suppl 2, S151–S157.

McNeill, A., Simonavičius, E., Brose, L. S., Taylor, E., East, K., Zuikova, E., Calder, R., & Robson, D. (2022). Nicotine vaping in England: an evidence update including health risks and perceptions. *A report commissioned by the Office for Health Improvement and Disparities.* London: Office for Health Improvement and Disparities.

Montgomery, J. M., Nyhan, B., & Torres, M. (2018). How conditioning on posttreatment variables can ruin your experiment and what to do about it. *American Journal of Political Science, 62*, 760–775.

Nelson, V. A., Goniewicz, M. L., Beard, E., Brown, J., Sheals, K., West, R., & Shahab, L. (2015). Comparison of the characteristics of long-term users of electronic cigarettes versus nicotine replacement therapy: A cross-sectional survey of English ex-smokers and current smokers. *Drug and Alcohol Dependence, 153*, 300–305. https://doi.org/10.1016/j.drugalcdep.2015.05.005

Notley, C., Ward, E., Dawkins, L., & Holland, R. (2018). The unique contribution of e-cigarettes for tobacco harm reduction in supporting smoking relapse prevention. *Harm Reduction Journal, 15*, 31.

Palmer, A. M., Smith, T. T., Nahhas, G. J., Rojewski, A. M., Sanford, B. T., Carpenter, M. J., & Toll, B. A. (2021). Interest in quitting e-cigarettes among adult e-cigarette users with and without cigarette smoking history. *Journal of the American Medical AssociationNetw Open., 4*(4). https://doi.org/10.1001/jamanetworkopen.2021.4146

Pesola, F., Phillips-Waller, A., Beard, E., Shahab, L., Sweanor, D., Jarvis, M., & Hajek, P. (2023). Effects of reduced-risk nicotine-delivery products on smoking prevalence and cigarette sales: an observational study. *Journal of Public Health Research., 11*(7), 1–39. https://doi.org/10.3310/RPDN7327

Piasecki, T. M. (2006). Relapse to smoking. *Clinical Psychology Review, 26*(2), 196–215. https://doi.org/10.1016/j.cpr.2005.11.007

Pirie, K., Peto, R., Reeves, G. K., Green, J., & Beral, V. (2013). Million Women Study Collaborators. The 21st century hazards of smoking and benefits of stopping: A prospective study of one million women in the UK. *The Lancet, 381*(9861), 133–141.

Sæbø, G., & Scheffels, J. (2017). Assessing notions of denormalization and renormalization of smoking in light of e-cigarette regulation. *International Journal of Drug Policy, 49*, 58–64.

Simonavicius, E., McNeill, A., Shahab, L., & Brose, L. S. (2019). Heat-not-burn tobacco products: A systematic literature review. *Tobacco Control, 28*, 582–594.

Shadel, W. G., & Mermelstein, R. (1996). Individual differences in self-concept among smokers attempting to quit: Validation and predictive utility of measures of the smoker self-concept and abstainer self-concept. *Annals of Behavioral Medicine, 18*, 151–156.

Shahab, L., Goniewicz, M. L., Blount, B. C., Brown, J., McNeill, A., Alwis, K. U., Feng, J., Wang, L., & West, R. (2017). Nicotine, carcinogen, and toxin exposure in long-term E-cigarette and nicotine replacement therapy users: A cross-sectional study. *Annals of Internal Medicine, 166*(6), 390–400. https://doi.org/10.7326/M16-1107

Stead, L.F., Koilpillai, P., Fanshawe, T.R., Lancaster, T. (2016). Combined pharmacotherapy and behavioural interventions for smoking cessation. *Cochrane Database of Systematic Reviews* Issue 3. Art. No.: CD008286. 10.1002/14651858. CD008286.pub3. Accessed June 2022.

Stoklosa, M., Cahn, Z., Liber, A., Nargis, N., & Drope, J. (2020). Effect of IQOS introduction on cigarette sales: evidence of decline and replacement. *Tob Control, 29*(4), 381–387.

Tabuchi, T., Kiyohara, K., Hoshino, T., Bekki, K., Inaba, Y., & Kunugita, N. (2016). Awareness and use of electronic cigarettes and heat-not-burn tobacco products in Japan. *Addiction, 111*, 706–713.

Tattan-Birch, H., Hartmann-Boyce, J., Kock, L., Simonavicius, E., Brose, L., Jackson, S., Shahab, L., & Brown, J. (2022). Heated tobacco products for smoking cessation and reducing smoking prevalence. *Cochrane Database of Systematic Reviews.* https://doi.org/10.1002/14651858.CD013790.pub2. Issue 1. Art. No.: CD013790.

Tombor, I., Shahab, L., Brown, J., & West, R. (2013). Positive smoker identity as a barrier to quitting smoking: findings from a national survey of smokers in England. *Drug and Alcohol Dependence, 133*, 740–745.

Vangeli, E., Stapleton, J., & West, R. (2010). Residual attraction to smoking and smoker identity following smoking cessation. *Nicotine & Tobacco Research, 12*, 865–869.

Walker, N., Parag, V., Verbiest, M., Laking, G., Laugesen, M., & Bullen, C. (2020). Nicotine patches used in combination with e-cigarettes (with and without nicotine) for smoking cessation: a pragmatic, randomised trial. *The Lancet Respiratory Medicine, 8*(1), 54–64.

West, R., Bush, V., Kock, L., Kale, D., Brown, J. (2023). Trends in electronic cigarette use in England. <https://smokinginengland.info/graphs/e-cigarettes-latest-trends> Accessed July 2023.

West, R., & Hajek, P. (2004). Evaluation of the mood and physical symptoms scale (MPSS) to assess cigarette withdrawal. *Psychopharmacology (Berl), 177*, 195–199.

West, R., Ussher, M., Evans, M., & Rashid, M. (2006). Assessing DSM-IV nicotine withdrawal symptoms: a comparison and evaluation of five different scales. *Psychopharmacology (Berl), 184*, 619–627.

Xu, S. S., Meng, G., Yan, M., Gravely, S., Quah, A. C. K., Ouimet, J., O'Connor, R. J., Sutanto, E., Yoshimi, I., Mochizuki, Y., Tabuchi, T., & Fong, G. T. (2020). Reasons for regularly using heated tobacco products among adult current and former smokers in Japan: Finding from 2018 ITC Japan survey. *International Journal of Environmental Research and Public Health, 17*(21), 8030.