



Perceived harm of heated tobacco products, e-cigarettes, and nicotine replacement therapy compared with conventional cigarettes among ever and current heated tobacco users

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ABSTRACT

Aims: There is limited knowledge on how ever and current heated tobacco product (HTP) users perceive the relative harm of various nicotine-containing products. The aim of this study was to explore relative harm perceptions of HTPs, e-cigarettes, and nicotine replacement therapy (NRT) relative to conventional cigarettes (CCs) among ever versus current HTP users, and exclusive (who use only a HTP) versus dual/poly-users (concurrent users of HTP and CCs and/or e-cigarettes).

Methods: Data came from 1423 ever or current Hungarian adult HTP users who participated in a cross-sectional web-based survey in 2020. Unadjusted and adjusted logistic regression analyses were performed to explore the associations between relative harm perceptions, HTP use patterns, past tobacco use, HTP dependence, and socio-demographic variables.

Results: 81.2% of the sample was current HTP users, of them 78.4% were exclusive HTP users. Compared to CCs, 86.2% of the sample perceived HTP to be less harmful, with current and exclusive HTP users endorsing more this belief, followed by NRT (79.8%), and e-cigarettes (45.2%). In general, neither socio-demographic variables nor past tobacco use, HTP use pattern, and HTP dependence were related to perceived harmfulness across the tested products. However, there was a specific pattern for each tested product with a set of explanatory variables.

Conclusions: Ever/current HTP users presented misperceptions about the harms of HTPs, e-cigarettes, and NRT. They underestimated the potential health benefits of NRT and had distorted harm perceptions about HTPs and e-cigarettes. Public education about the relative harms of different nicotine and tobacco products is urgently needed.

1. Introduction

Emerging nicotine and tobacco products such as electronic cigarettes (e-cigarettes) and heated tobacco products (HTPs) are relatively new members of the risk continuum related to tobacco and nicotine products (World Health Organization (WHO), 2019). Based on the number of toxic compounds and nicotine delivery of various tobacco and nicotine products, combustible cigarettes (CCs) are regarded as the most hazardous product while nicotine replacement therapy (NRT) as the least risky for health (Hatsukami & Carroll, 2020). Although it is well known that nicotine is addictive, toxic and pose some risk to health, the risk of health harm by medicinal nicotine products is far less compared to combusted tobacco products and lower than heated tobacco and

nicotine products which use generate numerous harmful substances that are responsible for adverse health outcomes (Hatsukami & Carroll, 2020; Lu et al., 2021; National Academies of Sciences, Engineering, and Medicine, 2018; Simonavicius et al., 2019).

For many years, the public health community generally emphasized that there is no safe tobacco product and mostly disregarded communicating the risk continuum of nicotine products for consumers, which may lead to erroneous relative risk perceptions of tobacco products (Czoli et al., 2017). In line with the appearance of various nicotine products in the market, the assessment of nicotine misperceptions became necessary (Shi et al., 2020). Independent of smoking status, misperceptions about the health harms of nicotine is common, which could deter smokers from using safe and effective quitting aid like NRT.

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(Shi et al., 2020).

The ample evidence on the harms of tobacco use, declining smoking prevalence due to effective tobacco control efforts, and increasingly health-conscious people encouraged the tobacco industry to develop modified risk tobacco products as well as invest in e-cigarettes and enter its market. (El-Toukhy et al., 2018; World Health Organization, 2021). Recently, the tobacco industry developed well-structured and targeted marketing strategies for potential consumers to encourage them for initiating or switching to e-cigarette and/or HTP use for harm reduction or smoking cessation purposes (Collins et al., 2019; Lempert & Glantz, 2020; McKelvey et al., 2018). These marketing claims often emphasize the reduced exposure to chemicals, reduced risks of tobacco-induced diseases and the possibility to quit smoking (McKelvey et al., 2018; Richardson et al., 2015). Tobacco harm reduction is one of the major debates that divide the public health community which opinion may be influenced by industry funded scientific research (Hendlin et al., 2019; World Health Organization, 2021). As for e-cigarettes, growing evidence supports the possible substantially less health risk of vaping than CC smoking in some smokers, and their harm reduction potential for current adult tobacco users who switch completely to e-cigarette use (Lindson-Hawley et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2018). Regarding HTPs, there is some evidence to support the tobacco industry's reduced exposure claims for HTPs, but the evidence is insufficient on whether HTPs could significantly reduce the risk of tobacco-related diseases (Lempert & Glantz, 2020; Lu et al., 2021; McKelvey et al., 2018; Peruga et al., 2020; Tattan-Birch et al., 2022). That is, independent studies cannot confirm that HTP aerosol is indeed less harmful to health compared to CC smoke and e-cigarette aerosol even if reduced exposure to some harmful and potentially harmful constituents of HTP aerosol was detected (Lempert & Glantz, 2020; Lu et al., 2021; McKelvey et al., 2018; Simonavicius et al., 2019). In overall, targeted aggressive marketing and harm reduction claims of new products by the tobacco industry coupled with conflicting information about the harmfulness of emerging tobacco and nicotine products by public health bodies may result in misperception of harm in tobacco and/or nicotine product users (Huang et al., 2019; World Health Organization, 2021). Exposure to imbalanced risk information may press smokers to switch or initiate emerging products like HTPs and e-cigarettes and to disregard safe and effective cessation aids like NRT.

Recent studies found that smokers exposed to HTP advertising on various platforms commonly perceive HTPs as less harmful than CCs (Chen-Sankey et al., 2021; East et al., 2021; Gravely et al., 2020). Several studies identified that smokers believe that e-cigarettes and HTPs are less harmful than CCs. (Gravely et al., 2020; Kim et al., 2020; Persoskie et al., 2019; Sutanto et al., 2020) Moreover, current HTP users were even more likely to endorse this belief. (East et al., 2021; Gravely et al., 2020; Kim et al., 2020) In contrast, a review study concluded that smokers were more likely to overestimate the harmfulness of NRT compared to CCs than the general population. (Czoli et al., 2017).

Previous studies assessing harm perceptions of HTPs, e-cigarettes and NRTs had a sample not limiting exclusively on HTP ever and current users, (Gravely et al., 2020; Kim et al., 2020; Lotrean et al., 2020; Sutanto et al., 2020) therefore little is known about the relative harm perceptions of this special population. It is supposed that some of the HTP users have previous experience with various nicotine products. Besides, a group of smokers may be more receptive to messages claiming either reduced harm/risk of alternative tobacco and nicotinic products or even they hear conflicting information about a product such as e-cigarettes. Thus, many kind of alternative tobacco and nicotine products are represented in their thoughts, of which they may intend to try the product that they perceive to be the least harmful compared to CC smoking.

Out of the almost 8.4 million Hungarians 15 years old and older in years 2019–2020, 27.2–29% were current smoker, while 1.0–2.2% were current e-cigarette user, and only 0.5–1.3% were current HTP user. (Cselkó & Kovács, 2020; European Commission. Directorate General for

Health and Food Safety. et al., 2021; Hungarian Central Statistical Office, 2019) According to a representative national survey, 1.4% of respondents were dual users of e-cigarettes and CCs while 0.6% were current e-cigarette users who were either former smokers or never smokers. (Hungarian Central Statistical Office, 2019) Due to the limited national data on HTPs use, users distribution by smoking status is unknown, however, like as a whole in the member states of the European Union, it is suspected that current and former smokers are more likely to use HTPs than never smokers. (Laverty et al., 2021) In Hungary, both e-cigarettes and HTPs are legally available, however their sale is restricted to National Tobacco Shops, advertising, promotion, and sponsorship is prohibited, and use in public indoor places and some outdoor spaces are also prohibited.

To date, the scientific community has very limited knowledge on how ever and current HTP users perceive the relative harm of various nicotine-containing products and whether they have distorted harm perceptions. Therefore, this study aimed to explore relative harm perceptions of HTPs, e-cigarettes, and NRT relative to CCs among ever versus current HTP users and current exclusive HTP users (who use only a HTP) versus dual/poly-users (concurrent users of HTP and CCs and/or e-cigarettes).

2. Methods

2.1. Participants and procedure

A cross-sectional web-based survey was conducted among Hungarian adult (age 18 +) persons who have ever tried an HTP even only for one-two puffs or currently used HTPs (those who had used an HTP at least once in the past 30 days) in February–June 2020. The convenience sample was obtained by posting the survey on two Hungarian university websites (Eötvös Loránd University and Semmelweis University), on several Hungarian press websites with a press release inviting website visitors to participate, and a survey campaign was also released on Facebook. After reading the description of the study, participants consented to participate voluntarily and anonymously in the survey. No financial or other incentive was offered for participation. The study was approved by the Institutional Review Board of Eötvös Loránd University, Budapest, Hungary (Registration Number: 2020/41).

Of the 3628 initial participants who agreed to participate in the survey, we excluded the followings: those who submitted a blank survey ($n = 502$); duplicate cases based on respondents' IP address ($n = 108$); submitted the questionnaire within an unrealistic response time ($n = 537$); indicated an unrealistic year of birth ($n = 9$); had never tried using a HTP or did not respond whether they had ever tried a HTP ($n = 391$), and did not report his/her past tobacco use ($n = 49$) or were non-tobacco user ($n = 9$). Of the 2023 eligible participants who had ever tried an HTP, 600 were excluded from the current analytical sample due to incomplete responses for questions assessing perceived harms of HTPs and other nicotine containing products. Therefore, 1423 respondents were included in the current analytical sample.

2.2. Measures

2.2.1. Perceptions of harmfulness

Perceptions of the relative harmfulness of HTPs, e-cigarettes, and NRT compared to CCs were assessed by direct questions with continuous rating response options ("In your opinion, compared to smoking conventional cigarettes, using HTPs/e-cigarettes/NRT is much less harmful/a little less harmful/about the same harmful/a little more harmful/much more harmful."). (Czoli et al., 2017) Responses were dichotomized to less harmful ('much less harmful' and 'a little less harmful') versus other ('about the same harmful', 'a little more harmful', 'much more harmful') categories.

2.2.2. HTP use patterns

Ever HTP users were defined as those who had ever tried an HTP even only for one-two puffs. Current HTP users were defined as those who had used an HTP at least once in the past 30 days.

Respondents indicated the frequency of their HTP use in the past 30 days (daily; less than daily, but at least once a week; less than weekly, but at least once a month; less than monthly; not at all). Responses of past 30 days HTP users were collapsed into a binary variable (daily versus non-daily HTP use).

Exclusive HTP users versus dual/poly-users were defined by a question measuring the pattern of smoking/nicotine use in the past 30 days. Participants who responded “I used only a HTP” were regarded as exclusive HTP users, who responded “I used a HTP and CCs alternately during a day” (n = 223) or “I used an HTP and an e-cigarette alternately during a day” (n = 26) were regarded as dual users, while those who used an HTP, CCs, and an e-cigarette alternately during a day (n = 16) were regarded as poly-users. Due to small sample sizes for the latter two categories, dual user and poly-user categories were collapsed into a dual/poly-user category.

HTP dependence was assessed by questions derived from the Penn State Electronic Cigarette Dependence Index (PS-ECDI). (Foulds et al., 2015) In each 10 items, “e-cigarette use” was substituted with “heated tobacco product use”. The wording of items was almost identical with the PS-ECDI, therefore in this article, we abbreviate this measure as Penn State Dependence Index (PS-DI) modified for HTP. We used pre-defined response options for items corresponding to the 2-item Heaviness of Smoking Index of the PS Cigarette Dependence Index and substituted “cigarettes” with “heat sticks (e.g., HEETS)” in the item assessing the number of heat sticks per day and “smoke” with “use your

heated tobacco product” in the item assessing time to first use. Scoring of the PS-DI modified for HTP ranged between 0 and 20 where higher score means higher dependence. Internal consistency of the PS-DI modified for HTP was $\alpha = 0.66$ in our sample.

2.2.3. Covariates

Past tobacco use was assessed with a set of questions measuring daily, occasional use and ever trial of various tobacco products (CCs, roll-your-own cigarettes, cigar, cigarillo, pipe, hookah, and smokeless tobacco products) and e-cigarettes. Responses of past daily and occasional users were collapsed into past CC-only user, past dual user (used CCs and e-cigarettes alternately), and past poly-user (used CCs and ≥ 1 other tobacco product alternately) categories.

Socio-demographic characteristics included sex, age, education, and type of permanent residence.

2.3. Statistical analysis

For overall and for group comparisons, we conducted Chi square tests for categorical variables and Mann-Whitney tests for continuous variables due to the non-normal distribution of age and PS-DI modified for HTP variables explored by Saphiro-Wilk test. Considering the overall sample and HTP use patterns, we calculated the proportions of participants who perceived HTPs, e-cigarettes, and NRT less harmful than CCs. Univariate and separate multiple binary logistic regression analysis explored the associations between relative harm perceptions and HTP use patterns, past tobacco use, and HTP dependence among ever versus current HTP users and exclusive HTP versus dual/poly-users, adjusting for socio-demographic variables. Statistical significance was set at $p <$

Table 1
Descriptive characteristics of the sample.

Variable	Total,n (%)1423 (100)	Ever used a HTP,n (%)268 (18.8)	Current HTP user,n (%)1155 (81.2)			p-values
			Total	Exclusive HTP users,906 (78.4)	Dual/poly- users,249 (21.6)	
Gender						
Male	579 (40.7)	148 (55.2)	431 (37.3)	325 (35.9)	106 (42.6)	$p^a < 0.001$
Female	844 (59.3)	120 (44.8)	724 (62.7)	581 (64.1)	143 (57.4)	$p^b = 0.053$
Age (years)						$p^a = 0.341$
Mean (SD)	39.9 (11.6)	39.5 (12.7)	40.0 (11.4)	39.8 (11.2)	40.8 (12.0)	$p^b = 0.258$
Age group (years)						
19–29	332 (22.6)	65 (24.3)	256 (22.2)	200 (22.1)	56 (22.5)	$p^a = 0.026$
30–39	360 (25.3)	79 (29.5)	281 (24.3)	231 (25.5)	50 (20.1)	$p^b = 0.368$
40–49	422 (29.7)	58 (21.6)	364 (31.5)	282 (31.1)	82 (32.9)	
50–59	271 (19.0)	54 (20.1)	217 (18.8)	168 (18.5)	49 (19.7)	
≥ 60	49 (3.4)	12 (4.5)	37 (3.2)	25 (2.8)	12 (4.8)	
Education						
Technical school or less (without graduation certificate)	227 (16.0)	53 (19.8)	174 (15.1)	135 (14.9)	39 (15.7)	$p^a = 0.127$
High school or vocational school (with graduation certificate)	689 (48.4)	119 (44.4)	570 (49.4)	442 (48.8)	128 (51.4)	$p^b = 0.614$
College or university	507 (35.6)	96 (35.8)	411 (35.6)	329 (36.3)	82 (32.9)	
Permanent residence type						
Capital	460 (32.3)	78 (29.1)	382 (33.1)	297 (32.8)	85 (34.1)	$p^a < 0.001$
County seat/city	465 (32.7)	69 (25.7)	396 (34.3)	316 (34.9)	80 (32.1)	$p^b = 0.720$
Town/village	498 (35.0)	121 (45.1)	377 (32.6)	293 (32.3)	84 (33.7)	
Frequency of HTP use						
Daily	–	–	1035 (91.5)	870 (97.4)	165 (69.3)	$p^b < 0.001$
Non-daily	–	–	96 (8.5)	23 (2.6)	73 (30.7)	
Past tobacco use pattern						
CC-only	450 (31.6)	40 (14.9) ^a	410 (35.5)	340 (37.5)	70 (28.1)	$p^a < 0.001$
CC and e-cigarette dual user	144 (10.1)	23 (8.6)	121 (10.5)	92 (10.2)	29 (11.6)	$p^b = 0.023$
Poly-tobacco user	829 (58.3)	205 (76.5)	624 (54.0)	474 (52.3)	150 (60.2)	
Penn State Dependence Index modified for HTPs						
Mean (SD)	–	–	7.1 (3.4)	7.3 (3.3)	6.1 (3.4)	$p^b < 0.001$

p^a = p-value of Chi-square test or Mann-Whitney *U* test for ever versus current user group comparison; p^b = p-value of Chi-square test or Mann-Whitney *U* test for exclusive HTP versus dual/poly-user group comparison. CC = conventional cigarette, HTP = heated tobacco product.

0.05 and confidence intervals were tested at the 95% confidence level. All analyses were performed using IBM SPSS version 25.0.

3. Results

3.1. Characteristics of the sample

Descriptive characteristics of the sample are displayed in Table 1. More than 80% of the sample was current HTP users, of them 78.4% were exclusive HTP users. The majority of the sample was female, aged < 50 year-old, had high school or vocational school certificate and were past poly-tobacco users. Significantly greater proportion of current HTP users was female, aged 40+, lived in the capital or county seats/cities, and smoked only CCs in the past compared to ever HTP users. Significantly more exclusive HTP users were daily HTP users, smoked only CCs in the past, and had greater HTP dependence compared to dual/poly-users.

3.2. Relative harm perceptions of HTPs, e-cigarettes, and NRT compared to CCs

Overall, the majority of respondents (86.2%) perceived HTPs to be less harmful compared to CCs, followed by NRT (79.8%) while less than half of participants believed e-cigarettes to be less harmful than CC (Fig. 1). Current HTP users and exclusive HTP users perceived HTPs as less harmful than CCs in significantly greater proportion than ever HTP users and dual/poly-users, respectively. Relative harm perceptions of e-cigarettes and NRT compared to CC did not differ significantly by HTP user groups.

Table 2 presents factors associated with the perceptions that HTPs, e-cigarettes, and NRT separately are less harmful than CCs. In general, neither socio-demographic variables nor past tobacco use, HTP use pattern, and dependence were related to the perceived harmfulness of the tested products. Nevertheless, there was a specific pattern for each tested product with a set of explanatory variables. Regarding the perceived harmfulness of HTP compared to CC in univariate regression models, although higher educational level, living in county seats/cities or in the capital, daily and exclusive HTP use, and higher HTP dependence level were all associated with the less harmful perceptions of HTP

compared to CC, some of these associations disappeared in multiple models. Among ever HTP users, males, current users with high school or vocational school certificate were more likely to perceive HTP as less harmful than CC compared to females, less educated respondents and ever users. Including only current users in a multiple logistic regression model, older age and exclusive HTP use was associated with significantly greater odds for perceiving HTPs as less harmful than CCs.

For the perceived harmfulness of e-cigarettes compared to CCs among ever and current HTP users, males as well as past CC and e-cigarette dual users had greater odds for perceiving e-cigarettes as less harmful than CCs in the multiple regression models, but the significant effect of past poly-tobacco use and HTP dependence identified in the univariate models were disappeared in the regression model of ever HTP users. Moreover, current HTP use patterns were not associated with the perceived harmfulness of e-cigarettes.

For the perceived harmfulness of NRT compared to CCs in the multiple regression model of ever and current HTP users, older respondents were more likely to believe NRT as less harmful than CCs compared to their younger counterparts. In the multiple regression model of the current user group, beside older age, higher HTP dependence were also associated with greater odds for perceiving NRT as less harmful than CCs. Neither current HTP use patterns nor past tobacco use had an effect for the perceived harmfulness of NRT.

4. Discussion

To our knowledge, this is the first study in Central Eastern Europe which explored relative harm perceptions of HTPs, e-cigarettes, and NRT in a relatively large sample of ever and current HTP users, exclusively. Relative harm misperceptions of HTPs, e-cigarettes and NRT were common, with approximately 20% of our sample believing falsely that NRT is as or more harmful than CCs while for e-cigarettes, more than half of respondents believed so. Although currently it is unknown exactly where HTPs fall within the risk continuum of nicotine products, HTPs might pose less health risk than CCs but suspected to be more harmful than e-cigarettes and NRT based on the scarce independent evidence. (Lu et al., 2021; Simonavicius et al., 2019) Even though HTP can reduce exposure to harmful chemicals, their harm reducing effect is currently insufficiently explored. (Lu et al., 2021; Tattan-Birch et al.,

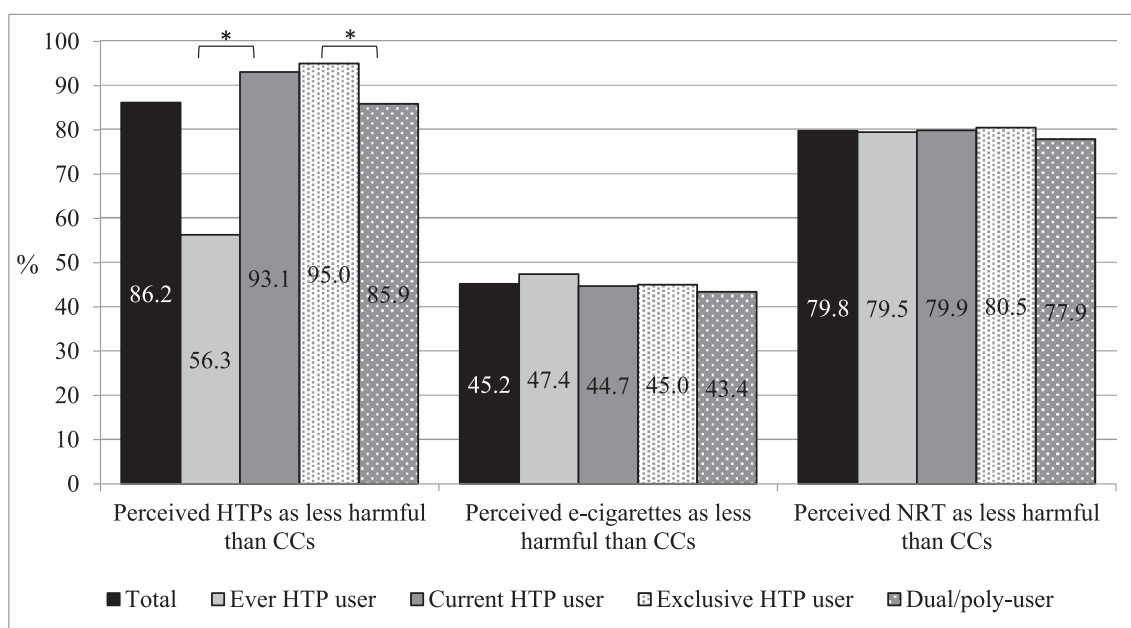


Fig. 1. Frequencies of relative harm perception of using heated tobacco products (HTPs), e-cigarettes and nicotine replacement therapy (NRT) compared to conventional cigarettes (CCs) by HTP use patterns. *p < 0.001, CC = conventional cigarette, HTP = heated tobacco product, NRT = nicotine replacement therapy.

Table 2

Relative harm perception of using heated tobacco products (HTP), e-cigarettes and nicotine replacement therapy (NRT) compared to conventional cigarettes (CCs) among ever and current HTP users in multiple logistic regression models.

Variables	Perceived HTP as less harmful than CCs				Perceived e-cigarettes as less harmful than CCs				Perceived NRT as less harmful than CCs			
			Ever user ^a	Current user ^b			Ever user ^a	Current user ^b			Ever user ^a	Current user ^b
	n (%) / M (SD)	OR (95 % CI)	aOR ^c (95 % CI)	aOR ^d (95 % CI)	n (%) / M (SD)	OR (95 % CI)	aOR ^c (95 % CI)	aOR ^d (95 % CI)	n (%) / M (SD)	OR (95 % CI)	aOR ^c (95 % CI)	aOR ^d (95 % CI)
Sex												
Females	727 (86.1)	Ref.	Ref.	Ref.	339 (40.2)	Ref.	Ref.	Ref.	666 (78.9)	Ref.	Ref.	Ref.
Males	499 (86.2)	1.00 (0.74–1.36)	1.47 (1.03–2.12)	1.29 (0.76–2.17)	304 (52.5)	1.65 (1.33–2.04)	1.57 (1.25–1.96)	1.44 (1.11–1.85)	470 (81.2)	1.15 (0.88–1.50)	1.21 (0.92–1.60)	1.34 (0.97–1.86)
Age	39.9 (11.7)	1.00 (0.99–1.01)	1.00 (0.99–1.02)	1.03 (1.00–1.05)	39.9 (11.9)	1.00 (0.99–1.01)	1.00 (0.99–1.01)	1.01 (0.99–1.02)	40.4 (11.5)	1.02 (1.01–1.03)	1.01 (1.00–1.03)	1.03 (1.00–1.03)
Education												
Technical school/less	181 (79.7)	Ref.	Ref.	Ref.	92 (40.5)	Ref.	Ref.	Ref.	177 (78.0)	Ref.	Ref.	Ref.
High school or vocational school	607 (88.1)	1.88 (1.26–2.80)	1.76 (1.14–2.78)	1.45 (0.71–2.95)	314 (45.6)	1.23 (0.91–1.67)	1.25 (0.92–1.71)	1.13 (0.79–1.61)	533 (77.4)	0.97 (0.67–1.39)	1.04 (0.72–1.50)	1.03 (0.67–1.57)
College/university	438 (86.4)	1.61 (1.07–2.43)	1.52 (0.95–2.44)	0.92 (0.45–1.87)	237 (46.7)	1.29 (0.94–1.77)	1.27 (0.92–1.76)	1.12 (0.78–1.62)	426 (84.0)	1.49 (1.00–2.20)	1.48 (0.99–2.20)	1.47 (0.93–2.33)
Settlement type												
Town/village	411 (82.5)	Ref.	Ref.	Ref.	220 (44.2)	Ref.	Ref.	Ref.	396 (79.5)	Ref.	Ref.	Ref.
County seat/city	412 (88.6)	1.65 (1.14–2.38)	1.24 (0.83–1.88)	1.05 (0.57–1.94)	205 (44.1)	1.00 (0.77–1.29)	0.99 (0.77–1.29)	1.02 (0.76–1.36)	372 (80.0)	1.03 (0.75–1.41)	0.99 (0.72–1.36)	1.03 (0.72–1.49)
Capital	403 (87.6)	1.50 (1.04–2.15)	1.15 (0.76–1.73)	0.79 (0.44–1.41)	218 (47.4)	1.14 (0.88–1.47)	1.11 (0.86–1.44)	1.19 (0.89–1.60)	368 (80.0)	1.03 (0.75–1.41)	0.98 (0.71–1.35)	0.93 (0.65–1.33)
HTP use pattern												
Ever HTP user	151 (56.3)	Ref.	Ref.	–	127 (47.4)	Ref.	Ref.	–	213 (79.5)	Ref.	Ref.	–
Current HTP user	1075 (93.1)	10.41 (7.47–14.50)	11.67 (8.14–16.73)	–	516 (44.7)	0.90 (0.69–1.17)	1.00 (0.76–1.32)	–	923 (89.9)	1.03 (0.74–1.43)	1.03 (0.73–1.44)	–
Dual/poly-user	214 (85.9)	Ref.	–	Ref.	108 (43.4)	Ref.	–	Ref.	194 (77.9)	Ref.	–	Ref.
Exclusive HTP user	861 (95.0)	3.13 (1.96–4.99)	–	2.94 (1.72–5.05)	408 (45.0)	1.07 (0.81–1.42)	–	1.20 (0.87–1.66)	729 (80.5)	1.17 (0.83–1.64)	–	1.21 (0.83–1.78)
Non-daily HTP user	87 (86.1)	Ref.	–	Ref.	48 (47.5)	Ref.	–	Ref.	80 (79.2)	Ref.	–	Ref.
Daily HTP user	985 (94.0)	2.52 (1.36–4.67)	–	1.33 (0.63–2.80)	466 (47.5)	0.88 (0.59–1.33)	–	0.72 (0.44–1.18)	835 (79.7)	1.03 (0.62–1.70)	–	0.72 (0.40–1.32)
Past tobacco use												
Exclusive CC user	398 (88.4)	Ref.	Ref.	Ref.	174 (8.7)	Ref.	Ref.	Ref.	364 (80.9)	Ref.	Ref.	Ref.
CC + e-cigarette	121 (84.0)	0.69 (0.40–1.17)	0.79 (0.44–1.42)	0.76 (0.34–1.72)	75 (52.1)	1.72 (1.18–2.52)	1.62 (1.11–2.38)	1.61 (1.05–2.46)	122 (84.7)	1.31 (0.79–2.18)	1.26 (0.76–2.12)	1.29 (0.73–2.31)
Poly-user	707 (85.3)	0.76 (0.54–1.07)	1.26 (0.83–1.91)	1.13 (0.65–1.98)	394 (47.5)	1.44 (1.14–1.82)	1.29 (1.00–1.66)	1.32 (1.00–1.74)	650 (78.4)	0.86 (0.64–1.14)	0.89 (0.65–1.21)	0.94 (0.69–1.32)
Penn State Dependence Index modified for HTPs	7.1 (3.4)	1.10 (1.02–1.17)	–	1.05 (0.97–1.13)	7.3 (3.5)	1.04 (1.01–1.08)	–	1.04 (1.00–1.08)	7.2 (3.4)	1.06 (1.01–1.10)	–	1.07 (1.02–1.13)
Nagelkerke-R ²	–	–	25.1%	7.5%	–	–	3.0%	3.0%	–	–	2.1%	3.9%

Ref. = reference category; OR = odds ratio; aOR = adjusted odds ratio; CI = confidence interval; M (SD) = mean (standard deviation); Ever user^a = n = 1423; Current user^b = n = 1125; aOR^c = aORs for ever and current HTP users; aOR^d = aORs for current HTP users; CC = conventional cigarette; HTP = heated tobacco product.

2022) Despite the uncertainties whether HTPs can reduce harm, in our study, more than 90% of current HTP users and almost 60% of ever HTP users perceived HTPs as less harmful than CCs. Previous studies detected that 22–48% of adult respondents perceived HTPs less harmful compared to CCs with smokers representing greater endorsement of this perception. (Gravelly et al., 2020; Kim et al., 2020; Lotrean et al., 2020; Sutanto et al., 2020) Parallel with our study, greater agreement with the less health harm of HTPs than CCs (43–73%) was also identified among current exclusive HTP, dual or poly-users compared to HTP non-users. (Gravelly et al., 2020; Kim et al., 2020) However, in our study, believing HTPs as less harmful than CCs was remarkably higher among current HTP users which may be due to several factors including sampling bias, selective attention to and retention of harm-related information, and the psychological mechanism of cognitive dissonance. Users often bolster more positive risk perception for their currently used tobacco product which may mitigate their cognitive dissonance. (Czoli et al., 2017) Like decades earlier, marketing tactics employed by the tobacco industry appears to target all types of potential users whose common characteristic could be a health-conscious attitude towards their own health and others' health. (Hatsukami & Carroll, 2020; Xu et al., 2020) However, individuals with current smoking behavior and health-conscious attitude may experience strong cognitive dissonance which they intend to reduce and rationalize. (Fotuhi et al., 2013) In an environment which lacks strong commitment in promoting smoking cessation, individuals may endorse the industry mediated "less harmful" beliefs of HTPs then engage in a behavior like switching from CC smoking to HTP use which could reduce smokers' cognitive dissonance and may help to rationalize their continued tobacco use. (Fotuhi et al., 2013).

Previous studies explored that 34–66% of their respondents believed that e-cigarettes are less harmful than CCs with current and former smokers endorsing more likely this perception. (Churchill et al., 2020; Fong et al., 2019; Kiviniemi & Kozłowski, 2015; Sutanto et al., 2020; Wilson et al., 2019) Interestingly, only less than half of Hungarian HTP users believed so despite that 37.1% of our sample used e-cigarettes regularly in the past and 13.7% was current daily or occasional e-cigarette user (dual/poly-users). Some possible explanations for this misperception could be that both e-cigarettes and HTPs are strictly regulated as tobacco products in Hungary, however, the tobacco industry can utilize several legal loopholes to widely promote HTPs over e-cigarettes by social advertising in various media platforms. (Joó et al., 2021) On the other hand, compared to e-cigarettes, HTPs may have better accessibility in Hungary and in general, HTPs may seem easier to use, operate, and maintain than the wide variety of e-cigarettes. Furthermore, the increasing scientific evidence on the possible health harms of e-cigarettes as well as the tobacco industry's reduced exposure claims of HTPs might generate a distorted shift in consumers' harm perception and product choice. (Chen-Sankey et al., 2021; McKelvey et al., 2018; World Health Organization, 2021).

Despite that NRT is the least harmful nicotine product and being an approved medicinal product for decades, (Hatsukami & Carroll, 2020) one-fifth of our sample perceived as not less harmful than CCs. Moreover, current HTP users endorsed a little favorable harm perception towards HTPs compared to NRT. Previous studies detected that about 20–60% of their respondents claimed that NRT is as harmful as CC, (Shi et al., 2020) therefore our result could be regarded as favorable but still call for urgent correction of NRT harm misperceptions.

Our finding that current HTP users perceived HTPs as the least harmful product may indicate that Hungarian consumers were convinced by the tobacco industry's claims that HTPs are a novel pioneering method for tobacco harm reduction. Our results are in parallel with the most recent Eurobarometer survey which explored that messages promoting potential harm reduction effect of HTP use are convincing for many Hungarian smokers. That is, more than half of Hungarian HTP users indicated the less harmful belief of HTPs as the main reason to start using HTPs. Besides, the less harmful belief of e-

cigarettes as a motive beyond initiating e-cigarette use was decreased over time and only less than one-third of e-cigarette users indicated it as a reason to start vaping. For Hungarian HTP users, initiating HTP use as an aid to stop or reduce smoking was also an important motive but to a much lesser extent than the less harmful belief of HTPs. (European Commission. Directorate General for Health and Food Safety. et al., 2021) This may also support that the reduced exposure and reduced risk marketing claims of the tobacco industry successfully reach the target audience which are reflected also by our results.

In our study, none of the socio-demographic and use pattern variables were consistently associated with the relative harm perception of all studied products. Previous studies explored that males, younger, and higher education level respondents are more likely to endorse the less harmful belief of emerging nicotine and tobacco products than CCs. (Fong et al., 2019; Kim et al., 2020; Xu et al., 2020) We found that males endorsed more likely the less harmful belief of HTPs and e-cigarettes than females, although this association was not significant for NRT. Older respondents perceived HTPs and NRT to be significantly less harmful than CCs, but age was unrelated to the relative harm perception of e-cigarettes. Both ever and current HTP users who were past dual CC and e-cigarette users perceived e-cigarettes as less harmful than CCs. Although perceiving HTP or e-cigarette use as less harmful than CC smoking did not differed significantly by HTP dependence status, current HTP users with greater HTP dependence perceived significantly more likely NRT as less harmful than CCs.

This study is not without limitations that should be addressed. We used only direct questions to assess respondents' harm perceptions, however, both direct and indirect assessment is recommended to measure accurately harm perceptions. (Churchill et al., 2020; Czoli et al., 2017) Second, the generalizability of results based on this convenience online sample of HTP users is limited. Respondent bias may have also existed as users with more positive experiences and perceptions towards HTPs may have been more motivated to participate in the study. Finally, our sample was predominated by females which may indicate their more health-conscious attitude, attractiveness of HTP designs for them, and their more common health information seeking Internet use. (Hiller et al., 2017; Manierre, 2015; Moodie et al., 2015).

Overall, this study found that the majority of HTP ever and current users considered HTPs to be less harmful than CCs with current and exclusive HTP users endorsing more this belief than ever HTP users and dual/poly-users, respectively. In addition, NRT and e-cigarette harm perceptions were distorted as current HTP users underestimated the potential health benefits of NRT and e-cigarettes compared to the health risk of smoking. Consistent with other studies, our findings highlight the urgent need for accurate and effective public education about the relative harms of different nicotine and tobacco products (Czoli et al., 2017; Gravelly et al., 2020; Kiviniemi & Kozłowski, 2015; Wilson et al., 2019).

CRedit authorship contribution statement

Melinda Péntzes: Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Visualization. **Tamás Joó:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Róbert Urbán:** Conceptualization, Methodology, Investigation, Writing – review & editing, Project administration.

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.

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