Medical Science

To Cite:
Pełka M, Augustowski L, Sadowska J, Pejas O, Śliż D. Perceived Harm and Cessation Related to Heated Tobacco Use. *Medical Science* 2026; 30: e203ms3962
doi: https://doi.org/10.54905/disssi.v30i176.e203ms3962

Authors' Affiliation:
[1]Students' Scientific Group of Lifestyle Medicine, 3rd Departament of Internal Medicine and Cardiology, Medical University of Warsaw, Warsaw, Poland
[2]3rd Department of Internal Medicine and Cardiology, Medical University of Warsaw, Poland

***Corresponding author:**
Maciej Pełka,
Students' Scientific Group of Lifestyle Medicine, 3rd Departament of Internal Medicine and Cardiology, Medical University of Warsaw, Żwirki i Wigury 61 St., 02-091 Warsaw, Poland
E-mail address: pelka.maciej.pl@gmail.com

Peer-Review History
Received: 30 January 2026
Reviewed & Revised: 25/February/2026 to 29/September/2026
Accepted: 12 October 2026
Published: 21 October 2026

Peer-review Method
External peer-review was done through double-blind method.

Medical Science
pISSN 2321–7359; eISSN 2321–7367

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DISCOVERY SCIENTIFIC SOCIETY

Perceived Harm and Cessation Related to Heated Tobacco Use

Maciej Pełka[1]*, Łukasz Augustowski[1], Julia Sadowska[1], Olga Pejas[1], Daniel Śliż[2]

ABSTRACT

Introduction: Heated tobacco products are marketed as healthier alternatives to conventional cigarettes, but their actual influence remains poorly understood. Since there is no available assessment tool for nicotine dependence among heated tobacco users, it is difficult to evaluate the level of addiction. The present study aims to assess harmfulness and cessation-related factors associated with heated tobacco products. The group includes non-users, conventional cigarette smokers, heated tobacco users, and dual users. *Materials and methods*: We conducted an online survey covering socio-demographic features and perceived health risks of heated tobacco products. We used the Fagerström Test for Nicotine Dependence and a 1-10 self-report scale to assess the nicotine dependence severity. We modified the questions based on the responder's answers. *Results*: The vast majority of non-tobacco users perceived heated tobacco products to be harmful. The responses acquired from nicotine users were more diverse. According to the Fagerström Test for Nicotine Dependence, the highest level of nicotine dependence was observed among heated tobacco users, followed by dual users and conventional cigarette smokers. Results from the 1- 10 self-report scale showed a similar pattern. *Conclusions*: Heated tobacco users and dual users appeared to be more nicotine dependent than conventional cigarette smokers, as indicated by both the Fagerström Test for Nicotine Dependence and the 1–10 self-report scale. The health risks associated with heated tobacco products vary depending on nicotine status.

Keywords: heated tobacco products, nicotine, smoking, cessation

1. INTRODUCTION

Lung cancer is the most common cause of cancer-related death around the world. Smoking cessation continues to be one of the main methods of prevention (Warren & Cummings, 2013). Approximately 1.8 million deaths each year are caused by tobacco use, based on the World Health Organization (WHO) data. In Poland, tobacco use is estimated to cause over 70.000 deaths each year (Fal et al., 2022). The health complications from conventional cigarettes are vast. They range from cardiovascular disease and chronic obstructive pulmonary disease (COPD) to cancers of the oral cavity, oropharynx, nasopharynx, hypopharynx or oesophagus (Kotlyarov, 2023; Weber et al., 2021). Heated tobacco products (HTP) and electronic cigarettes are labelled as alternative nicotine products. Since their launch, HTP have gained popularity in recent years. In Poland, the prevalence of daily heated tobacco

use was 4% in 2022 (Jankowski et al., 2022). Unlike conventional cigarettes, HTP rely on heating the tobacco sticks to a temperature below the point of combustion. This produces the inhalable aerosol. During this proces, pyrolysis does not take place. Unlike conventional cigarettes (CCs), HTP are promoted as products with less exposure to tar compounds (Bitzer et al., 2020; Akram et al., 2025).

Scientific evidence shows that their long-term impact remains not well understood. In recent years, HTP have gained popularity among individuals who seek substitutes for healthy reasons. (Popova et al., 2018; Znyk & Kaleta, 2025). This leads to misunderstandings about risk and promotes ongoing nicotine use. Based on the research, the main reasons for starting and ongoing use of HTP are curiosity, social influence, and reduced harm, especially among younger users. (Fearon et al., 2024). In Poland, the prevalence of HTP users within the previous 30 days was 10.9% in 2024. 4.9% of participants declared using HTP on a daily basis (Jankowski et al., 2024). To assess nicotine dependence level for CCs the Fagerström Test for Nicotine Dependence (FTND) is used. Scores range from 0 to 10, where higher scores indicate stronger physical nicotine dependence (Heatherton et al., 1991). Since there is no equivalent scale has been developed for HTP, it is difficult to assess the dependence of HTP users and dual users.

The aim of this study is to examine how smokers and non-smokers in Poland perceive the HTP and their potential role in quitting (Zhou et al., 2024). This research also considers dual users to better capture whether HTP serve as a substitute for, or a 'stepping stone' to, cessation of conventional smoking. Our study aims to assess the knowledge, risk perceptions, and cessation-related factors associated with heated tobacco products among tobacco users and non-tobacco users in Poland. We hope our research will help in understanding the relationship between the level of dependence and HTP, thus providing data for the development of a standardized assessment tool (Duan et al., 2022; Fearon et al., 2024).

2. REVIEW METHODS

Data Collection and Study Population

The study took place between 01.04 and 01.07.2024. An online survey was made using Google Forms. Participants were recruited through Facebook groups. These groups were focused on heated tobacco products, health-related concerns, and smoking cessation. Participation in the study was voluntary and anonymous. The collected data contained no personal information. The inclusion criteria were a minimum age of 18. Exclusion criteria included age below 18 years and incomplete responses. The survey was divided into four main sections: a description of the study population; perception of the health risks associated with heated tobacco products; severity of dependence based on the Fagerström Test for Nicotine Dependence (FTND); and self-reported severity of dependence on a scale of 1-10.

Health risk perception

All participants, regardless of smoking status, were asked questions regarding the perceived health effects of heated tobacco products.

Analysis of Tobacco Use and Smoking Habits

The question 'Do you smoke traditional cigarettes or use heated tobacco products?' was used to obtain the nicotine status of the participants. Based on that, the participants were labeled as conventional cigarette smokers, HTP users, dual users, or non-users.

Level of Nicotine Dependence

Nicotine dependence was measured with the Fagerström Test for Nicotine Dependence (FTND) (Heatherton et al., 1991), a standardized and validated tool originally developed to evaluate nicotine dependence among conventional cigarette smokers. We adapted the FTND to be more understandable for HTP users and dual users. Terms related with cigarettes and smoking were replaced with 'HTP use' and 'tobacco stick'. FTND scoring criteria were applied to measure the dependence level: 7–10 points (highly dependent), 4–6 points (moderately dependent), and <4 points (minimally dependent). Participants were asked to self-report their nicotine dependence on a scale: 1 (no dependence) to 10 (severe dependence). For statistical analysis, self-reported dependence scores were grouped into three categories: 1–4 points, 5–8 points, and 9–10 points.

Data Analysis

The acquired data were exported to Microsoft Excel. To examine the differences in the sections 'perception of the health risks associated with heated tobacco products', 'severity of addiction based on the FTND', and 'self-reported dependence scale (1–10)', the chi-squared

tests (Pearson's chi-square test, likelihood chi-square test) were used. The Kruskal-Wallis rank ANOVA was performed to evaluate the differences in nicotine dependence, measured by both the Fagerström Test for Nicotine Dependence and the self-reported dependence scale (1-10). Jonckheere-Terpstra trend test was used to assess rising trends across groups. Differences were considered statistically significant at $p<0.05$.

3. RESULTS

Description of the Study Population

A total of 752 individuals were initially enrolled in the study. Only 740 met the inclusion criteria. Twelve participants were excluded due to incomplete responses or suspected insincerity. Among the 740 responders, 457 (61.8%) were women and 283 (38.2%) were men. Regarding smoking status, 436 participants (58.9%) identified as non-smokers, while 304 (41.08%) responders declared as a smokers, heated tobacco users, or dual users. Among them, 39 (5.27%) individuals were exclusive users of conventional cigarettes, while 205 (27.70%) reported using only HTP. Only 60 (8.10%) dual users were noted (Table 1).

Table 1. Demographic profile by gender, age, marital status, education status, occupational status, residence status, nicotine-users status

Variable		Number of participants (N)	Percentage of participants (%)
Gender	Male	283	38.24
	Female	457	61.76
Age (years)	18-26	517	69.86
	27-35	103	13.92
	36-50	89	12.03
	>50	31	4.19
Marital status	Cohabitation	280	37.84
	Single	341	46.08
	Married	101	13.65
	Divorced	8	1.08
	In separation	1	0.13
	Widow	2	0.27
	Not listed above	7	0.95
Education status	Higher	219	29.59
	College education	261	35.27
	Middle	243	32.84
	Primary	4	0.54
	Vocational	13	1.76
Occupational status	Intellectual work	225	30.40
	Physical work	39	5.27
	Combined physical and intellectual work	91	12.30
	Student	375	50.68
	Unemployed	10	1.35
Residence status	Village	94	12.70
	Up to 50,000	93	12.57
	50,000-150,000	58	7.84
	150,000-500,000	78	10.54
	More than 500,000	417	56.35

Nicotine-users status	Non-smokers	436	58.92
	CCs	39	5.27
	HTP users	205	27.70
	Dual users	60	8.10

Perception of the health risks associated with heated tobacco products

The perceived harmfulness of HTP was assessed among all participants regardless of nicotine status (N = 740). Statistically significant differences were observed across all questions. This suggests a correlation between nicotine user status and their perception of heated tobacco products. Most non-smokers perceived HTP as less healthy alternative to conventional cigarettes and considered the emitted aerosol to be harmful to bystanders, while nicotine users demonstrated an opposite view (Table 2).

Table 2. Influence of nicotine products on health

	Do you consider HTP to be healthier alternative than conventional cigarettes?		Do you consider the aerosol emitted from heated tobacco products to be harmful to bystanders?		Do you consider heated tobacco products to be as thoroughly researched as conventional cigarettes?		Do you consider heated tobacco products to be effective in supporting smoking cessation efforts?	
Variable	Yes N (%)	No N (%)	Yes N (%)	No N (%)	Yes N (%)	No N (%)	Yes N (%)	No N (%)
Non-smokers	172 (23.25)	264 (35.67)	351 (47.43)	85 (11.49)	28 (3.78)	408 (55.14)	71 (9.59)	365 (49.32)
Cigarette smokers, HTP users, dual users	215 (29.05)	89 (12.03)	144 (19.46)	160 (21.62)	84 (11.35)	220 (29.73)	93 (12.57)	211 (28.51)
In total	387 (52.30)	353 (47.70)	495 (66.89)	245 (33.11)	112 (15.14)	628 (84.86)	164 (22.16)	576 (77.84)

Severity of dependence based on Fagerström Test for Nicotine Dependence (FTND)

Nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence. No statistically significant differences in responses were found across observed groups, except for two items in Table 3. For the post-awakening interval to first tobacco use, Pearson's chi-squared test indicated no significant differences between the groups, whereas the likelihood chi-square test yielded a significant result. In contrast, for daily tobacco stick consumption, both the Pearson's chi-squared test and likelihood chi-square test showed statistically significant differences. This indicates that the pattern of tobacco use influences the post-awakening interval to first tobacco use and the quantity of tobacco consumed daily. The Kruskal–Wallis ANOVA was used to compare total FTND scores among CCs, HTP users, and dual users. No statistically significant differences were found between the groups. A significant increasing trend pattern was observed in total and mean rank scores based on the Jonckheere-Terpstra test. This trend was observed among CC, dual users, and HTP users (Table 6). Based on the FTND scoring criteria, the vast majority of participants (n = 179) exhibited minimal nicotine dependence. The largest proportions of individuals with moderate and high dependence were observed among HTP users, followed by dual users and cigarette smokers. However, the differences were not statistically significant. Detailed participant responses who declared as conventional cigarette users, HTP users and dual user (N=304) are presented in Tables 3-5. Table 6 summarizes the severity of nicotine dependence according to FTND scoring.

Table 3. Cigarettes and tobacco sticks count and time to first cigarette of HTP after waking up (N = 304)

How many tobacco sticks per day do you use?				
Variable	10 or less	11 to 20	21 to 30	31 or more
HTP users	91	86	25	3
Dual users	43	13	2	2
In total	134	99	27	5

How many cigarettes per day do you smoke?				
	10 or less	11 to 20	21 to 30	31 or more
CCs	26	10	3	0
Dual users	49	7	2	2
In total	75	17	5	2
How soon after you wake up do you smoke your first cigarette or use your HTP?				
	Within 5 minutes	6 to 30 minutes	31 to 60 minutes	After 60 minutes
CCs	3	11	1	24
HTP users	28	64	33	80
Dual users	11	20	10	19
In total	42	95	44	123

Note. Tables 3-5 present responses only from participants who currently smoke cigarettes and/or use HTP (N=304: 39 cigarette smokers, 205 HTP users, and 60 dual users) out of the total sample of 740 participants, non-users did not answer these items.

Table 4. Difficulty refraining from smoking/HTP use in prohibited places and most disliked product to give up throughout the day (N = 304)

Do you find it difficult to refrain from smoking or using HTP in places where it is forbidden?		
	Yes (N)	No (N)
CCs	10	29
HTP users	45	160
Dual users	16	44
In total	71	233
Which cigarette or tobacco stick would you hate most to give up?		
	The first one in the morning (N)	Any other (N)
CCs	17	22
HTP users	87	118
Dual users	22	38
In total	126	178

Note. Tables 3-5 present responses only from participants who currently smoke cigarettes and/or use HTP (N=304: 39 cigarette smokers, 205 HTP users, and 60 dual users) out of the total sample of 740 participants, non-users did not answer these items.

Table 5. Frequency of smoking/HTP use after waking up and during illness (N = 304)

Do you smoke or use HTP more frequently during the first hours after waking than during the rest of the day?		
	Yes (N)	No (N)
CCs	7	32
HTP users	30	175
Dual users	14	46
In total	51	253
Do you smoke or use HTP when you are so ill that you are in bed most of the day?		
	Yes (N)	No (N)
CCs	13	26
HTP users	98	107
Dual users	29	31
In total	140	164

Note. Tables 3-5 present responses only from participants who currently smoke cigarettes and/or use HTP (N=304: 39 cigarette smokers, 205 HTP users, and 60 dual users) out of the total sample of 740 participants, non-users did not answer these items.

Table 6. Level of nicotine dependence according to the Fagerström Test for Nicotine Dependence (FTND)

Variable	Minimum score	Maximum score	Median value	Total of ranks	Mean rank	Minimally dependent N (%)	Moderately dependent N (%)	Highly dependent N (%)
CCs	0	9	1	4935.00	126.53	27 (69.23)	8 (20.51)	4 (10.26)
HTP users	0	9	3	32465.50	158.36	116 (56.59)	65 (31.71)	24 (11.70)
Dual users	0	10	3	8959.50	149.32	36 (60.00)	17 (28.33)	7 (11.67)
In total						179	90	35

Self-reported dependence scale (1-10)

Participants were asked to rate their perceived level of nicotine dependence on a self-reported scale. The Kruskal–Wallis ANOVA was used to compare self-reported dependence scores among CCs, HTP users and dual users. No, statistically significant differences were found between the groups. Additionally, the Jonckheere-Terpstra test was conducted to evaluate a potential monotonic trend, but no statistically significant upward trend was observed in the self-reported dependence scale (Table 7).

Table 7. Self-reporting nicotine dependence scale

Variable	Minimum score	Maximum score	Median value	Total of ranks	Mean ranks
Conventional cigarettes smokers	1	10	6	5204.50	133.44
HTP users	1	10	6	32192.50	157.03
Dual users	1	10	7	8963.00	149.38

4. DISCUSSION

According to the FTND classification, the highest numbers of participants classified as moderately or highly dependent were observed among HTP users, followed by dual users and conventional cigarette users, respectively. Despite the insignificant p-values, the outcomes from dual users and HTP users according to FTND are perceived to be more nicotine dependent than conventional cigarette smokers. Our findings are consistent with previous studies. Poly-tobacco consumers and HTP users have been associated with higher dependence and more prevalence respectively (Huh et al., 2022; Sung et al., 2018). A question referring to the time of the first smoke after waking up was statistically meaningful, according to the maximum likelihood chi-square test, but negligible based on Pearson's chi-squared test, the majority of participants smoked or used their first HTP 60 minutes after they woke up.

Our findings cannot be directly compared to those of Lau et al., (2022), as their study also focused on the time-to-first-smoke after waking up but with three different cut-offs – under 5, 15, and 30 min. Both daily conventional cigarette users and dual users (with daily cigarette users) showed higher nicotine dependence than exclusive non-daily conventional cigarette users, across all cut-offs. HTP users showed higher levels of nicotine dependence compared to non-daily cigarette smokers, but only when the 30 and 15 cut-offs were applied. A similar pattern was observed among dual users and non-daily cigarette users (Lau et al., 2022). The time-to-first-smoke cigarette after waking up might be a valuable measure of nicotine dependence for HTP as well as for conventional cigarette smokers. This points out the need for tailored cessation strategies. The efficient interventions for conventional smokers may require adjustment or greater intensity for dual and HTP users, who may report stronger addiction. In the self-reported scale, we noted an upward trend in both total ranks and mean ranks. It progressed from conventional cigarette smokers to dual users and HTP users. Despite the insignificant p-value, this might indicate a monotonic pattern. Individuals who exclusively smoke conventional cigarettes rated their nicotine dependence as the lowest. In contrast, dual users and HTP users rated it at higher and the highest levels, respectively.

Our findings were in partial agreement with those of Hwang et al., (2023), who reported that dual users and triple users self-identified as highly addicted. Our results were still consistent with previous research, showing that poly-users of tobacco products exhibited elevated levels of nicotine addiction compared to the single users (Huh et al., 2022). These results highlight the importance of the development of novel tobacco cessation strategies for dual and HTP users. These populations might experience higher nicotine dependence. Data show that the majority of nicotine users considered HTP to be a less harmful alternative than conventional cigarettes. Most of the non-smokers disagreed. Results reported by Pénzes et al., (2022) were consistent with our findings. Current and exclusive HTP users considered heated tobacco products to be less harmful than conventional cigarettes. However, another study observed that more dual users and exclusive conventional cigarette smokers perceived HTP to be as harmful as conventional cigarettes or worse

(Goulette et al., 2023). Another study reported that 51.5% of participants who declared themselves as 'never smokers' had considered heated tobacco products to be associated with lower levels of harm compared to conventional cigarettes (Wężyk-Caba et al., 2022).

In our study, most non-smokers considered the aerosol emitted by heated tobacco products harmful to bystanders. However, slightly more than half of conventional cigarette smokers, HTP users, and dual users did not consider heated tobacco products harmful. A similar pattern was observed by Sparrock et al., (2023). They observed that 19.7% of participants from the study population (3.8% never users, 24.1% susceptible never users, 51.1% current HTP users) agreed with the statement 'IQOS does not harm bystanders'. In our research, both non-smokers and nicotine users predominantly did not consider HTP to be effective in supporting smoking cessation efforts. A comparable pattern has been reported: most participants across all three groups did not believe that HTP facilitates smoking cessation (Kim et al., 2020). Additionally, we found that a large proportion of participants did not consider heated tobacco products to be as thoroughly researched as conventional cigarettes. Misperceptions of HTP as less harmful emphasize the need for healthcare professionals to correct these false impressions. These results support targeted educational interventions. Several restrictions should be considered while interpreting the results. First of all, the study was conducted using an online survey. Therefore, a potential risk of insincere answers should be considered. We were unable to assess participants' current physical condition. This may have influenced the interpretation of the data. HTP are considered to be relatively novel nicotine products on the Polish market, as they were introduced in 2017 (Znyk et al., 2025), resulting in a lack of knowledge among respondents regarding HTP.

Our study population consisted of 740 respondents, most of whom identified as non-smokers. As a result group sizes among cigarette smokers, HTP users, and dual users were small and uneven. Measuring the occasional use of nicotine products poses a methodological challenge, because of the irregular consumption and reliance on self-reported data. In our self-report online survey, we attempted to evaluate the level of nicotine dependence. However, users of heated tobacco products might not have perceived using them regularly as a form of addiction, which could lead to an underestimation of the results. The difference in p-value in time-to-first-smoke might have resulted from a limited study population. The likelihood chi-squared test was more sensitive for smaller sample sizes compared to Pearson's chi-squared test. The main strength of this study was the use of a validated instrument, the Fagerström Test for Nicotine Dependence, alongside an extended set of questions covering multiple areas of interest. We believe that further research is needed to clarify the perception of harmfulness and cessation-related factors associated with heated tobacco products, using a larger sample size or a newly developed questionnaire measuring dependence on heated tobacco products.

5. CONCLUSION

The data obtained indicate a correlation between smoking status and the perception of risks associated with HTP. Tobacco product users in particular tend to perceive HTP as less harmful, while not considering them helpful in quitting smoking. Differences in FTND scores suggest that HTP users may be more vulnerable to developing higher nicotine dependence than cigarette smokers. This aligns with previous reports in the literature. The subjective assessment of their own addiction by http users also suggests a higher degree of nicotine dependence in this group. A further limitation, was the relatively homogeneous and small sample, recruited primarily through social media, which may limit the possibility of fully generalizing the results. These observations highlight the need for further, more representative research on the addictive potential of HTP and the social perception of these products. This study provides insight into public awareness of HTP and their addictive potential. It could be helpful in research on tailored educational campaigns.

Acknowledgments

This manuscript has been read and approved by all the authors. Each of the authors believes that this manuscript represents honest work done by us.

Authors' Contributions

Conceptualization: Maciej Pełka, Daniel Śliż
Methodology: Maciej Pełka, Daniel Śliż
Formal Analysis: Maciej Pełka, Julia Sadowska
Sources: Maciej Pełka, Łukasz Augustowski, Olga Pejas, Julia Sadowska
Visualization: Maciej Pełka, Łukasz Augustowski
Investigation: Maciej Pełka, Łukasz Augustowski, Olga Pejas, Julia Sadowska
Supervision: Daniel Śliż

Validation: Daniel Śliż
Writing: Maciej Pełka, Łukasz Augustowski, Olga Pejas, Julia Sadowska
Project administration: Maciej Pełka, Daniel Śliż
All authors have read and agreed with the published version of the manuscript

Informed consent
Not applicable.

Ethical approval
Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Funding
This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest
The authors declare that they have no conflicts of interest, competing financial interest or personal relationship that could have influenced the work reported in this paper.

Data and materials availability
All data associated with this study will be available based on the reasonable request to the corresponding author.

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