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PERCEPTIONS AND USE OF POD-BASED E-CIGARETTES: A SCOPING REVIEW

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ABSTRACT

Objectives: This scoping review aims to synthesize the use and perceptions of pod-based electronic cigarettes worldwide.

Methods: We conducted a search in PubMed, Embase, and Web of Science in July 2024. The search strategy included keywords related to "pod-based electronic cigarettes," "use," and " perception." We selected observational studies reporting the prevalence of pod-based electronic cigarette usage and perceptions regarding pod-based electronic cigarettes.

Results: From 2,269 articles found in the databases, we selected 14 articles for our final review, including 12 studies focusing on the prevalence of pod-based electronic cigarette usage and seven studies examining perceptions related to these devices. The prevalence of ever using pod-based electronic cigarettes varied significantly, ranging from 5.9% to 29.2%. In contrast, the current usage rate was lower, falling between 1.6% and 23.2%. Additionally, the perception of the harms associated with pod-based electronic cigarettes encompassed a wide range, with figures between 53.8% and 91.3%. Meanwhile, the perception of their addictiveness varied from 32.7% to 91.5%.

Conclusion: The prevalence of pod-based electronic cigarette use was relatively high, with youth showing a greater tendency to use pod-style electronic cigarettes compared to young adults. Additionally, studies focusing on electronic cigarette users revealed lower perceptions of the harmful effects and the addictiveness of pod-based electronic cigarettes compared to studies conducted on the general population.

Keywords: pod-based electronic cigarette; ever use, current use, perceptions, harm, addictiveness.

1. INTRODUCTION

Numerous studies worldwide have shown the association between the use of e-cigarettes (ECs) and various health issues in multiple organs, such as respiratory and cardiovascular systems, as well as mental health problems [1,2]. Additionally, ECs contain different amounts of nicotine and have been linked to subsequent tobacco smoking and other unhealthy behaviors, such as non-prescription drug use, cannabis consumption, and alcohol use [3,4]. Most importantly, despite being marketed as a tool to help quit smoking, several studies indicated a significant increase in EC use among young people without a smoking history, and many of them reported using these products regularly [5].

A concerning issue is that the design of e-cigarette products is continuously updated, with many new styles and features being introduced to the market. The new generation of electronic nicotine delivery systems in pod form was launched in 2015 and quickly became a prominent product in the EC industry due to its attractive design, variety, and ease of concealment [6]. While previous types of EC require e-liquid to be added to the tank, pod-based ECs use pre-filled cartridges that

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are easy to replace when empty. Additionally, the sleek, compact, and "high-tech" design of pod-based ECs allows users to easily conceal the device in the palm of their hand, making it less noticeable to those unfamiliar with this product line [7]. JUUL, a well-known brand of pod-mod ECs, has contributed to the surge in youth vaping through advertising campaigns targeted at young people. It has been the most popular electronic brand among teenagers and young adults in the United States [8]. JUUL's sales experienced a significant surge, and as of July 2, 2018, it accounted for 68% of the United States e-cigarette market, representing a remarkable increase of 783% compared to the previous year ending June 16, 2018 [9].

Moreover, the perception of the harms associated with pod-based ECs plays a significant role in their usage. Several studies have demonstrated that misconceptions regarding the harms and addictive potential of ECs were significantly associated with the intention to use and the initiation of usage in the future [10,11].

Although some studies have reviewed the use and perceptions of the harms of ECs in general, research focusing on pod-style ECs still needs to be more extensive. Some studies have been conducted to describe the use and perceptions of pod-based ECs; however, the reported results vary across different studies. Therefore, we conducted this scoping review to synthesize existing published articles related to the use and perceptions of pod-based ECs.

2. MATERIALS AND METHODS

2.1. Literature Search

This scoping review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines [12].

2.2. Data sources

We conducted a search for relevant articles in PubMed, Embase, and Web of Science in July 2024.

2.3. Search strategy

The search strategy included keywords related to "pod-based electronic cigarettes," "use," and "perception." These keywords were combined using Boolean operators (AND, OR) to create a comprehensive search strategy. The search keywords for pod-based ECs included “pod-based e-cigarettes”, “pod mods”, “pod systems”, “pod e-cigarettes”, “pod e-cigs”, “pod-based e-liquids”, “pod-style e-cigarettes”, “pod-type e-cigarettes”, and “JUUL”. Keywords for usage included “use” and “prevalence”. Keywords for perception encompassed “harm perception”, “perception”, “awareness”, and “knowledge”.

2.4. Selection criteria

We selected observational studies that described the prevalence of pod-based EC usage and perceptions regarding pod-based EC. Since pod-based ECs were first introduced in 2015, we included articles published from January 1, 2015. Research reports, conference presentations, systematic reviews, meta-analyses, articles published in non-peer-reviewed journals, and publications in languages other than English were excluded. Additionally, we excluded studies that did not report the prevalence of pod-based EC usage in the general population or did not provide the absolute number of individuals who had ever used or were currently using these products. For example, studies that only reported the prevalence of pod-based EC usage among individuals who had previously or were currently using ECs were excluded.

2.5. Selection of relevant studies

Two researchers independently reviewed the titles and abstracts of records retrieved from the databases and assessed their relevance based on the selection criteria. Any discrepancies in decisions between the researchers were resolved through discussion. Data extracted from the studies included title, year of publication, name of the first author, study design, study area, sample size, data collection period, characteristics of participants (age and gender), prevalence of ever using pod-based ECs, prevalence of current pod-based EC usage (defined as using at least once in the past 30 days), prevalence of pod-based EC usage in the past 7 days, and perception of the harms and addictiveness of pod-based EC.

3. RESULTS

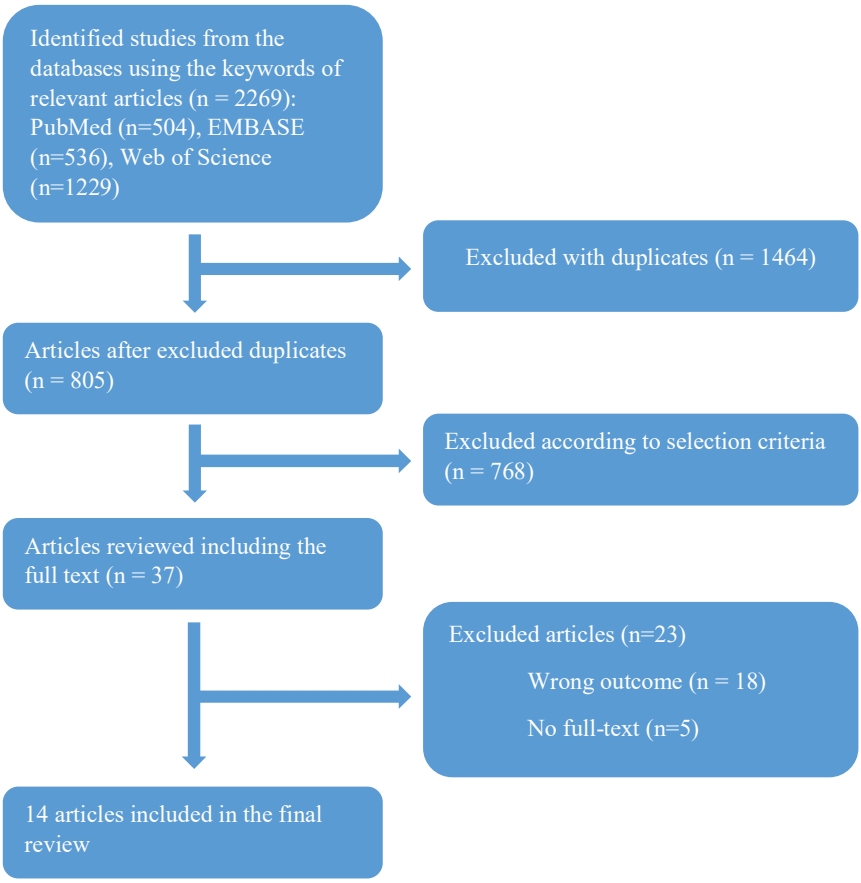

Figure 1. Flow diagram of identification of relevant studies

Figure 1 demonstrates the selection process for the studies included in the final analysis. The search results from the three databases identified a total of 2,269 articles. Of these, 1,464 duplicates were removed, and 742 articles were excluded through title and abstract screening. Full-text screening of the remaining 37 articles resulted in the exclusion of 23 articles due to several reasons, as shown in Figure 1. 14 articles met the selection criteria, including 12 studies that reported the prevalence of pod-based EC usage and 7 studies that reported perceptions related to pod-based ECs.

Table 1. Characteristics of selected studies reporting the prevalence of pod-based EC

Study	Country	Sample size	Age (Range or Mean ± SD)	Gender proportion	
				% Male	% Female
McKelvey, 2018 [13]	US	437	19,3 ± 1,7	35.9	62.6
McKelvey, 2020 [14]	US	437	20,1 ± 1,6	35.2	64.8
Russell, 2020 [15]	US	9865	13-17 years	51.0	49.0
Chen-Sankey, 2020 [16]	US	341	≥18 years	57.2	42.8
Lin, 2020 [17]	US	363 (Wave 6)	19.3 ± 1.65	32.0	66.4
		333 (Wave 7)	19.7 ± 1.62	31.5	66.7
North, 2021 [18]	US	3543	21-34 years 24,0 ± 2,3	34.0	66.0
Wagoner, 2021 [19]	US	1836	26,2 ± 0,5	47.6	52.4
Singer, 2022 [20]	US	873	14-21 years	100.0	0.0
Alshaibani, 2023 [21]	Kuwait	3032	≥18 years	45.3	54.7

Table 1 shows the characteristics of selected studies reporting the prevalence of pod-based EC. There are 11 studies from the United States, and only one was conducted in Kuwait. The sample sizes varied significantly, ranging from 112 participants to 9,865 participants. The study population consisted of relatively young individuals, including adolescents and young adults. Furthermore, the male-to-female ratio varied across the studies, with the percentage of males ranging from 31.5% to 100%.

Table 2. Characteristics of selected studies reporting the perceptions of pod-based EC

Study	Country	Population	Sample size	Age (Range or Mean ± SD)	Gender proportion	
					% Male	% Female
Case, 2020 [22]	US	among JUUL users	510	24,3 ± 2,4	46.3	53,7
Russell, 2020 [15]	US	among all participants	9865	13-17 years	51,0	49,0
North, 2021 [18]	US	among all participants	3543	21-34 24,0 ± 2,3	34,0	66,0
Strombotne, 2021 [23]	US	among all participants	1610	16,1 ± 1,4	51,0	49,0
Wagoner, 2021 [19]	US	among all participants	1836	26,2 ± 0,5	47,6	52,4
Singer, 2022 [20]	US	among all participants	873	14-21 years	100%	-
Obisesan, 2023 [24]	US	pod-mods user	112	18-24 years 20,5 ± 1,2	49 (43,7%)	63 (56,3%)

Table 2 illustrates the characteristics of selected studies reporting the perceptions of pod-based EC. All studies were carried out in the United States. The sample sizes varied significantly, from 112 participants to 9,865 participants. The percentage of males ranged from 34.0% to 100.0%.

Table 3. Use of pod-based ECs

Study	Data collection period	Sample size	Use of pod-based ECs		
			Ever use (%)	Current use (%)	Use in the past 7 days (%)
McKelvey, 2018 [13]	4/2018-6/2018	437	15.6	9.2	5.7
McKelvey, 2020 [14]	1/2019-3/2019	437	26.3	13.5	-
Russell, 2020 [15]	11/2018-12/2018	9865		15.7	
Chen-Sankey, 2020 [16]	4/2018	341	19.0	23.2	
Lin, 2020 [17]	4/2018-8/2018	363	14.9	8.8	5.5
	8/2018-11/2018	333	22.5	10.2	6.3
North, 2021 [18]	2018	3543		2.8	
	2019	3543		6.7	
Wagoner, 2021 [19]	Spring 2018	1836	5.9	1.6	
	Fall 2018	1836	12.7	3.4	
Singer, 2022 [20]	1/2019-12/2019	873	29.2	12.0	
Alshaibani, 2023 [21]	1/2021-2/2021	3032		8.3	

Six studies reported the prevalence of ever using pod-based ECs, while nine studies reported the prevalence of current usage. Additionally, two studies provided data on the prevalence of pod-based EC usage in the past 7 days. The data collection period for these studies primarily took place in 2018 and 2019, with only one study collecting data in 2021. The prevalence of ever using pod-based ECs ranged from 5.9% to 29.2%. The prevalence of current usage was lower, falling between 1.6% and 23.2%. Furthermore, the prevalence of pod-based EC usage in the past 7 days was reported in 2 studies, ranging from 5.5% to 6.3%. (Table 3)

Table 4. Perception of pod-based EC

Study		Perception	%
Perception of pod-based EC/ JUUL harm to health	Case, 2020 [22]	Not harmful	46.5
		Harmful (Some harmful/Extremely harmful)	53.8
	Russell, 2020 [15]	No harm	6.1
		A little harm	18.4
		Some harm	29.5
		A lot of harm	45.9
	North, 2021 [18]	extremely harmful (coded as 1) to not at all harmful (coded as 4)	Mean (SD) 2.0 (0.83)
	Strombotne, 2021 [23]	Perception of lung cancer risk caused by JUUL scale value from 0 to 10 (0: not likely, 10 highly likely)	Mean (SD) 7.29 (2.84)
		Perception of JUUL secondhand smoke harm scale value from 0 to 10 (0: not likely, 10 highly likely)	Mean (SD) 6.48 (3.21)
	Singer, 2022 [20]	No harm/little harm	8.6
		Some harm	50.8
		A lot of harm	40.5
Perceived harmfulness of pod-based EC/ JUUL vs. cigarettes	Russell, 2020 [15]	Less harmful	39.3
		Equally harmful	39.2
		More harmful	11.8
		Don't know	9.7
	Wagoner, 2021 [19] Wave 11	Much less/a little less harmful	48.9
		As/a little more/more harmful than cigarettes	51.1
	Wagoner, 2021 [19] Wave 12	Much less/a little less harmful	47.3
		As/a little more/more harmful than cigarettes	52.7
	Obisesan, 2023 [24]	Less harmful	58.0
		Equally harmful	36.6
		More harmful	5.4
Perception of pod-based EC/JUUL addictiveness	Case, 2020 [22]	Not at all addictive	67.3
		Somewhat addictive/very addictive	32.7
	Russell, 2020 [15]	Very unlikely	7.3
		Somewhat unlikely	10.0
		Neither likely nor unlikely	12.5
		Somewhat likely	34.8
		Very likely	35.3
	North, 2021 [18]	"very addictive" (coded as 1), "somewhat addictive" (coded as 2), and "not at all addictive" (coded as 3)	Mean (SD) 1.8 (0.62)
	Strombotne, 2021 [23]	scale value from 0 to 10 (0: not likely, 10 highly likely)	Mean (SD) 7.11 (2.85)
	Singer, 2022 [20]	Not likely	8.5
		Somewhat likely	40.0
		Very likely	51.5

Study		Perception	%
Perceived addictiveness of pod-based EC/ JUUL vs. cigarettes	Russell, 2020 [15]	Less addictive	29.3
		Equally addictive	51.6
		More addictive	11.0
		Don't know	8.0
	Singer, 2022 [20]	More nicotine in cigarette pack	9.4
		More nicotine in JUUL pack	36.7
		About the same	53.9
	Obisesan, 2023 [24]	Less addictive	13.4
		Equally addictive	47.3
		More addictive	39.3

Table 4 reveals findings on the perception of pod-based EC. Three studies reported the perception of the harmful effects of pod-based ECs on health, with the proportion of respondents indicating that pod-based ECs have "some harm" or "a lot of harm" ranging from 53.8% to 91.3%. The study by North (2021) reported an average perception level regarding the harms of pod-based ECs at 2.0 (SD = 0.83). Additionally, Strombotne et al. (2021) indicated that the average perception of lung cancer risk from using JUUL was 7.29 (SD = 2.84), while the average perception of the harmfulness of emissions from JUUL was 6.48 (SD = 3.21). Four studies reported the perceived harmfulness of JUUL compared to traditional cigarettes. The perception that JUUL is equally or more harmful than traditional cigarettes ranged from 42% to 52.7%. The perception of JUUL's addictiveness was highest in Singer's study at 91.5%. Three studies examined the perceived addictiveness of JUUL compared to cigarettes, showing rates ranging from 62.6% to 86.6%.

4. DISCUSSION

In this study, we compiled nine research studies reporting the prevalence of pod-based EC usage within the general population. Most studies were conducted in the United States during 2018 and 2019, except for a single study from Kuwait in 2021. The prevalence of ever using pod-based ECs ranged from 5.9% to 29.2%, while the prevalence of current usage fell between 1.6% and 23.2%. Two studies by North et al. [18] and Wagoner et al. [19] reported significantly lower rates of pod-based EC usage compared to the others. In North's study, data was collected twice, once in 2018 and 2019, with current usage rates of 2.8% and 6.7%, respectively [18]. In the study by Wagoner, the prevalence of ever using pod-based ECs was reported at 5.9% in the spring of 2018 and increased to 12.7% in the fall of 2018. Meanwhile, the current usage rates of pod-based ECs were 1.6% in the spring of 2018 and rose to 3.4% in the fall of 2018 [19]. Both studies focused on young adults, with an average age of 24.0 ± 2.3 years and 26.2 ± 0.5 years in North's and Wagoner's studies respectively, which could explain the lower usage rates observed since younger counterparts tend to use pod-based ECs more frequently. The findings from Vallone's research reveal that individuals aged 15-17 had a significantly higher likelihood of ever using JUUL compared to the 25-34 age group, with an odds ratio of 4.68 (95% CI: 3.10-7.06). Similarly, those aged 18-21 were also more likely to have a history of using JUUL, with an odds ratio of 4.48 (95% CI: 3.12-6.42). Moreover, in this study, individuals aged 15-17 were 16.19 times more likely to currently use JUUL than those in the 25-34 age group (OR=16.19, 95% CI: 8.89-29.50) [25]. Younger individuals, such as adolescents, are often attracted to pod-based ECs due to their sleek design, portability and diverse appealing flavors [6]. Most of the remaining studies conducted on adolescent populations indicate that ever-use prevalence ranges from 15.6% to 26.3%, while current use varies between 8.3% and 23.2%. Compared to the prevalence of EC use [26], pod-based EC use is not significantly lower. By the end of 2018, JUUL accounted for 76% of the retail e-cigarette market [27]. In this study, some longitudinal studies recorded an increase in the prevalence of pod-based EC use [17-19]. Notably, in the study conducted by Wagoner et al., although the prevalence of ever-use of pod-style ECs was the lowest among all studies, it was more than doubled within a few months after that. Furthermore, the research by Singer reported the highest prevalence of ever-use of ECs among all studies. This can be explained by the fact that all participants in this study were male, as previous studies have shown a higher prevalence of e-cigarette use among males compared to females [28].

Five studies examined the perception of the harmful effects of pod-based ECs on health. Among these, Singer et al. reported a high perception of the harmfulness of pod-based ECs at 91.3%. Additionally, this study described the highest rate of perception concerning the addictiveness of pod-based ECs at

91.5%. In contrast, the lowest perception rate was observed in the study by Case et al., at 53.8%. This could be explained by its focus on current pod-based EC users. EC users often exhibit a lower perception of the harmful effects of pod-based ECs compared to non-users [15]. The lowest perceived harmfulness of JUUL compared to cigarettes in the study by Obisesan could be attributed to similar reasons, as the participants were current users of pod-based ECs. Regarding the perceived addictiveness of JUUL compared to traditional cigarettes, the rates indicating that pod-based ECs are perceived as similar or more addictive than traditional cigarettes were relatively high in the studies by Singer and Obisesan (90.6% and 86.6%, respectively). These two studies involved specific participant groups (males and current pod-based EC users), resulting in differing perceptions compared to the study by Russell, which reported only 62.6%.

Our study synthesizes the use and perceptions of the harm of pod-based ECs, a new generation of e-cigarettes, over recent years. However, our research has some limitations. First, the data collection periods in the studies predominantly occurred in 2018 and 2019, with only one study collecting data in 2021. Additionally, most studies were conducted in the United States, which limits the generalizability of findings to the global population. Future research should include a broader range of studies from different countries and more recent data to provide an updated understanding of pod-based EC usage.

5. CONCLUSIONS

The prevalence of pod-based ECs use was relatively high, with youth showing a greater tendency to use pod-style ECs compared to young adults. Similar to traditional cigarettes and e-cigarettes, the prevalence of pod-based ECs use was also higher among males than females. In longitudinal studies conducted on the same participant group, the rate of pod-based ECs use increased rapidly over a short period. Additionally, studies focusing on EC users revealed lower perceptions of the harmful effects and the addictiveness of pod-based ECs compared to studies conducted on the general population.

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