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**ORIGINAL ARTICLE****Association between the use of electronic cigarettes and subsequent initiation of tobacco cigarettes in the youth population of a city: A retrospective cohort study***Khadeejah Hussain<sup>1\*</sup>, Sancheti P. V.<sup>2</sup>, Agrawal M<sup>1</sup>, Parande M. A.<sup>2</sup>, Tambe M. P.<sup>2</sup>, Borle P<sup>2</sup>**<sup>1</sup>B. J. Government Medical College, Pune-411001 (Maharashtra) India, <sup>2</sup>Department of Community Medicine, B. J. Government Medical College, Pune-411001 (Maharashtra) India*

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**Abstract**

*Background:* Previous use of electronic cigarettes has shown to open a gateway for subsequent initiation of combustible cigarettes in the youths. *Aim and Objectives:* This study aimed to compare the incidence of subsequent initiation of smoking combustible cigarettes among the E-cigarette users and E-cigarette non-users in the age group of 16 to 25 years. Further, the role of various factors which led to the initiation of smoking combustible cigarettes in E-cigarette users was studied. *Material and Methods:* A retrospective cohort study was conducted among youths from general population for a duration of 4 months in a metro city. Cohort of youths (age group of 16 to 25 years) using E-cigarette and not using E-cigarette were taken as subjects. Subjects were interviewed using an approved questionnaire containing sections about demographic data, details of behaviours related to E-cigarette use. *Results:* Those who had previous E-cigarette exposure had 7.27 times the risk of subsequent initiation of combustible cigarettes than those who did not have previous E-cigarette exposure (Relative Risk = 7.27). In present study, 'Curiosity' stood out as the factor reported by most (70.45%) of the participants, which led to the initiation of smoking combustible cigarettes in E-cigarette users, followed by 'Adventure' (40.91%), 'Peer Pressure' (31.82%), 'Need for more nicotine' (29.55%) and lastly, 'Stressful life' (25%). *Conclusion:* The incidence of initiating subsequent combustible cigarette use in E-cigarette users was higher than that in E-cigarette non-users.

**Keywords:** E-cigarette, Subsequent Combustible Cigarette Use, Nicotine

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**Introduction**

Electronic cigarettes, commonly known as E-cigarettes, introduced in the year 2007 have gained considerable popularity in India in recent years. These battery-operated devices are designed to mimic the sensation of smoking by heating a liquid, typically containing flavourings and varied amounts of nicotine, which is then inhaled as a vapour. While E-cigarettes were introduced as a potential harm reduction tool for smokers trying to quit traditional tobacco products [1], many express concerns over their safety and potential appeal to non-smokers, particularly the youth. The regulatory landscape surrounding E-cigarettes in India

has undergone significant changes, with the government implementing bans and restrictions to address these concerns and protect public health in September 2019 [2]. E-cigarette is considered as a popular method to help quit tobacco smoking. However, there is paucity of data with respect to its safety and efficacy [3]. E-cigarettes work by heating a liquid solution that contains nicotine, flavorings, and other chemicals, producing an aerosol that is inhaled into the lungs. This process of inhaling the aerosol produced by e-cigarettes is commonly referred to as "vaping" [4-5]. Recently, the Indian Government has called for a ban on all e-

cigarettes and taken steps to restrict access to vaping products from the market. This major decision was an attempt to safeguard the younger population from using E-cigarette and its possible longer-term addiction together with its promotions by domestic industries. However, many high school and college going children still indulge in its use considering it as a safe product. These products come with their bag of side effects [6-8]. Due to the addictive nature of nicotine-containing products, nicotine has become a substance of abuse. The capacity of substances of abuse to interact with and modulate the biochemical activities in the areas of the brain associated with learning may underwrite to the robust addictive characteristics of these drugs [9]. Nicotine addiction is a significant concern associated with E-cigarette use in adolescents. E-cigarettes typically contain nicotine, which is a highly addictive substance. Nicotine can quickly produce a pleasurable sensation in the brain, leading to a sense of reward and reinforcement. This can create a strong psychological dependence on nicotine, making it difficult for individuals to quit using e-cigarettes or other nicotine-containing products. Adolescents who use e-cigarettes and other nicotine-containing products are particularly vulnerable to developing addiction because their brains are still developing. Nicotine exposure during adolescence can alter brain development, leading to changes in the reward system and increasing the risk of developing addiction to other substances later in life [10]. Research has shown that nicotine exposure during adolescence can have long-term effects on brain function, including impairments in attention, learning, and memory. Furthermore, adolescents who use E-cigarettes are more likely to experiment with other substances, such as alcohol and marijuana, which can further

increase the risk of addiction. Therefore, preventing and discouraging E-cigarette use among adolescents is critical to reducing the risk of nicotine addiction and associated negative health effects. This can be achieved through public education campaigns, regulatory policies, and comprehensive tobacco prevention and control programs [11]. Acute side effects include throat and mouth irritation, dry cough, dizziness, nausea, and headaches. Some studies have also documented acute lung injuries and arterial endothelial damage due to excessive short-term use of E-cigarettes. Additionally, there is a risk of accidental nicotine poisoning, particularly in children who may be attracted to the appealing flavours of E-cigarettes. Prolonged use of E-cigarettes may lead to respiratory issues, such as lung inflammation and decreased lung function. There is also growing concern about the cardiovascular effects of E-cigarettes, including an increased risk of heart disease. Furthermore, E-cigarettes can be addictive due to the presence of nicotine, which can lead to dependence and withdrawal symptoms when use is discontinued. Many studies conducted in the western countries have established that those who started use of E-cigarettes as their first tobacco product have a higher chance of initiating smoking of combustible cigarettes in the future [12-15]. However, very few studies have been conducted in India to establish the public health problem.

### **Study rationale**

E-cigarette use can potentially open a gateway to combustible cigarettes as nicotine in any form is addictive. This can lead to an obstinate habit in the youth thereby leading to an increased tendency for experimentation with other forms of nicotine, primarily combustible cigarettes. Use of tobacco in any form is harmful. Intake of tobacco subdues the

response of the immune system. The individual is then prone to infection which in turn hampers wound healing [16-19]. In the developing countries like India, youth are mainly susceptible to initiation and dependence on tobacco products [20]. In India, studies have revealed that among 4 to 75 % of 13 to 15 year old individuals report use of some form of tobacco or other in their lifetime. More than one-third (35%) of adults in India use tobacco in some form, 21 percent of adults use only smokeless tobacco, 9 percent only smoke tobacco and 5 percent smoke as well as use smokeless tobacco. Tobacco use is high (18%) even among population aged 15-24 years. Prevalence of tobacco use decreases with increase in education among both males and females. Most of current smokers and smokeless tobacco users use tobacco every day. Prevalence of tobacco use is higher among rural (38%) than urban (25%) population. Two in every five daily tobacco users are aged 20- 34 years and start using tobacco before attaining the age of 18 years. There is a high prevalence of oral tobacco use among females. One fourth of females initiate tobacco usage before the age of 15 years. Three in every five daily tobacco users use tobacco within half an hour after waking up [20-21].

With this background, the study was undertaken to compare the incidence of subsequent initiation of smoking combustible cigarettes among the E-cigarette users and E-cigarette non-users in the age group of 16 to 25 years and to study the role of various factors which led to the initiation of smoking combustible cigarettes in E-cigarette users.

## Material and Methods

### Study design and sampling

This was a retrospective cohort study conducted in 4 months of study duration. Study was conducted among youth population aged 16-25 years,

residing in a metro city and attending junior or senior colleges. Prior permission was obtained from respective college and all participants were personally interviewed after taking written informed consent. Assent was taken from participants less than 18 years. We received approval from the Institutional Ethics Committee for conducting the study with reference no. BJGMC/IEC/Pharmac/ND-Dept.0723135-135.

Participants who had used E-cigarettes for minimum one year were taken as study cohort and those who had never used E-cigarettes were taken as comparison group respectively.

Exposure to E-cigarette was determined as per following criteria-

- Study cohort group included those who had used E-cigarettes (even single use of 1-2 puffs) before June 2022 (for minimum one year before the study duration).
- Comparison group (unexposed group) included those who have never used E-cigarettes or any other form of tobacco products before June 2022 (one year before the study duration).

Participants who had used combustible cigarettes as their first nicotine-containing product before June 2022 were excluded from the study.

Snowball sampling method was used to find study participants using E-cigarettes. Comparison group was matched for age and socioeconomic status.

Outcome variable-

Current combustible cigarette smoking –

- Use of E-cigarettes before June 2022 as first nicotine containing product and shifting or using combustible cigarettes as on December 2023, was called as subsequent initiation of combustible cigarettes.

- No use of any type of nicotine containing product before June 2022 and use of combustible cigarettes as on December 2023; was considered as initiation of combustible cigarettes smoking.

Sample size was calculated using following formula:

$$n \text{ (each group)} = \frac{(p_0q_0 + p_1q_1) (z_{1-\alpha/2} + z_{1-\beta})^2}{e^2}$$

Where  $p_0$  is Proportion of unexposed at risk of outcome = 10.2

$p_1$  is Proportion of exposed at risk of outcome = 47.7

alpha (two-sided) = 0.05 (or 5%)

beta = 0.20 (or 20%).

Permissive error ( $e$ ) = 15%

Using the formula, a minimum sample size of 120 for each group was taken for present study.

#### Data collection

Participants were interviewed using an approved questionnaire containing sections about demographic data, details of behaviour pattern related to E-cigarette use. Fagerstrom's Test for Nicotine Dependence and similar points-based set of questions was used to estimate nicotine dependence in E-cigarette users and tobacco cigarette users [22]. Data regarding initiation of E-cigarette use, reasons of E-cigarette use, subsequent initiation of combustible cigarette use, and its reasons were documented.

#### Data analysis

Data were analysed statistically, illustrations and graphical representations of the data were plotted as per the objectives of the study. Descriptive statistical analysis and inferential statistical analysis of data using appropriate statistical methods was

carried out using Microsoft Excel and Statistical Package for Social Sciences (SPSS) Software version 29, manufacture IBM. Relative risk and risk difference were calculated. Chi-square test was used for finding association.

#### Results

##### Demographic profile of the study participants

Out of the total of 122 E-cigarette users surveyed, 83 (68.03%) were male, and 39 (31.97%) were female participants. Similarly, out of 121 E-cigarette non-users, 76 (62.81%) were male, and 45 (37.19%) were female participants. This distribution is depicted in figure 1. These findings indicate a predominant male representation in both groups. Significant representation of female 31.97% was observed in E-cigarette user group. Maximum participants were in the age group of '18 to 20 years', with 51 males and 26 females. This was followed by 26 males and 10 females aged between '21 to 22 years'. In the age group of '23 years and above', there were 5 males and 2 females. Lastly, there was 1 male and 1 female in the 'Less than 18 years' category. The majority of participants, totalling 215 (88.47%), identified as Hindu by religion, followed by 18 (7.41%) who identified as Muslim. Additionally, 5 (2.06%) participants identified as Christian, with another 5 (2.06%) belonging to other religions.

Table 1 depicts course wise distribution of study participants. The largest proportion of study participants, amounting to 185 (76.13%), belonged to the Science stream. Following this, there were 38 (15.64%) participants from the Commerce stream, and 20 (8.23%) participants from the Arts stream.

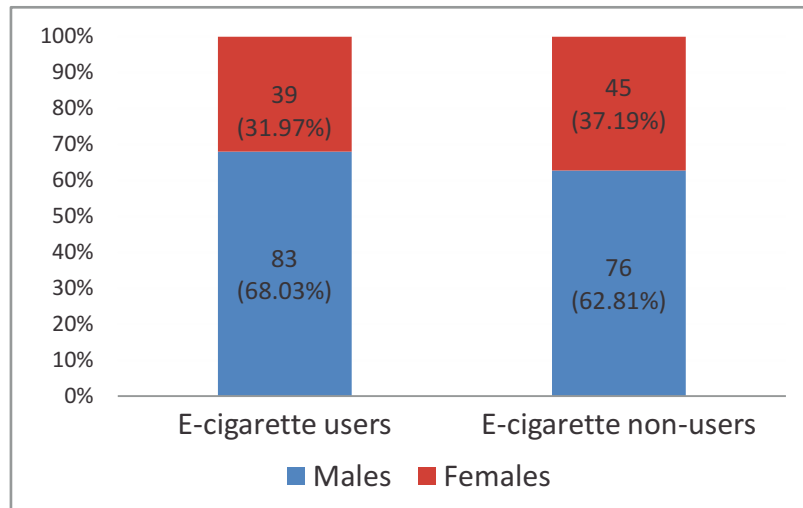


Figure 1: Sex wise distribution of study participants

Table 1: Course wise distribution of study participants

Stream	E-cigarette users N (%)	E-cigarette non-users N (%)	Total N (%)
Arts	14 (11.48)	06 (4.96)	20 (8.23)
Commerce	28 (22.95)	10 (8.26)	38 (15.64)
Science	80 (65.57)	105 (86.78)	185 (76.13)
<b>Total</b>	122 (50.20)	121 (49.80)	243 (100)

**Association between E-cigarette use and subsequent initiation of cigarette smoking**

Table 2 shows the association between E-cigarette use and subsequent initiation of cigarette smoking. Out of 122, E-cigarette users, 88 (72.13%) initiated combustible cigarette smoking subsequently. Twelve participants (9.92%) from E-cigarette non-users group subsequently initiated combustible cigarette use. Subsequent initiation of cigarette smoking was higher in E-cigarette users than in E-cigarette non user, which was statistically significant (Chi-square value = 97.093, df = 1, p value = 0.000).

**Incidence in exposed group (exposure to E-cigarette) = 721.3 per 1000 E-cigarette users.**

**Incidence in non-exposed group (E-cigarette non-users) = 99.2 per 1000 E-cigarette non-users.**

The incidence of initiating subsequent combustible cigarette use in E-cigarette users was higher than that in E-cigarette non-users. Those who had previous E-cigarette exposure had 7.27 times the risk of subsequent initiation of combustible cigarettes than those who did not have previous E-cigarette exposure (Relative Risk = 7.27), with attributable risk 62.21 percent.

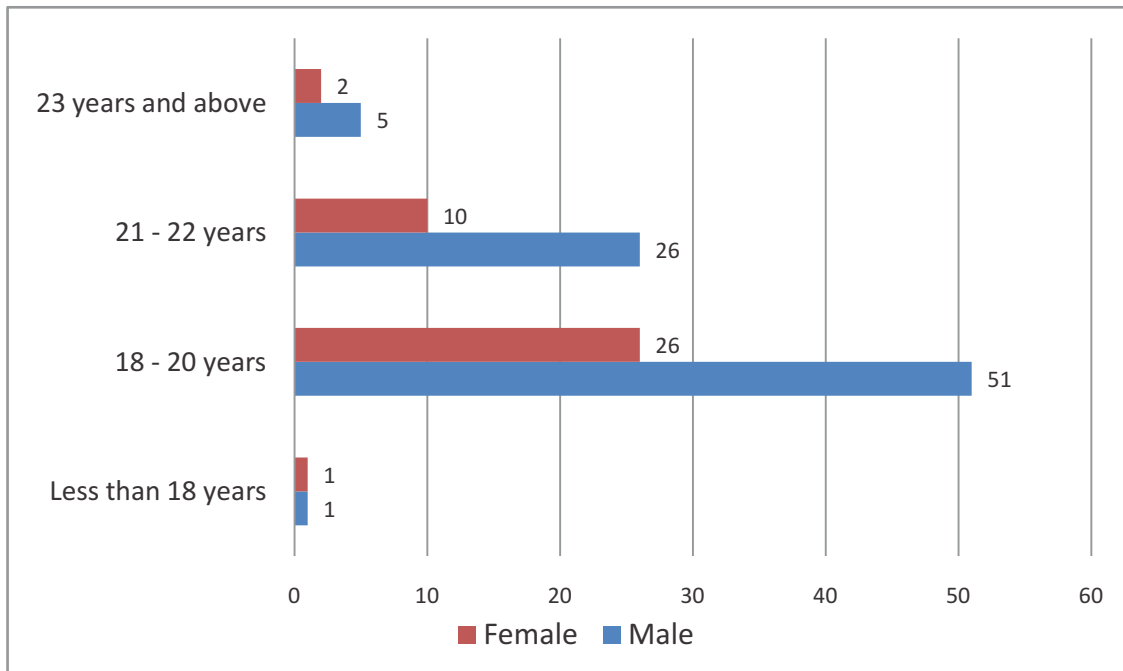


Figure 2: Age and sex wise distribution of E-cigarette users

Table 2: Association of E-cigarette use and subsequent initiation of cigarette smoking

Association	Subsequent initiation of combustible cigarette smoking N (%)	Combustible cigarette non-users at present N (%)	Total N (%)
E-cigarette users	88 (72.13)	34 (27.87)	122 (100)
E-cigarette non-users	12 (9.92)	109 (90.08)	121 (100)
<b>Total</b>	<b>100 (41.15)</b>	<b>143 (58.85)</b>	<b>243 (100)</b>

\*Pearson Chi-square value = 97.093, df = 1, p value = 0.000

**Relative risk = 7.27 CI (4.204 – 12.58)**

**Risk difference = 62.21% (52.64 – 71.79%)**

Table 3 shows the association between frequency of E-cigarette use and subsequent initiation of cigarette smoking. Among 28 individuals who used E-cigarettes daily, 24 (85.71%) subsequently began using combustible cigarettes. Among 14 E-

cigarette users who used them "Once in 2-3 days," 13 individuals (92.86%) subsequently initiated combustible cigarette use. Similarly, out of 8 individuals who used e-cigarettes "Once a week," 7 of them (87.5%) subsequently initiated combustible cigarette use. Likewise, among 72 individuals



who used e-cigarettes "Occasionally," 44 of them (61.11%) subsequently initiated combustible cigarette use. However, out of 121 participants who had never tried an E-cigarette, only 12 (9.91%) subsequently initiated combustible cigarette use. Table 4 shows the distribution of participants according to duration in years between first-time use of E-cigarette and subsequent first-time use of combustible cigarette. It was observed that the majority of users transitioned to combustible cigarettes within 1 year (45.45%) of use. A smaller percentage, 36.36% shifted between 1 to 2 years of use. Only 10.23% switched between 2 to 3 years of use, and 7.95% transitioned after 3 years.

**Reasons for initiation of E-cigarette use and subsequent combustible cigarette use**

Figure 3 shows the factors causing initiation of E-cigarette use and factors causing subsequent initiation of combustible cigarettes among the E-cigarette users. Among the factors that led to the

initiation of E-cigarette use, 'Curiosity' stood out amongst the other factors with 102 participants (83.61% of E-cigarette users) reporting it. 'Considered harmless and cool' was reported by 40 participants (32.79% of E-cigarette users). It was followed by 'Peer pressure' (38 participants; 31.15% of E-cigarette users), 'Attractive flavours' (35 participants; 28.69% of E-cigarette users) and lastly 'Stressful life' (11 participants; 9.02% of E-cigarette users). Among the factors that led to the subsequent initiation of combustible cigarettes in E-cigarette users, again 'Curiosity' stood out as the most reported factor with 62 participants (70.45%). It was followed by 'Adventure' reported by 36 participants (40.91%) and 'Peer Pressure' reported by 28 participants (31.82%). A number of people also stated that they experienced the 'Need for more nicotine' 26 participants (29.55%) and thereby considered the shift. Lastly, 'Stressful life' 22 participants (25%) acted as another reason.

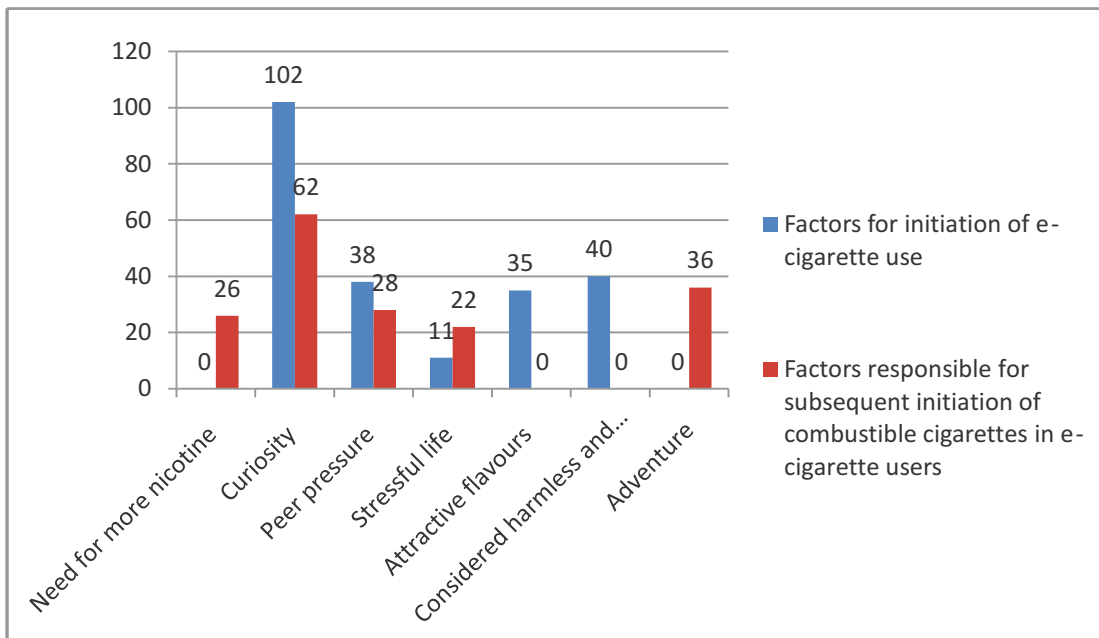
**Table 3: Association between frequency of E-cigarette use and subsequent initiation of cigarette smoking**

Frequency of E-cigarette use	Combustible cigarette users	Combustible cigarette non-users	Total
Daily	24 (85.71%)	04 (14.29%)	28 (100%)
Once in 2 – 3 days	13 (92.86%)	01 (7.14%)	14 (100%)
Once a week	07 (87.5%)	01 (12.5%)	08 (100%)
Occasionally	44 (61.11%)	28 (38.89%)	72 (100%)
Never tried	12 (9.91%)	109 (90.08%)	121 (100%)
Total	100 (41.15%)	143 (58.84%)	243 (100%)

\*Pearson Chi – square value = 106.10, df = 4, p value < 0.00001

**Table 4: Distribution of participants according to duration in years between first-time use of E-cigarette and subsequent first-time use of combustible cigarette**

Duration in years	Males N (%)	Females N (%)	Number of users N (%)
Within 1 year	23 (57.5)	17 (42.5)	40 (100)
Between 1 to 2 years	20 (62.5)	12 (37.5)	32 (100)
Between 2 to 3 years	07 (77.8)	02 (22.2)	09 (100)
More than 3 years	05 (71.4)	02 (28.6)	07 (100)
<b>Total</b>	<b>55 (55)</b>	<b>33 (33)</b>	<b>88 (100)</b>



**Figure 3: Factors causing initiation of E-cigarette use and factors causing subsequent initiation of combustible cigarettes among E-cigarette users**

**Discussion**

In the present study, among E-cigarette users surveyed, 68.03% were male, and 31.97% were female participants. Whereas, among combustible cigarette users, 62% were male and 38% were

female participants. These findings indicate a predominant male representation in both groups. It also shows significant number of females were using E-cigarette. In a study conducted in the US



by Lee & Oh (2019), a significant association was found between ever vaping and gender (OR = 0.77, 95% CI = 0.65, 0.91) [22].

In present study, the risk of subsequent initiation of combustible cigarettes was 7.27 times in E-cigarette users than in E-cigarette non-users. In a study conducted by Harlow *et al.*, (2022) among 9,584 youth at baseline, those who initiated E-cigarettes were 2.4 times as likely to subsequently initiate cigarette smoking as youth who did not initiate E-cigarettes (risk ratio = 2.4, 95% CI = 2.1, 2.7), after accounting for time-dependent confounding and selection bias. The risk estimated may be more due to geographic and cultural practices in the two countries [23]. In a separate study conducted by Berry *et al.*, (2019) in the United States, it was found that among youth, prior use of E-cigarettes was linked to more than a fourfold increase in the likelihood of ever using cigarettes (OR = 4.09; 95% CI = 2.97, 5.63) and nearly a threefold increase in the likelihood of current cigarette use (OR = 2.75; 95% CI = 1.60-4.73) compared to those with no history of tobacco use. Between 2013-2014 and 2015-2016, approximately 21.8% of new instances of ever using cigarettes (178,850 youths) and 15.3% of current cigarette use (43,446 youths) among adolescents aged 12 to 15 years in the US may be attributed to prior E-cigarette use. These findings underscore the association between E-cigarette use and heightened risk of initiating cigarette use, especially among youths initially considered at lower risk [24]. In another study conducted among U.S. adolescents by Dutra and Glantz (2014) to examine E-cigarette use and conventional cigarette use, it was seen that the use of E-cigarettes was associated with higher odds of ever or current cigarette smoking and higher odds

of established smoking. It concluded that the use of E-cigarettes does not discourage, and may encourage conventional cigarette use among U.S. adolescents [25]. Findings of the present study closely align with this. At a broader population level, the use of E-cigarettes may play a role in the initiation of cigarette smoking among youths, echoing findings from present study.

It was observed that the majority of users (45.45%) transitioned to combustible cigarettes within 1 year of use followed by 36.36% E-cigarette users who shifted to combustible cigarette between 1 to 2 years of use. Aleyan *et al.*, (2018) conducted a study in Canada and found that among the baseline sample of non-susceptible never-smokers, 45.2% of current E-cigarette users reported trying a cigarette after 2 years compared with 13.5% of non-current E-cigarette users. Among the baseline sample of susceptible never-smokers, 62.4% of current E-cigarette users reported trying a cigarette after 2 years compared with 36.1% of non-current E-cigarette users. Overall, current E-cigarette users were more likely to try a cigarette 2 years later [26]. In our current study, we investigated the factors contributing to the initiation of E-cigarette use among participants. Our findings indicate that 'Curiosity' was the most prominent factor, cited by 102 participants (83.61% of E-cigarette users). Following this, 'Considered harmless and cool' were reported by 40 participants (32.79% of E-cigarette users), while 'Peer pressure' was mentioned by 38 participants (31.15% of E-cigarette users). 'Attractive flavours' were cited by 35 participants (28.69% of E-cigarette users), and finally, 'Stressful life' was mentioned by 11 participants (9.02% of E-cigarette users). In a study conducted in New Zealand by Wamamili *et al.*, (2020)

curiosity (67.4%), enjoyment (14.4%) and quitting (2.4%) were common reasons for vaping. 76.1% (73.4–78.7) of respondents believed E-cigarettes were less harmful than cigarettes [27]. In the current study, it was observed that individuals who regularly used E-cigarettes, either daily, once in 2-3 days, or once a week, were more likely to transition to combustible cigarettes compared to occasional E-cigarette users or those who did not use E-cigarettes at all. In the study carried out by Lee and Oh (2022) in the U.S, it was found that more frequent vaping was associated with greater risk of smoking initiation (risk ratio  $\geq 3$  days/month = 1.8, 95% CI = 1.4, 2.2; 1-2 days/month = 1.2; 95% CI = 0.93, 1.6 vs. 0 days/month) [22], which add to the evidence that increase in frequency of E-cigarette use also adds to the risk of subsequent initiation of combustible cigarette smoking. Newer generations of E-cigarettes are capable of delivering high nicotine concentrations and lead to youth addiction and subsequent combustible cigarette use. The combination of E-cigarettes and cigarettes is more harmful than using E-cigarettes alone or to smoking cigarettes alone [28]. The latest generation of E-cigarette devices deliver nicotine and toxicants at higher levels than earlier devices, especially in experienced users. E-cigarettes pose a risk for nicotine exposure, dependence, and combustible cigarette uptake. E-cigarettes and their delivered toxicants appear harmful to multiple organ systems, although the current body of evidence is limited, especially in terms of long-term effects. Further research is warranted with a focus on individual devices, E-liquid constituents, user characteristics, and patterns of use. Any potential benefit of E-cigarettes for smoking

cessation must be weighed against the risks. Given the potential longer-term effects, efforts to prevent E-cigarette use in youth are critical [29]. The dilemmas from E-cigarettes arise from their contrasting benefits and risks. They may help current smokers quit conventional cigarettes, but their long-term effects are unknown, and they may serve as an entry point to nicotine addiction for non-smokers, particularly adolescents. For adult smokers, a recent Cochrane review found high certainty that e-cigarettes produce higher quit rates than nicotine replacement therapy. However, the substitution of E-cigarettes as an aid to smoking cessation may lead to long-term use of the E-cigarettes themselves. For non-smokers, E-cigarettes hold no benefits, and they may increase the risk of nicotine addiction for adolescents, in part because they are more appealing and easily concealed than cigarettes [30].

### Conclusion

The incidence of initiating subsequent combustible cigarette use in E-cigarette users was higher than that in E-cigarette non-users. Strict regulations and implementation of ban on E-cigarettes should be looked into so as to reduce subsequent initiation of combustible cigarette use to reduce its adverse impact; for the greater good of the society and country at large.

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**\*Author for Correspondence:**

Dr. Khadeejah Hussain, B. J. Government Medical College, Pune-411001 (Maharashtra) India  
Email: khadeejah.ug@gmail.com Cell: 9112623056

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