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**Electronic nicotine delivery systems: prevalence and perception of risk/harm in individuals with mental illness**

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## INTRODUCTION

E-cigarettes were believed to be a safer alternative to combustible tobacco products, especially for smokers who intended to quit smoking.<sup>(1)</sup> Initial studies showed a promising spike in the quit attempts and successful quit rates of smokers who used electronic nicotine delivery systems (ENDS)<sup>(2)</sup> compared to those who underwent approved therapies.<sup>(1,3)</sup> Despite these encouraging results, several concerns were raised regarding the safety, efficiency and long-term impact, which includes the fear that ENDS can act as a gateway for combustible tobacco product use.<sup>(4,5)</sup> A study among adolescents showed that ENDS users had a 16-time higher likelihood of initiating cigarette use at follow-up than non-users.<sup>(6)</sup> A higher risk of subsequent cigarette consumption was also observed in non-smokers who had used e-cigarettes only.<sup>(7)</sup> Significant association has been reported between e-cigarette use and chronic lung diseases such as asthma in smokers and non-smokers.<sup>(8)</sup> ENDS also have adverse health impacts on other organ systems such as the cardiovascular system, nervous system, skeletal and immune system.<sup>(9-11)</sup>

People with mental illness (MI) are at a higher risk of dying prematurely than the general public.<sup>(12)</sup> The prevalence of smoking and nicotine dependence (ND) is also higher in those with MI (39.5%)<sup>(13)</sup> compared to the normal population (12%), based on studies conducted locally.<sup>(14)</sup> Also, individuals with MI have a lower chance of quitting.<sup>(13,15,16)</sup> ND affects treatment outcomes by interfering with the metabolism of psychiatric medications<sup>(17)</sup> and those with MI who smoke have higher mortality rates.<sup>(18)</sup> In a study conducted in the US among patients with MI, a steady increase in e-cigarette use from 0% to 25% was noted from 2009 to 2013.<sup>(19)</sup> The prevalence of e-cigarette use was 11%<sup>(19)</sup> among the patient population as compared to 2.6% in the general population in 2014.<sup>(19,20)</sup> With the increasing use of ENDS worldwide, especially among vulnerable groups (with MI), it is imperative to understand the prevalence of e-cigarette use and the perception of harm of smokers and non-smokers towards

e-cigarettes. There is a dearth of literature in Singapore on the ENDS milieu. It is currently unknown whether people are still using ENDS despite the ban in Singapore and if they are aware of the harms associated with it. This study aims to understand the prevalence of ever and daily smoking of ENDS, use patterns and the perception of risk/harm towards these products in a sample of psychiatric patients in Singapore.

## METHODS

This cross-sectional study recruited 380 participants with depressive or schizophrenia spectrum and other psychotic disorders from a tertiary psychiatric care institution. The inclusion criteria were: aged 21–65 years, having the mental/cognitive ability to complete the survey, and a diagnosis of depressive disorder or schizophrenia spectrum and other psychotic disorders. The detailed study methodology has been published previously.<sup>(13)</sup> Participants who identified themselves as smokers and had smoked at least 100 cigarettes in their lifetime were categorised as smokers, while those who identified themselves as smokers or past smokers but had not smoked 100 cigarettes in their lifetime, and those who had never smoked were classified as non-smokers.<sup>(13)</sup> The survey was conducted in English, Chinese, Malay or Tamil, as preferred by the participants. All participants provided written consent and followed the approved ethics procedure (Domain-Specific Review Board reference no. 2018/00772).

The sample size was calculated to estimate the prevalence of current smoking in people with MI.<sup>(16)</sup> With an estimate of 10% missing data, 349 participants were required for the study. Quota sampling was used to recruit about 40%–60% participants across different age groups (aged < 40 years and  $\geq$  40 years), gender and diagnoses.

The ENDS questionnaire was adapted from previously published questions, with modifications to accommodate local regulations.<sup>(21)</sup> The questionnaire had three sections that captured usage (ever and current use, type of product used, place/country of use), reasons for

use/cessation and perception of risk/harms (relative risk perception, concerns) in ever smokers. The non-smokers answered questions on awareness (awareness and source of information) and risk perception.

A descriptive analysis was performed on the data (sociodemographic and perceptions of risk/harm). Logistic regression was performed to examine the association between sociodemographic variables that showed a significant relationship in the univariate analysis and ever use of ENDS. Chi-square test was used to compare the differences in risk perceptions between ever smokers and non-smokers. All statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp, Armonk, NY, USA).

## **RESULTS**

The study recruited a total of 380 participants, which included smokers (n =150) and past smokers (n = 34), who were grouped as ‘ever smokers’ (n = 184), and 196 non-smokers, according to their use of any tobacco products.<sup>(13)</sup> The participants answered questions on their ENDS use and risk perception towards ENDS. The mean age of the participants was  $40.6 \pm 12.0$  (range 21–63) years. The sample included 139 (75.5%) male participants. The majority of the participants were Chinese (63.6%), followed by Malay (20.1%), Indian (13.6%) and other ethnicities (2.7%). The detailed sociodemographic characteristics of the participants are presented in Table I.

**Table I. Sociodemographic characteristics of the participants.**

| Sociodemographic factor                                  | No. (%)                   |                          | p-value |
|--|---------------------------|--------------------------|---------|
|  | Ever smokers<br>(n = 184) | Non-smokers<br>(n = 196) |         |
| <b>Age (yr)</b>  |                           |                          | 0.014   |
| 21–40  | 79 (42.9)                 | 109 (55.6)               |         |
| 41–65  | 105 (57.1)                | 87 (44.4)                |         |
| <b>Gender</b>  |                           |                          | < 0.001 |
| Male   | 139 (75.5)                | 71 (36.2)                |         |
| Female   | 45 (24.5)                 | 125 (63.8)               |         |
| <b>Ethnicity</b>   |                           |                          | < 0.001 |
| Chinese  | 117 (63.6)                | 162 (82.7)               |         |
| Malay  | 37 (20.1)                 | 18 (9.2)                 |         |
| Indian   | 25 (13.6)                 | 14 (7.1)                 |         |
| Other  | 5 (2.7)                   | 2 (1.0)                  |         |
| <b>Religion</b>  |                           |                          | 0.002   |
| Christianity   | 47 (25.5)                 | 75 (38.3)                |         |
| Buddhism   | 46 (25.0)                 | 44 (22.4)                |         |
| Hinduism   | 10 (5.4)                  | 7 (3.6)                  |         |
| Islam  | 41 (22.3)                 | 20 (10.2)                |         |
| Free thinker   | 31 (16.8)                 | 34 (17.3)                |         |
| Other  | 9 (4.9)                   | 16 (8.2)                 |         |
| <b>Highest educational qualification</b>                 |                           |                          | < 0.001 |
| Primary school or below                                  | 38 (20.7)                 | 13 (6.6)                 |         |
| Secondary school   | 56 (30.4)                 | 46 (23.5)                |         |
| Pre-university (junior college/vocational institute/ITE) | 71 (38.6)                 | 94 (48.0)                |         |
| University   | 19 (10.3)                 | 43 (21.9)                |         |
| <b>Marital status</b>                                    |                           |                          | 0.002   |
| Married  | 30 (16.3)                 | 32 (16.3)                |         |
| Single   | 116 (63.0)                | 148 (75.5)               |         |
| Separated/widowed/divorced                               | 38 (20.7)                 | 16 (8.2)                 |         |
| <b>Employment status</b>                                 |                           |                          | 0.173   |
| Employed   | 81 (44.0)                 | 98 (50.0)                |         |
| Unemployed   | 89 (48.4)                 | 77 (39.3)                |         |
| Economically inactive                                    | 14 (7.6)                  | 21 (10.7)                |         |
| <b>Monthly personal income (SGD)</b>                     |                           |                          | 0.318   |
| < 2,000  | 154 (83.7)                | 154 (78.6)               |         |
| 2,000–3,999  | 24 (13.0)                 | 30 (15.3)                |         |
| ≥ 4,000  | 6 (3.3)                   | 12 (6.1)                 |         |
| <b>Children</b>  |                           |                          | 0.019   |
| Yes  | 50 (27.3)                 | 34 (17.3)                |         |
| No   | 133 (72.7)                | 162 (82.7)               |         |
| <b>Diagnosis</b>   |                           |                          | 0.056   |
| Depression   | 95 (51.6)                 | 82 (41.8)                |         |
| Schizophrenia  | 89 (48.4)                 | 114 (58.2)               |         |

ITE: Institute of Technical Education

Around 30.4% (n = 56) of ever smokers (n = 184) reported lifetime use of ENDS. Around 83.9% (n = 47) of participants in this group reported local use of the product, 37.5% (n = 21) used it overseas, and 21.4% (n = 12) used it both locally and overseas. The most common ENDS used were e-vaporisers (n = 26), followed by e-cigarettes (n = 24) and e-pipes (n = 2). Only 3.6% of the ever smokers reported current daily use (at the time of the interview), 10.7% indicated using the products rarely and the majority (85.7%) had stopped using it at the time of the interview. The top reasons cited for stopping ENDS use included difficulty in purchasing ENDS (40.4%), the fact that it did not reduce craving for cigarettes (19.2%), high cost (17.3%) and not liking the taste (17.3%). The participants also endorsed other reasons such as the local ban on e-cigarettes and the intention to use it only for social interaction as factors that prompted them to stop their ENDS use. The top three reasons for trying ENDS were curiosity (83.9%), availability of ENDS in different flavours (55.4%) and their use as a substitute in the participant's attempt to quit smoking cigarettes (32.1%). The detailed reasons are indicated in Fig. 1. Among participants who endorsed that they had never used ENDS (n = 109), 19.3% had never heard of ENDS before, 40.3% refrained from using them as they were unavailable locally, 26.1% felt that they were expensive and 21% cited health concerns.

Participants who were aware of ENDS (n = 165) were asked about their perception of harms associated with ENDS. Only 27.3% felt that ENDS were more harmful than regular cigarettes. About 26.1% reported that they did not know how harmful ENDS were as compared to regular cigarettes, 24.2% felt that they had about the same level of harm and 22.4% reported that ENDS were less harmful than regular cigarettes. The same group was queried if they thought ENDS were more addictive than regular cigarettes. 41.8% indicated that they were not sure, 37% answered in the negative and 21.2% answered that they were more addictive than regular cigarettes.

Around 43.6% (n = 72) of the participants were concerned about the long-term safety of ENDS, 27.3% (n = 45) felt that they could act as a gateway for non-smokers and children to start tobacco use, while 17% (n = 28) were worried that advertisements and celebrity endorsements would make smoking popular again. The other concerns cited included the safety of ENDS (n = 11).

Around 60.2% (n = 118) of the non-smokers were aware of ENDS. Around 44.1% reported that they heard about ENDS from their friends, 35.6% from social media, 41% from the Internet and 11% through advertisements. Other sources cited included the media (TV/radio/cinema; n = 24).

Only 29.7% (n = 35) of the non-smokers endorsed that ENDS should be banned and 25.4% (n = 30) perceived ENDS to be less harmful than regular cigarettes. Only 28% (n = 33) felt that ENDS were more acceptable than cigarettes and 22.9% (n = 27) felt that passive smoking was less harmful with ENDS. Around 26.3% (n = 31) of non-smokers were unsure about the implications of ENDS use. Like the ever smokers, the main concern cited was long-term risk of ENDS (65.8%, n = 77), the possibility of ENDS acting as a gateway for future cigarette use among non-smokers and children (53%, n = 62), and the advertising and celebrity endorsements making smoking popular (35%, n = 41). Around 9.4% of those who endorsed other reasons highlighted safety concerns as a main concern.

Around 30.3% (n = 36) of non-smokers felt that ENDS were more addictive than regular cigarettes, while 47.9% (n = 57) indicated that they were unsure about the comparative addictive potential of ENDS. There were significant differences in the comparative addictive potentials of ENDS between ever smokers and non-smokers, with the latter endorsing higher perception of addictiveness (p = 0.008).

Age, gender, ethnicity, marital status and diagnosis were associated with ever use of ENDS (Table II).

**Table II. Factors associated with the use of electronic nicotine delivery systems.**

| Sociodemographic factor                             | OR  | 95% CI |       | p-value  |
|---|-----|--------|-------|----------|
|   |     | Lower  | Upper |          |
| <b>Age (yr)</b>                                     |     |        |       |          |
| 21–40   | ref |        |       |          |
| 41–65   | 0.4 | 0.2    | 1.0   | 0.05*    |
| <b>Gender</b>                                       |     |        |       |          |
| Male  | ref |        |       |          |
| Female  | 0.4 | 0.2    | 0.8   | 0.01*    |
| <b>Ethnicity</b>                                    |     |        |       |          |
| Chinese   | ref |        |       |          |
| Malay   | 2.3 | 1.0    | 5.3   | 0.05*    |
| Indian  | 2.0 | 0.8    | 5.2   | 0.15     |
| Others  | 1.4 | 0.1    | 17.4  | 0.80     |
| <b>Education level</b>                              |     |        |       |          |
| Primary school                                      | ref |        |       |          |
| Secondary school                                    | 1.6 | 0.4    | 6.5   | 0.54     |
| Pre-university (junior college/diploma/ITE)         | 1.4 | 0.4    | 5.8   | 0.62     |
| Degree and above                                    | 0.4 | 0.1    | 2.3   | 0.32     |
| <b>Marital status</b>                               |     |        |       |          |
| Single  | ref |        |       |          |
| Married   | 0.3 | 0.1    | 1.0   | 0.05*    |
| Separated/divorced/widowed                          | 0.9 | 0.3    | 2.7   | 0.84     |
| <b>Number of household members</b>                  | 1.1 | 0.8    | 1.3   | 0.68     |
| <b>Clinician's diagnosis</b>                        |     |        |       |          |
| Depressive disorder                                 | ref |        |       |          |
| Schizophrenia spectrum and other psychotic disorder | 0.2 | 0.1    | 0.4   | < 0.001* |

\**p*-value is statistically significant. CI: confidence interval; OR: odds ratio; ref: reference group

Compared to younger adults (age 21–40 years), older adults had lower odds of ENDS use (odds ratio [OR] 0.40, 95% confidence interval [CI] 0.16–0.99,  $p = 0.05$ ). Females had lower odds of ENDS use than males (OR 0.38, 95% CI 0.19–0.75,  $p = 0.01$ ). Compared to individuals of Chinese ethnicity, those of Malay ethnicity had higher odds of ENDS use (OR 2.3, 95% CI 1.0–5.3,  $p = 0.05$ ). Those who were married had lower odds of ENDS use (OR 0.27, 95% CI 0.07–1.00,  $p = 0.05$ ) compared to those who were single. Compared to those with depressive disorders, those with schizophrenia spectrum and other psychotic disorders had lower odds of ENDS use (OR 0.18, 95% CI 0.08–0.04,  $p < 0.001$ ).

## DISCUSSION

The current study examined the prevalence of ENDS use in ever smokers and the perception of risk/harm of ENDS in ever smokers and non-smokers with MI. A lifetime prevalence of 30.4% was observed among the ever smokers, with 3.6% reporting current daily use. This number is in agreement with previous reports in patients with MI elsewhere, where a prevalence of 37%–40% lifetime use and 7% current use was reported in smokers.<sup>(22,23)</sup> The majority of the ever smokers who used ENDS (85.7%) stopped using it at the time of the interview, and the reasons cited included difficulty in purchasing e-cigarettes in Singapore. E-cigarettes are banned in Singapore and their sale/use is a punishable offence. However, 83% of the participants who reported use were able to purchase and possess ENDS in Singapore.

A large proportion of the ever smokers who had used ENDS tried them out of curiosity. Previous studies have shown that curiosity towards the product is a driving factor for initiating ENDS use.<sup>(24,25)</sup> Kong et al<sup>(25)</sup>, in their qualitative study, showed that curiosity, availability of ENDS in different flavours, family influence and their use as a substitute for regular cigarettes were the main factors that prompted the experimentation with e-cigarettes. This is in agreement with our results, where the participants reported curiosity as the main reason, followed by availability of different flavours and for quitting regular cigarettes. Kong et al<sup>(25)</sup> also identified safety/health concerns, lack of interest and cost as reasons for discontinuation, which were similar to the factors highlighted by our patients for discontinuing ENDS.

The perception of harm associated with ENDS was fair in the current study, with 27.3% of the ever smokers perceiving it as more harmful than regular cigarettes, compared to 2.3%–5.1% in other studies.<sup>(26)</sup> In another study among people with MI, more than half of the participants with MI perceived ENDS to be safer.<sup>(23)</sup> Hefner et al<sup>(27)</sup> addressed the perception of harm in ENDS users and indicated that it is generally lower in this group owing to the belief

that as ENDS can be used in places where cigarettes are forbidden, they should be less harmful than cigarettes. In Singapore, ENDS are illegal and the dissemination of information through the media has contributed to the increased awareness about the harms of using ENDS. The non-smokers in the study cited that they heard about ENDS through mainstream media, the Internet and social media, which have been used in Singapore for anti-ENDS campaigns.<sup>(28)</sup> By contrast, a larger proportion of the ever smokers and non-smokers were unsure about the addictive potential of ENDS, while nearly a quarter perceived ENDS to be more addictive than regular cigarettes. Jankowski et al<sup>(29)</sup> have shown that e-cigarettes are at least two times more addictive than regular cigarettes, an observation that was attributed to the higher nicotine content in second-generation e-cigarettes and increased frequency of use in young adults. The perception of addictiveness of ENDS varied significantly across different studies.<sup>(30,31)</sup> Gibson et al<sup>(32)</sup> addressed this discrepancy in perception across various studies and concluded that the perception of addictive potential varies based on the characteristics of ENDS such as the type, nicotine concentration and use patterns (experimental vs. established user). The majority of the ever smokers in our study quit ENDS and only a small percentage were current daily users. Their ability to quit ENDS might have given them the perception that ENDS might not be as addictive as what is indicated in awareness programmes. Nonetheless, evidence shows that favourable perceptions towards ENDS (e.g. the belief that ENDS are less harmful/less addictive than regular cigarettes) are associated with ENDS use in future.<sup>(33-35)</sup>

A significant proportion of participants in the current study showed concerns about the long-term safety of ENDS. A qualitative study among smokers showed that smokers were apprehensive about the safety of ENDS and were unwilling to use them despite their struggle to quit smoking.<sup>(36)</sup> This perception could act as a deterrent for ENDS use. The non-smokers expressed these concerns higher than ever smokers, which is in agreement with previous reports – this can be explained based on the health behavioural model using the theory of

reasoned action, where beliefs/attitudes precede actual behaviour.<sup>(26)</sup> More than half of the non-smokers (53%) and 27.3% of the ever smokers felt that ENDS can act as a gateway for future tobacco use. This is a concern that has been well discussed in the research community with similar studies reporting participants' concerns<sup>(37,38)</sup> that ENDS being regarded as a harmless product will facilitate transition to regular tobacco use by building nicotine dependence, especially among adolescents.

We observed that age, gender, ethnicity, marital status and type of diagnosis were associated with ENDS use. Spears et al<sup>(39)</sup> reported similar observations where younger age, lower education and ethnicity (Blacks and Hispanics) were associated with higher odds of ENDS use in a national survey in the United States. Similar studies have shown strong associations between age, gender and ENDS use, with younger age, Malay ethnicity and male gender showing higher odds of ENDS use than older adults, Chinese ethnicity and female gender.<sup>(40)</sup> These results corroborate population-level studies conducted in Singapore where Malay ethnicity, male gender and younger age showed higher odds of smoking and nicotine dependence.<sup>(41,42)</sup> This could be due to lower risk perception and lack of awareness about the harms of ENDS use among these specific sociodemographic clusters, as reported by Hooper et al.<sup>(43)</sup> These groups could benefit from awareness and harm reduction programmes that would improve their knowledge of the harms associated with ENDS.

This study addresses the prevalence of ENDS use and perception of harm in a vulnerable group who are at a higher chance of smoking-related harms, which adds value to the research topic. The study had several limitations, including its cross-sectional nature and use of quota sampling. Although the quota sampling ensured sufficient representation of different age groups ( $\geq 40$  and  $< 40$  years), gender and disease types (depressive disorder, schizophrenia spectrum and other psychotic disorder), the non-random nature of the study could have introduced sampling bias, thus affecting the generalisability of the results. Also, the

cross-sectional nature of the study captured the attitudes of the participants at the time of the interview. It is possible that attitudes change over time, which is not addressed in this study. ENDS are banned in Singapore; thus, it is possible that some of the participants might not have reported their ENDS use despite the study team's assurances of confidentiality. The ENDS questionnaire in this study was a very short version intended to capture a preliminary view of the ENDS milieu in Singapore, which could pave the way for larger studies. Future studies should explore a more in-depth and extensive view of ENDS use among those with MI and factors that could deter them from such use.

Given the fact that ENDS use is moderate despite the legal restrictions and there is insufficient evidence on the efficacy and safety of ENDS in smoking cessation in those with MI, continued monitoring of ENDS use and health behaviours is warranted to avoid adverse health outcomes.

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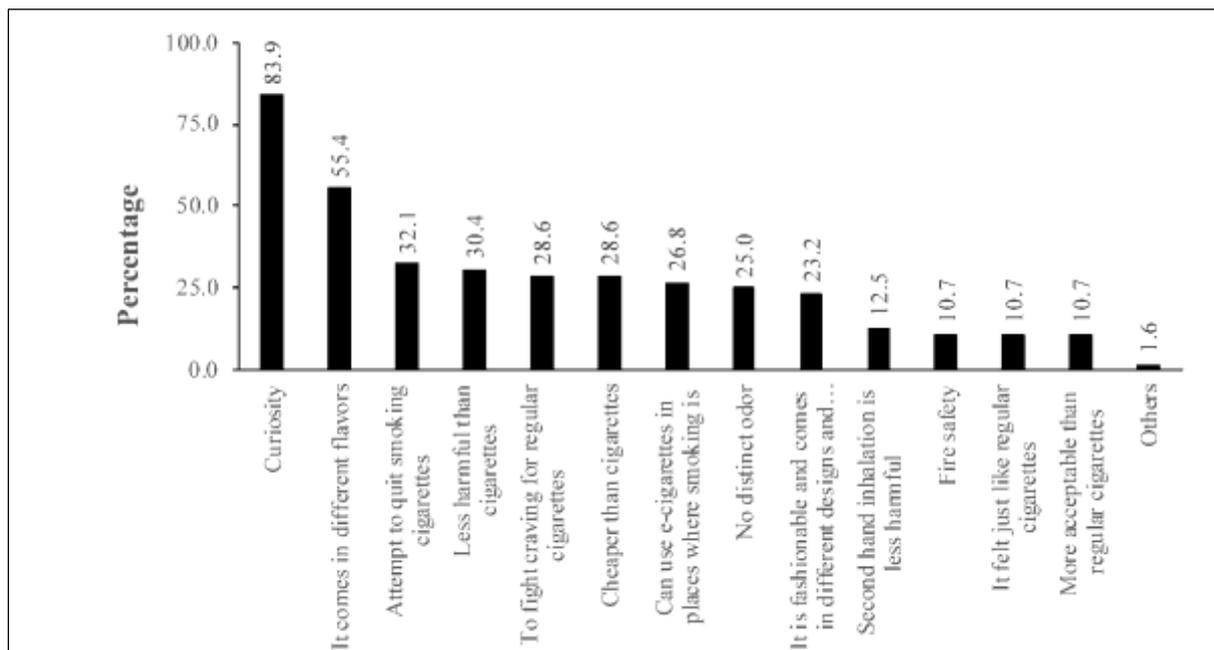
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**FIGURE**

**Fig. 1** Bar chart shows the participants' reasons for trying electronic nicotine delivery systems.