

Caries Experience among Cigarette and E-Cigarette Users: A 6-Month Prospective Study

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Abstract

This study aimed to evaluate and compare the caries experience among cigarette smokers, e-cigarette smokers, and non-smokers. This observational study involved 135 participants; with 45 participants in each group respectively. Dental caries was recorded and evaluated using the DMFT score. The results were compared using analysis of variance (MANOVA) for analysis between the groups and the Wilcoxon Rank test for analysis within the groups. The outcomes of the analysis were insignificant between the groups ($p = 0.370$) at baseline and ($p = 0.480$) at the 6-month follow up. The result was significant within the group; cigarette users ($p = 0.005$), e-cigarette users ($p = 0.000$), and control group ($p = 0.025$). In conclusion, cigarette and e-cigarettes usage has potential detrimental effect on caries development. However, more longitudinal studies required to provide more evidences.

Keywords: Dental Caries, DMFT, E-cigarette, Oral Health, Vaping

INTRODUCTION

Oral diseases represent an increasingly important public health problem in the social awareness [1]. In Malaysia, the prevalence of tooth decay amongst adults is 90%, with two out of ten teeth being affected on average [2–4]. There has been a recent increase in the popularity of alternative types of cigarettes, namely electronic nicotine delivery system (ENDS) or electronic cigarettes (e-cigarettes) [5]. E-cigarettes are devices that vaporize liquid solutions to produce mist containing various concentrations of nicotine [6].

Although the current government policy on nicotine control is being established to include e-cigarettes, this industry is almost completely unregulated in Malaysia at the time of writing this article. There are no standard governance for controlling the concentration of liquids used in e-cigarettes as well as the aerosols produced [7]. In light of the fact that e-cigarettes are neither cigarettes nor smokeless tobacco, they managed to evade the advertising bans of tobacco products.

To date, there is little documented evidence on the effects of e-cigarette towards oral health. A short observational study conducted in 2011 reported mouth irritation, sore throat, dry mouth, and oral ulcers after 4 weeks of use [8]. Although clinical studies on the said topic are scarce, the products may increase the risk of periodontal damage due to presence of high levels of nicotine [9]. In fact, the effects of e-cigarette usage on oral health have been reported in Malaysia [10]. However, the findings of other studies on the effects of e-cigarette on oral health were few and inconsistent.

In view of the conflicting evidence on the oral health of cigarette and e-cigarette users, the aim of this study was to compare the occurrence of caries between the control group (non-cigarette and non-e-cigarette users), cigarette users, and e-cigarette users.

MATERIALS AND METHODS

Sample size

This study was approved by the IIUM Research Ethical Committee (Approval No: IREC 556). With reference to [11], the sample size calculation was done using the Openepi software (version 3.01). Data from previous studies indicated that the occurrence of the outcome was 31% among the exposed groups. With consideration of Type 1 Type 2 errors, a sample size of minimum of 34 was required for each arm. After allocating for a 20% dropout rate, the aforementioned number became 123, or 41 participants for each arm.

The participants were divided into three groups: control, cigarette users, and e-cigarette users. The dental examination was conducted at Dental Specialist Clinic, Kulliyyah of Dentistry. Each participant was given a participant information sheet prior to signing a consent form.

Dental examination

Clinical oral examination was performed by a trained examiner, with the respondent on a dental chair. The equipment used for the exercise included dental mirrors, dental explorers, periodontal probes, and an overhead light from the dental chair. All data were recorded in clinical forms (one form for each participant). For intra-examiner reliability, a reliability test was conducted prior to starting the research project. A Cohen Kappa value of at least 0.6 indicated good reliability. The result showed a Cohen Kappa value of 0.89.

Dental caries

Caries statuses of the participants were assessed using the DMFT/dmft index according to WHO [12]. All the teeth were examined visually for caries. The DT/dt, MT/mt and FT/ft are referred to the number of decayed, missing and filled permanent/primary teeth, respectively.

Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences (SPSS) software (version 23.0) (SPSS Inc, Chicago, Ill., USA). Means and standard deviations were

calculated for the continuous data. To compare the oral health status between groups at baseline and 6-month follow-up, the MANOVA test was used as there were more than two dependent variables. In addition, the Wilcoxon signed-rank test was used to compare the oral health status within the smoking group at baseline and 6-month follow-up.

RESULTS AND DISCUSSION

A total of 135 participants were included. The mean age for the control group was 29.78 years, while that of the cigarette and e-cigarette groups was 30.28 and 22.92 years respectively. Most of the participants in the control group were females (72.5%); males were predominant in the

cigarette and e-cigarette groups (97.5% each). The majority of the participants were Malays (99.1%); there was only one Indian. As for level of education, the majority of participants in the control group had tertiary education (95%). In contrast, the e-cigarette users had the least number of participants with tertiary education (25%). Regarding monthly income, 87.5% of the e-cigarette users earned less than RM 2,000, whereas 37.5% of respondents in the control group and 20% of cigarette users were in this bracket. These demographic data are presented in Table 1.

Table 1. Summary of demographic characteristics of control group, cigarette and e-cigarette users (n=135)

| <i>Characteristics</i> | <i>Control Group n (%) n=45</i> | <i>Cigarette Users n (%) n=45</i> | <i>E-cigarette Users n (%) n=45</i> |
|---------------------------------|---|---|---|
| Age | | | |
| <i>Mean Age (M ± SD)</i> | 29.78 ± 9.74 | 30.28 ± 8.31 | 22.92 ± 2.91 |
| <i>18-29</i> | 21 (46.7) | 25 (57.8) | 42 (93.3) |
| <i>30-49</i> | 39 (51.1) | 16 (35.5) | 3 (6.7) |
| <i>50-59</i> | 1 (2.2) | 4 (6.7) | 0 (0.0) |
| Gender | | | |
| <i>Male</i> | 16 (35.6) | 44 (97.8) | 43 (95.6) |
| <i>Female</i> | 29 (64.4) | 1 (0.7) | 2 (4.4) |
| Race | | | |
| <i>Malay</i> | 43 (95.6) | 45 (100.0) | 45 (100.0) |
| <i>Indian</i> | 2 (4.4) | 0 (0.0) | 0 (0.0) |
| Education | | | |
| <i>Primary</i> | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| <i>Secondary</i> | 3 (6.7) | 18 (40.0) | 27 (60.0) |
| <i>Tertiary</i> | 42 (93.3) | 27 (60.0) | 18 (40.0) |
| Income | | | |
| <i>Below RM4999</i> | 43 (95.6) | 41 (91.1) | 36 (80.0) |
| <i>RM5000 and above</i> | 2 (4.4) | 4 (8.9) | 9 (20.0) |
| Marital Status | | | |
| <i>Single</i> | 17 (37.8) | 27 (60.0) | 37 (82.8) |
| <i>Married</i> | 28 (62.2) | 18 (40.0) | 8 (17.8) |
| Occupation | | | |
| <i>Employed</i> | 32 (71.1) | 42 (93.3) | 29 (64.4) |
| <i>Unemployed</i> | 13 (28.9) | 3 (2.2) | 16 (35.6) |
| Period of smoking/vaping | | | |
| <i>1-10 years</i> | - | 29 (34.4) | 45 (100.0) |
| <i>11-25 years</i> | - | 16 (35.6) | 0 (0.0) |

Table 2. Adjusted mean and 95% confidence interval of the effect of smoking status on the periodontal health and caries index at baseline and 6-month follow up between the groups

| <i>Variables</i> | <i>Adjusted mean (95% CI)</i> | <i>F statistics (df)</i> | <i>p value</i> |
|--------------------------|-----------------------------------|--------------------------|--------------------|
| Baseline | | | |
| DMFT Index | | | |
| <i>Cigarette group</i> | 4.09 (3.14, 5.04) | 10.42 (2) | 0.370 ^a |
| <i>E-cigarette group</i> | 3.13 (2.18, 4.09) | | |
| <i>Control group</i> | 3.51 (2.56, 4.463) | | |
| 6 month follow up | | | |
| DMFT Index | | | |
| <i>Cigarette group</i> | 4.68 (3.00, 5.71) | 13.82 (2) | 0.480 ^b |
| <i>E-cigarette group</i> | 3.54 (2.17, 4.91) | | |
| <i>Control group</i> | 4.36 (3.00, 5.71) | | |

One-Way MANOVA $F(5, 128) = 91.198, p < 0.001$

^a Univariate MANOVA, post hoc for DMFT Index, there was no significant difference of mean between all groups.

^b Univariate MANOVA, post hoc for DMFT Index, there was no significant difference of mean between all groups.

Table 3. Comparison of median scores for oral health status within smoking status at baseline and 6 follow-up

| Variables | Median (IQR) | | Z statistics | p value |
|-------------------|-------------------|-------------------|--------------|--------------|
| | Baseline | 6 month | | |
| DMFT Index | | | | |
| Cigarette group | 3.00 (1.50, 6.50) | 3.00 (2.00, 6.50) | -2.812 | 0.005 |
| E-cigarette group | 3.00 (2.00, 4.00) | 4.00 (3.00, 5.50) | -3.828 | 0.000 |
| Control group | 2.00 (1.00, 5.00) | 3.00 (1.00, 7.00) | -2.242 | 0.025 |

Wilcoxon Sign Ranks Test

The present study evaluated the oral health of the control, cigarette, and e-cigarette groups. The ages of our participants varied considerably (20 – 64 years), whereby the means were 29.78, 30.28, and 22.92 years for the control, cigarette, and e-cigarette groups respectively. These findings further supported the idea that e-cigarette users were relatively younger; their average age is 19 years [13] as compared to 34 years for the cigarette users [14].

Globally, non-communicable diseases are universally contingent [15]. One of the most overlooked types of non-communicable diseases is dental or oral disease. Dental diseases has become a growing concern in many low and middle income countries [16]. In 2010, the National Oral Health Survey of Adults (NOHSA) stated that the national average for decayed, missing, and filled teeth (DMFT) was 11.8 with a quite high percentage of dental caries (89.5%).

With regard to the occurrence of caries, the absence of significant differences between the control, cigarette, and e-cigarette groups in this research was unexpected. The MANOVA was conducted to evaluate the caries experience between the groups. For the DMFT Index, there was no significant difference of mean between all groups at baseline and 6 month follow up. However, there was a significant difference in the median score for within the group between baseline and 6 month follow up for the DMFT Index for cigarette users ($p = 0.005$), e-cigarette users ($p = 0.000$) and control group ($p = 0.025$).

The reason behind this is not very clear, especially since smoking has been linked with increased incidences of dental caries [17]. However, the findings of the current study did not support those of previous research. On the other hand, it has also been suggested that the increase in caries development is independently related to the level of tobacco consumption [18]. There is a consensus among prominent researchers over the link between the two aspects. In addition, there are significant increases in the numbers of decayed, missing, and filled teeth in people who smoke more than 15 cigarettes daily [19]. In short, recent and prominent studies have established the correlation between smoking status and caries occurrence. A number of researchers have reported a higher caries experience happening (DMFT) and is suspected to be linked with cigarette smoking [20]. Cigarette smoking is known for its negative effects towards oral health. Smoking is a precedent to gum diseases which are clinically presented as gingival swelling and inflammation, loss of gingival attachment, gingival recession, and deeper

periodontal pockets [21]. This showed that smokers have poorer oral health compared to non-smokers in terms of caries experience. On the other hand, no previous studies reported on caries experience with the usage of e-cigarette. This study would provide a baseline data and a benchmark for further research.

To date, there are still very few studies on the oral health of cigarette and e-cigarette users. The results of our study can be a reference for comparing the detrimental effects of cigarette and e-cigarette smoking on oral health with respect to non-smokers. Moreover, it explained the harmful effects of tobacco and nicotine on periodontal health as well.

CONCLUSION

In conclusion, this study has shown that e-cigarettes had potentially detrimental effects on a person's caries experience. Evidently, there is an increase in the number of e-cigarette users around the globe because of the general belief that e-cigarettes are less harmful as compared to conventional cigarettes. As such, action must be taken to rectify this trend. More research needs to be done using a prospective method to provide more evidences of the effects of e-cigarettes on oral health.

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REFERENCES

- de Araújo Nobre, M., Maló, P. Prevalence of periodontitis, dental caries, and peri-implant pathology and their relation with systemic status and smoking habits: Results of an open-cohort study with 22009 patients in a private rehabilitation center. *J. Dent.* 2017, 8(10), 139. Available at: <http://dx.doi.org/10.1016/j.jdent.2017.07.013>
- Ministry of Health Malaysia (MOH), A lifetime of healthy smiles: National oral health plan for Malaysia 2011-2020. 2011. Available at: <http://ohd.moh.gov.my/v3/images/nohp20112020.pdf>
- Ministry of Health Malaysia (MOH), Annual report 2013. 2014. Available at: http://ohd.moh.gov.my/v3/images/pdf/annual_rpt2013.pdf
- Ministry of Health Malaysia (MOH), Oral healthcare for school children in Malaysia. 2006. Available at: <http://ohd.moh.gov.my/v3/images/pdf/ORAL%20HEALTHCARE%20SCHOOL%20CHILDREN%20IN%20MALAYSIA.pdf>
- Grana, R., Benowitz, N., Glantz, S. A., E-cigarettes: A scientific review. *Circulation.* 2014, 129(19), 1972–1986. doi: 10.1161/CIRCULATIONAHA.114.007667.

6. World Health Organization (WHO), WHO Report on the Global Tobacco Epidemic 2008: The MPOWER package. 2008. Available at: http://www.who.int/tobacco/mpower/mpower_report_full_2008.pdf
7. Polosa, R., Caponnetto, P., Morjaria, J., Papale, G., Campagna, D., Russo, C., Effect of an electronic nicotine delivery device (e-Cigarette) on smoking reduction and cessation: a prospective 6-month pilot study. *BMC Public Health*. 2011, 11, 786. doi: 10.1186/1471-2458-11-786.
8. Caponnetto, P., Auditore, R., Russo, C., Cappello, G. C., Polosa, R., Impact of an electronic cigarette on smoking reduction and cessation in schizophrenic smokers: A prospective 12-month pilot study. *Int. J. Environ. Res. Public Health*. 2013, 10(2), 446–461. doi: 10.3390/ijerph10020446
9. Genco, R. J., Borgnakke, W. S., Risk factors for periodontal disease. *Periodontol* 2000. 2013;62(1):59–94. doi: 10.1111/j.1600-0757.2012.00457.x.
10. Ghazali, A. F., Ismail, A. F., Faisal, G. G., Halil, M. H. M., Daud, A., Oral health of smokers and e-cigarette users: A case-control study. *J. Int. Dent. Med. Res*. 2018, 11(2), 428–432. Available at: https://www.researchgate.net/publication/328006246_Oral_Health_of_Smokers_and_E-Cigarette_Users_A_Case-Control_Study
11. Millar, J. W., Locker, D., Smoking and oral health status. *J. Can. Dent. Assoc*. 2007, 73(2), 155–155g. Available at: <http://www.cda-adc.ca/jcda/vol-73/issue-2/155.pdf>
12. World Health Organization (WHO), Oral Health Surveys - Basic Methods. 2013. Available at: https://www.who.int/oral_health/publications/9789241548649/en/
13. Institute for Public Health (IPH), Tobacco and E-cigarette Survey among Malaysian Adolescent (TECMA) 2016. 2016. Available at: https://www.researchgate.net/publication/331979474_Tobacco_and_e-cigarette_survey_among_adolescents_in_Malaysia
14. Institute for Public Health (IPH), National Health and Morbidity Survey 2015 - Report on Smoking Status Among Malaysian Adults. 2015. Available at: <http://www.moh.gov.my/moh/resources/NHMS2015-VolumeV.pdf>
15. Jaafar, N., Hakim, H., Azlida, N., Nor, M., Mohamed, A., Saub, R., et al., Is the burden of oral diseases higher in urban disadvantaged community compared to the national prevalence? *BMC Public Health*. 2014, 14(Suppl 3), S2. Available at: <http://www.biomedcentral.com/1471-2458/14/S3/S2>
16. Williams, D. M., Global oral health inequalities: the research agenda. *Adv. Dent. Res*. 2011, 2, 198–200. doi: 10.1177/0022034511402014
17. Featherstone, J. D. B., Singh, S., Curtis, D. A., Caries risk assessment and management for the prosthodontic patient. *Am. Collage Prosthodont*. 2011, 20, 2–9. doi: 10.1111/j.1532-849X.2010.00596.x
18. Hanioka, T., Ojima, M., Tanaka, K., Daily smoking May independently predict caries development in adults. *J. Evid. Based Dent. Pract*. 2014, 14(3), 151–153. doi: 10.1016/j.jebdp.2014.07.005
19. Ludwick, W., Massler, M., Relation of Dental Caries Experience and Gingivitis to Cigarette Smoking in Males 17 to 21 years old (At the Great Lakes Naval Training Centre). *J. Dent. Res*. 1952, 31(3), 18–21. doi: 10.1177/00220345520310030401
20. Aguilar-Zinser, V., Irigoyen, M. E., Rivera, G., Maupomé, G., Sánchez-Pérez, L., Velázquez, C., Cigarette smoking and dental caries among professional truck drivers in Mexico. *Caries Res*. 2008, 42(4), 255–262. doi: 10.1159/000135670
21. Benedetti, G., Campus, G., Strohmenger, L., Lingström, P., Tobacco and dental caries: A systematic review. *Acta Odontol. Scand*. 2013, 71(March 2012), 363–371. doi: 10.3109/00016357.2012.734409