JTS

The Journal of Transdisciplinary Studies, 6(3): 319-330, 2022
https://doi.org/10.22685/JTS.2022.6.3.319

# The Relationship Between the Subjective Level of Oral Health and the Use of Electronic Cigarettes*

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ARTICLE INFO

*Article history:*
Received 01 November 2022
Revised 15 December 2022
Accepted 16 December 2022

*Keywords:*
Drinking,
Electronic Cigarettes,
Subjective Level of Oral Health,
Tooth Brushing

ABSTRACT

With a view to examine and understand the factors influencing the subjective level of oral health of the smokers using electronic cigarettes, this study was conducted with 1,845 people aged 19 years or older who have smoked liquid electronic cigarettes containing nicotine within the last month for the final analysis. As a result of the study conducted, the factors influencing the subjective level of oral health of electronic cigarette smokers turned out to be age, level of education, drinking, and tooth brushing practice variables. The younger the age, the higher the level of education, the group drinking more than twice a week, and the group practicing tooth brushing, the subjective level of oral health turned out to be high ($p < 0.05$). Based on the results above, the relationship between the use of electronic cigarettes and the subjective level of oral health was confirmed, and it may be necessary to develop the smoking cessation program which can help improve the risk of electronic cigarettes for the oral health by age and provide information to change the smokers' perceptions and attitudes towards that end.

## 1. Introduction

According to the World Health Organization (WHO), smoking causes approximately over 8 million deaths worldwide each year. Among which, over 7 million people and about 1.2 million non-smokers are reported to have died from their exposure to second-hand smoke (Lee et al., 2021), and the Korea Centers for Disease Control and Prevention has also reported 58,000 deaths from direct smoking in 2019, and the socio-economic costs that can be incurred due to the direct and indirect effects at a loss of KRW 12,191.3 billion, respectively (Korea Centers for Disease Control and Prevention, 2022).

Accordingly, Korea is actively implementing smoking cessation services such as by enhancing the cigarette prices and introducing warning pictures on the cigarette packs while expanding the measures to actively support smoking cessation treatment to help reduce the rate of smoking and implementing

* This study was funded by Howon University's academic scholarship

campaigns (Choi, 2017). As a social atmosphere of encouraging smoking cessation is formed, the smokers want to quit smoking and choose the electronic cigarettes as a method based on the perception that the electronic cigarettes are safer than the ordinary cigarettes (Kim et al., 2013), and in 2020, the rate of electronic cigarette use is 5.2% for males and 1.1% for females, demonstrating the increasing trend at the present, and it may be assumed that the rate of electronic cigarette use has increased by about 7 times and 9 times compared to 2% for males and 0.3% for females in 2013, when the survey began on the use of electronic cigarettes. During the first half of 2022, the sales volume of electronic cigarettes also increased by 1.9% year on year, and the proportion of electronic cigarettes in sales has continued to increase (Ministry of Strategy and Finance, 2022).

It has also been claimed that, the electronic cigarettes, which are increasing as such, are in a state where the harms and safety of smoking have not yet been clearly confirmed or revealed, yet there is an inadequate evidence for the effect of smoking cessation (World Health Organization, 2019), and rather induces the non-smokers to smoke (Kim et al., 2015), and most of the medical practitioners claim that the electronic cigarettes are not harmful to the human body and render no effect of smoking cessation (Kim et al., 2015). Furthermore, any repeated exposure to the electronic cigarettes may cause inflammation in cells in the oral cavities, such as oral epithelium, and further accelerate the risk of aging, which may be a factor in changing the oral environment for the various oral diseases (Alharbi & Rouabhia, 2016), and hence, the electronic cigarettes can also be harmful to the oral health as well as the general health. Even if the use of electronic cigarettes is intended to achieve the purpose of smoking cessation, the possibility of nicotine addiction due to the continuous supply of nicotine could not be ruled out, and the opportunity to achieve smoking cessation may be missed out in the end (Goniewicz & Zielinska, 2012).

According to the County Health Ranking of the United States, it turned out that health behavior (57%) has the most influence on the health determinants (Oh et al., 2018), and it is influenced by the individual socio-economic factors while the subjective health level, which is used as an index to measure the health inequality, has been widely used as a reliable indicator for measuring the health conditions of the population since it is closely related to mortality (Jung et al., 2014). Furthermore, the oral health evaluation can help predict the early symptoms of systemic diseases by examine and understanding unhealthy lifestyles (Jung et al., 2014). While the effects of smoking and oral health have already been confirmed across many studies through the existing studies, and nevertheless, the rate of smoking is still not decreasing, and instead, the use of electronic cigarettes has increased. Hence, as with the ordinary cigarettes, electronic cigarettes also need to be considered as to their relevance to the oral health, alongside the proper perception of the risks that can cause serious consequences for the oral health due to the long-term exposure.

The studies on the oral health caused by smoking has actively been conducted, but relatively little interest has been expressed on the electronic cigarettes. In the previous studies, the high rate of smoking according to the subjective perception of oral health conditions for smoking and oral health conditions (Song & Jung, 2018) and the significance according to periodontal disease and subjective oral health conditions were confirmed (Song & Jung, 2018; Kim & Lee, 2017). As for the type of smoking, the confirmation of the association between the passive smoking and periodontal disease in direct smoking (Kim et al., 2017), the association between smoking and

dental caries (Kim et al., 2014), and the oral care status of the smokers and non-smokers (Chung & Han, 2003), most of them were the research reports made on the relationship between the smoking of ordinary cigarettes and oral health, and the studies on whether the use of electronic cigarettes influences oral health using the reliable community health data is yet inadequate.

Accordingly, by using the subjective perception of oral health, which may be used as an epidemiological index of the disease burden of oral disease or an index of treatment need or treatment result, it is intended to investigate the relationship between the use of electronic cigarettes and the perception of the subjective level of oral health by age. Ultimately, it is intended to provide the basic data to help improve the oral health level and the smoking cessation by enhancing the risk of electronic cigarettes and changing the perception and attitudes of the smokers.

## 2. Research Method

### *2.1 Research subjects*

This study utilized the data from the 2020 Community Health Survey conducted by the Korea Centers for Disease Control and Prevention. The secondary data were analyzed for the purposes of examining and understanding the relevant factors influencing the subjective level of oral health of the smokers using the electronic cigarettes. Among 229,269 people aged 19 or older who participated in the Community Health Survey, 1,845 people, who have smoked using the liquid electronic cigarettes containing nicotine within the last month, were analyzed as the subjects of the final study. The study was conducted after acquiring an approval through the deliberation exemption from the Institutional Bioethics Committee of OO University (IRB No. 1041585-202204-HR-002-01).

### *2.2 Research tools*

As for the general characteristics, gender, age, marital status, level of education, and economically active status variables were used. Age was categorized into 19-29 years old (young), 30-49 years old (middle-aged), 50-64 years old (prime-aged), and 65 years old or older (elderly). Marital status was classified into having a spouse and not having a spouse (single/separated/divorced/widowed). The level of education was classified into high school graduate or less and community college graduate or higher, and the state of economically active was classified into economically active and economically inactive.

As for the oral health related characteristics, drinking, stress level, and tooth brushing practice variables after lunch were used. Drinking was categorized into less than twice a week and more than twice a week. As for tress level, 'feeling very much' and ‘feeling much’ were categorized into the high stress group, and 'feeling a little' and 'not feeling much' into the low stress group. Tooth brushing practice after lunch was classified into practicing group and non-practicing group.

As for the subjective level of oral health, it was categorized into the two groups of the good subjective level of oral health group ('very good', 'good', and 'average') and the poor subjective

level of oral health group ('bad' and 'very bad') for the question "When you think about yourself, how do you feel about your oral health, including teeth and gums?" (OECD, 2020) for analysis.

### 2.3 Statistical analysis

The statistical analysis was performed by using the STATA ver.12.0 (StataCorp, College Station, TX, USA). The Chi-square test was conducted to determine the difference in the subjective level of oral health according to the general characteristics and oral health related characteristics of the subjects, and as for the factors influencing the subjective level of oral health of electronic cigarette smokers, the multivariate logistic regression analysis was used to calculate the odds ratio: OR and Confidence interval: CI, while the significance level for statistical significance was set to 0.05.

## 3. Results

### 3.1 General characteristics and oral health related characteristics of the research subjects

As a result of examining the general characteristics, males accounted for 88.7% and females 11.3% of the total subjects. In terms of age, 30-49 years of age accounted for the most at 50.5%, and those aged 65 or older accounted for the least at 1.2%. The subjects with a spouse accounted for 43.2%, which was less than those without a spouse. As for the level of education, 66.7% of them graduated from community college or higher, and the economically active accounted for 81.3%, which was more than economically inactive. As a result of examining the oral health related characteristics, drinking more than twice a week was 67.2%, and the high stress group accounted for 61.2%. Those practicing tooth brushing after lunch turned out to be 68.7% <Table 1>.

### 3.2 Differences in the subjective level of oral health according to the general characteristics and oral health related characteristics

Table 2 illustrates the results of analyzing the differences in the subjective level of oral health according to the general characteristics. In terms of age, as for the good subjective level of oral health group, those aged 19-29 years Were the highest at 81.6%, and the higher the age, the higher the poor level of oral health group ($p < 0.001$). The subjective good oral health group according to the marital status was 79.4% in the case without a spouse, and as for the level of education, those who graduated from community college or higher were 78.5%, which turned out to be higher than 73.6% for the high school graduates and below.

As a result of analyzing the differences in the subjective level of oral health according to the oral health related characteristics, there was a statistically significant difference except for the stress level. The group with good subjective oral health according to drinking was high at twice a week or more (78.8%), while the group with good subjective oral health according to the practice of tooth brushing after lunch was high at 80.0% ($p < 0.001$ ).

**Table 1.** General characteristics

| Characteristics division | | N | (%) |
|---|---|---|---|
| Sex | Male | 1,637 | (88.7) |
| | Female | 208 | (11.3) |
| Age | 19-29 | 705 | (38.2) |
| | 30-49 | 932 | (50.5) |
| | 50-64 | 186 | (10.1) |
| | ≥65 | 22 | (1.2) |
| Spouse | Yes | 797 | (43.2) |
| | No | 1,048 | (56.8) |
| Educational level | ≤High | 614 | (33.3) |
| | ≥College | 1,231 | (66.7) |
| Economic activity | Yes | 1,499 | (81.3) |
| | No | 346 | (18.7) |
| Drinking | <2 week | 576 | (32.8) |
| | ≥2 week | 1,182 | (67.2) |
| Subjective stress | Low | 715 | (38.8) |
| | High | 1,130 | (61.2) |
| Tooth brushing after lunch | Yes | 1,267 | (68.7) |
| | No | 578 | (31.3) |

**Table 2.** Differences subjective oral health level

| Variables | Categories | Subjective oral health level | | $\chi^2(p^*)$ |
|---|---|---|---|---|
| | | Good N(%) | Poor N(%) | |
| Sex | Male | 1,253(76.5) | 384(23.5) | 1.10(0.293) |
| | Female | 166(79.8) | 42(20.2) | |
| Age | 19-29 | 575(81.6) | 130(18.4) | 30.00(<0.001) |
| | 30-49 | 710(76.2) | 222(23.8) | |
| | 50-64 | 123(66.1) | 63(33.9) | |
| | ≥65 | 11(50.0) | 11(50.0) | |
| Spouse | Yes | 587(73.7) | 210(26.3) | 8.39(0.004) |
| | No | 832(79.4) | 216(20.6) | |
| Educational level | ≤High | 452(73.6) | 162(26.4) | 5.62(0.018) |
| | ≥College | 967(78.5) | 264(21.5) | |
| Economic activity | Yes | 1,148(76.6) | 351(23.4) | 0.47(0.489) |
| | No | 271(78.3) | 75(21.7) | |
| Drinking | <2 week | 420(72.9) | 156(27.1) | 7.44(0.006) |
| | ≥2 week | 931(78.8) | 251(21.2) | |
| Subjective stress | Low | 537(75.1) | 178(24.9) | 2.14(0.143) |
| | High | 882(78.0) | 248(22.0) | |
| Tooth brushing after lunch | Yes | 1,013(80.0) | 254(20.0) | 21.07(<0.001) |
| | No | 406(70.2) | 172(29.8) | |

* by chi-squared test

### 3.3 Factors influencing the subjective level of oral health of the smokers of electronic cigarettes

The results of analyzing the factors influencing the subjective level of oral health according to the general characteristics are as illustrated in Model I of Table 3. The odds ratio of the good subjective level of oral health group according to age was 0.477 times (95% CI: 0.317-0.717) for those aged 50-64 years compared to those aged 19-29 years, and it decreased as the age grew higher ($p < 0.001$). As for the level of education, the odds ratio of the subjective level of oral health group with community college graduate or higher was 1.265 times (95% CI: 1.003-1.596), and the higher the level of education, the higher.

The results of analyzing the factors influencing the subjective level of oral health according to the general characteristics and oral health related characteristics are as illustrated in Model Ⅱ. The odds ratio of subjects with good oral health according to drinking was 1.382 times higher (95% CI: 1.092-1.750) for the group drinking more than twice a week than for the group drinking less than twice a week. The odds ratio of the group with good subjective oral health according to the practice of tooth brushing after lunch was 0.605 times (95% CI: 0.479-0.765) lower for the non-practicing group than for the group which practiced tooth brushing after lunch ($p < 0.001$).

**Table 3.** Factors influencing the subjective oral health level of electronic cigarette smokers

| Variables | Categories | Model Ⅰ | | | Model Ⅱ | | |
|---|---|---|---|---|---|---|---|
| | | OR | 95%CI | *p* | OR | 95%CI | *p* |
| Sex | Male | 1 | | | 1 | | |
| | Female | 1.099 | 0.759-1.590 | 0.615 | 1.018 | 0.696-1.489 | 0.925 |
| Age | 19-29 | 1 | | | 1 | | |
| | 30-49 | 0.741 | 0.559-0.982 | 0.037 | 0.734 | 0.550-0.979 | 0.036 |
| | 50-64 | 0.477 | 0.317-0.717 | <0.001 | 0.442 | 0.291-0.672 | <0.001 |
| | ≥65 | 0.267 | 0.109-0.651 | 0.004 | 0.366 | 0.135-0.995 | 0.049 |
| Spouse | Yes | 1 | | | 1 | | |
| | No | 1.067 | 0.822-1.385 | 0.622 | 1.019 | 0.779-1.334 | 0.886 |
| Educational level | ≤High | 1 | | | 1 | | |
| | ≥College | 1.265 | 1.003-1.596 | 0.047 | 1.202 | 0.944-1.530 | 0.134 |
| Economic activity | Yes | 1 | | | 1 | | |
| | No | 1.001 | 0.739-1.355 | 0.994 | 1.018 | 0.745-1.390 | 0.910 |
| Drinking | <2 week | | | | 1 | | |
| | ≥2 week | | | | 1.382 | 1.092-1.750 | 0.007 |
| Subjective stress | Low | | | | 1 | | |
| | High | | | | 1.175 | 0.932-1.481 | 0.172 |
| Tooth brushing after lunch | Yes | | | | 1 | | |
| | No | | | | 0.605 | 0.479-0.765 | <0.001 |

* by multivariate logistic regression
* OR: odds ratio, CI: 95% confidence interval

## 4. Discussion

Through the announcement of its statement on the use of cigarettes and COVID-19, the WHO reported that smoking, which increases the severity of respiratory diseases, is a risk factor for COVID-19, and hence, the use of cigarettes ought to be stopped immediately (WHO, 2020). While the smokers of ordinary cigarettes use electronic cigarettes for the purposes of smoking cessation (Etter & Bullen, 2011), the safety or the effect of smoking cessation of electronic cigarettes has not yet been adequately reviewed or studied (Kim et al., 2013), and in particular, there are inadequate supporting data on the effect of risk or safety on the level of oral health. Accordingly, this study identifies the factors that influence the subjective level of oral health of the smokers using the electronic cigarettes, thereby improving the perception of electronic cigarette smoking and developing a smoking cessation education program and establishing a policy to reduce the electronic cigarette rate of smoking, and towards this end, the secondary data were utilized to provide the basic data, and the multivariate logistic regression analysis was conducted with the smokers who had used liquid electronic cigarettes containing nicotine within the past month, whose results are as follows.

It turned out that the differences in the subjective level of oral health according to the general characteristics of electronic cigarettes smokers were the highest for the group aged 19-29 years, and the higher the age, the higher the poor level of oral health group. The good level of oral health group turned out to be higher in the case of those with a community college degree or higher and without a spouse. In the existing paper, the lifetime experience of electronic cigarettes among the Korean adults was higher among the males, lowered with increasing age, and higher as the level of education was higher, and the experience of electronic cigarettes was higher among the subjects without a spouse than the subjects with a spouse (Her, 2020; Park et al., 2019; Kim et al., 2019; Son et al., 2021). Furthermore, when examining the results of a study (Park & Kim, 2014) which claimed that the smokers had a lower perception of the importance of oral health than the non-smokers (Kim et al., 2014), and that the smokers had a lower knowledge about the oral health care, it could be assumed that the subjective level of oral health is also not irrelevant.

The factors that influence the subjective level of oral health according to the general characteristics of electronic cigarettes smokers are the odds ratio of the good subjective level of oral health group according to age, which is 0.477 times higher for the group aged 50-64 years than the group aged 19-29 years, which decreased as the age increased. The highest rate of smoking was found among those in their 30s, and the higher the perception of good subjective oral health, the higher the risk of smoking as a research result (Song & Jung, 2018), supportive of which is the fact that young people prefer electronic cigarettes as an auxiliary means for smoking cessation (Pokhrel et al., 2014), and there may be several factors in terms of the trend of electronic cigarettes spreading, yet since the most exposure in publicity and promotion of electronic cigarettes companies using online marketing is also the younger age group (Kong et al., 2015), it is considered that they perceive themselves as having a high level of oral health as well as a high rate of experiencing electronic cigarettes. As for the level of education, the odds ratio of the subjective level of oral

health group with community college graduates or higher is 1.265 times, and the higher the level of education, the higher it was, and in the case of a high level of education that demonstrates a positive effect in the smoking cessation program (Kim, 2007), it is assumed that the current smokers or smokers who want to quit smoking have come to have the expectations related to smoking cessation in the process of accessing and confirming the information about the electronic cigarettes through various channels.

As for the factor influencing the subjective level of oral health according to the oral health related characteristics, it turned out that the odds ratio of the subjective oral health group according to drinking was 1.382 times higher for the group drinking more than twice a week than the group drinking less than twice a week, and the more frequently cigarettes are used, the more they drink excessively every day (Kim & Kim, 2021; Kang et al., 2010; Kim et al., 2015), and the rate of lifetime experience of electronic cigarettes is higher when drinking more than twice a week (Park et al., 2019), and the higher the frequency of drinking, the higher the prevalence of oral diseases (An, 2009), and given the correlation with the number of missing teeth (Kim et al., 2002), which are evidenced by the results which claim that the better oral health with less drinking, the oral health is good (Won & Park, 2013), whereas, there are also conflicting findings that the more users of electronic cigarettes drink less than twice a week (Son et al., 2021), and there is no relationship between binge drinking (Roberts et al., 2018). However, there is generally a positive correlation between the amount of nicotine and the amount of drinking (Dunbar et al., 2017), and the higher the drinking frequency, the higher the rate of smoking (Song & Jung, 2018; Kang et al., 2019), it is a major risk factor for the oral cancer and it can adversely affect oral health, and the more often the electronic cigarettes are used, the more likely to be unhealthy behaviors (Kim & Hong, 2016), and it would be necessary to further confirm the relationship between drinking and oral health caused by the use of electronic cigarettes.

It turned out that the odds ratio of the group with good subjective oral health according to the practice of tooth brushing after lunch was lower for the non-practicing group than for the group who practiced tooth brushing after lunch. Compared to the non-smokers and quitters, the smokers have a lower level of care in terms of the frequency and timing of tooth brushing (Han, 2007), and the smokers have a poorer oral hygiene care skills than the non-smokers (Kim & Lee, 2017; Lee & Kim, 2011), and in light of which, it is considered that the electronic cigarette smokers of the tooth brushing group in this study considered highly of the subjective level of oral health by performing the oral health behavior of tooth brushing. However, direct smoking has an effect on the periodontal disease, and periodontal pocket depth, attachment loss, tooth mobility, and furcation lesions appear to increase significantly among the smokers (Kim & Lee, 2017; Kim et al., 2017; Gye & Han, 2001), which increased the outpatient dental care costs and acts as a major cause of tooth loss (Jeong et al., 2015). Whereas, the highest rate of smoking was found when the frequency of tooth brushing was 2 times a day (Song & Jung, 2018; Kim et al., 2017; Jung & Chun, 2013), and the rate of smoking by year increased when the frequency of tooth brushing was 3 times or more per day, and such results (Song & Jung, 2018) are considered to be the behaviors to remove bad breath remaining in the oral cavities after smoking, and the direct cognition and behaviors for oral health care after using the electronic cigarettes would need to be examined thoroughly

from more diverse angles.

This study confirmed that there was a relationship between the use of electronic cigarettes by age and the perception of subjective level of oral health, yet as a cross-sectional study with some limitations in reflecting a wide range of factors, the factor influencing the relationship between the use of electronic cigarettes and the perception of subjective level of oral health could not be fully verified. Furthermore, the subjective oral health conditions, which are a representative index for measuring the differences in health conditions, have limitations that include the possibility of personal bias due to the individual characteristics. Subsequently, in consideration of the controversy over the harmfulness of smoking and electronic cigarettes, an in-depth additional analysis study on the differences in the subjective oral health of electronic cigarette smokers is needed. Notwithstanding which, this study is a meaningful one which can confirm the concept of well-being in a health condition that encompasses not only the objective evaluation that smoking is a socially influencing factor on health, but also the perception of the subjective level of oral health, and as such, it may be used as the useful grounds and the basic data for the provision of the accurate information to change the correct perception and attitudes towards the electronic cigarettes to improve the level of oral health among the young and old people, and for the development of programs for the smoking cessation education.

## 5. Conclusion

For this study, the data from the 2020 Community Health Survey were used, and the relevant factors between the use of electronic cigarettes and the perception of subjective level of oral health among the young adults aged 19 years and older were age, level of education, drinking, and tooth brushing practice. It was apparent that the subjective level of oral health was good for the tooth brushing practicing group of electronic cigarette smokers.

The smokers who primarily use the electronic cigarettes by and among the young and old groups have generally positive thoughts about their oral health. There is an increasing number of people who desire to quit smoking or who are currently smoking to achieve a smoking cessation effect primarily by using electronic cigarettes. Most of the information is transmitted online, and hence, the ripple effect is traveling faster and influences many young people, and hence, it is necessary to examine the relevance of smoking caused by the use of electronic cigarettes to oral health from various angles.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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