A Clinic Based Survey Investigating Self-Reported Oral Health-Related Quality of Life, Number of Natural Teeth, and Oral Hygiene Habits Among Elderly Singaporeans

by

Yudong Qian

Duke Global Health Institute
Duke University

Date:__________________________

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Truls Ostbye, Supervisor

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Bei Wu (New York University)

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Dennis A. Clements

Thesis submitted in partial fulfillment of
the requirements for the degree of Master of Science
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ABSTRACT
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Abstract

Background: Global aging poses various challenges for both developing and developed countries. The proportion of older adults in developed countries is currently much higher than in developing countries. Health authorities are now confronting increasing public health problems, including a growing burden of oral diseases among older people. Although the percentage of older adults who have retained their natural teeth has increased steadily during the past decades, the number of natural teeth might still contribute vastly to older people’s quality of life. As little research has been conducted in the Southeast Asia area, this study aims to 1) investigate the association of number of natural teeth and oral pain with oral health-related quality of life; 2) discover ethnic disparities in regards to number of natural teeth and oral health-related quality of life; and 3) examine factors related to number of natural teeth retained among elderly Singaporeans.

Methods: The study was carried out in a dental clinic conducting a questionnaire survey on patients who visited the clinic. Geriatric Oral Health Assessment Index (GOHAI) was used and the GOHAI total score (ranged from 12 - 60) was measured to describe participants’ oral health-related quality of life from three perspectives: physical, social, and mental health components. Participants’ dental records were linked to the questionnaire survey and data on their dental parameters were also collected. Linear regression analysis was conducted as the main method towards all the three study aims, whereas logistic regression analysis was performed as supplementary evidence especially for Aim 1. Non-parametric statistical tests were also used in case of normality assumption requirements throughout the analytical process.

Results: The mean GOHAI total score of the study subjects was 47.72 (SD = 7.45). The mean number of natural teeth was 18.27 (SD = 8.15). A positive association between number of natural teeth and GOHAI total score was found by the linear regression analysis.
(Coefficient = 0.20, 95%CI: 0.17, 0.44) and a Spearman correlation test (rh0=0.22, P < 0.01). A negative association between oral pain and GOHAI total score was detected by the linear regression (Coefficient = -5.88, 95%CI: -7.86, -3.91) and a Spearman correlation test (rho = -0.40, p < 0.001) as well. In terms of factors associated with number of natural teeth, older people with more number natural teeth were found to be associated with younger age, higher educational level, and flossing at least once a day. Ethnic disparities were observed with Malays exhibited the lowest number of natural teeth and GOHAI total score, compared to Chinese and Indians.

**Conclusions:** The oral health-related quality of life of the investigated population was generally fair. Ethnic disparities existed in oral health-related quality of life and number of natural teeth among older adults in Singapore that Malays had adverse oral health status compared to Chinese and Indians. With more number of natural teeth retained and less oral pain, a person was more likely to have better oral health-related quality of life. Flossing at least once a day might contribute to the retention of more natural teeth.
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I would like to thank Dr. Bei Wu, my former supervisor and current co-chair of my defense committee. She is a former professor at Duke Global Health Institute and current Dean’s Professor in Global Health at New York University Rory Meyers College of Nursing. She and I together came up with the proposal of this project and she has provided numerous support and guidance all through the research and post-research analysis processes. I would also like to thank my supervisor, Dr. Truls Ostbye, and the other member of my committee, Dr. Dennis A. Clements. This thesis would not have been possible without their expertise, guidance, patience and support.

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1. Introduction

Singapore is facing with a dramatic increasing trend of aging population over the years. According to the report from National University of Singapore, the proportion of Singaporeans aged 65 and above has increased from 7.2% in 2000 to 9.3% in 2011, and by 2030, is estimated to reach 19% [1]. Coulmas defined in his book that a society with 14% or more of its population are 65 years old or older as “aged society” [2]. By this definition, Singapore is predicted to be an aged society in 2020 with the population keeping aging at a faster rate than the United Kingdom (UK) and the United States of America (USA) [3]. The aging trend has brought a variety of challenges to the elderly population and the health care system in terms of a significant rise in mortality, prevalence of chronic diseases and disability [4]. Among the challenges, oral diseases of older adults is particularly important because of sharing same common risk factors with other diseases and having a significant influence on the quality of life of older adults [5].

According to WHO, dental challenges imposed on older adults are reflected by evidently high levels of tooth loss, dental caries experience, and the prevalence rates of periodontal disease, xerostomia and oral precancer/cancer [6]. A review about the dental challenges on aging population indicates the “dental transition” occurring alongside the aging trend that the retention of at least part of the natural dentition is increasing in the elderly population in developed countries [7]. A report from the Center for Disease Control and Prevention (CDC) pointed out that even with more older adults retaining their natural teeth, however, they remain at risk for dental caries and periodontal diseases [8]. As a complicated biological phenomenon, aging may develop a large number of pathological and/or physiological changes that could influence oral health status and dental treatments, possibly causing tooth loss, periodontal disease, tooth decay and oral cancer [9]. Studies have shown
the impact of oral diseases on individuals, as a result of pain and suffering, impairment of physical and cognitive function, and reduced quality of life, is considerable [4, 5, 10]. The experience of pain, endurance of dental abscesses, problems with eating and chewing, embarrassment about the appearance of tooth or about missing, discolored or damaged tooth can compromise people’s daily lives and well-being [11].

WHO defines quality of life as ‘individuals’ perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns [12]. Quality of life has been widely recognized as a valid parameter of assessment in almost every area of a person’s physical and mental health care, including oral health. The process of ageing influences all dimensions of personal quality of life, and the influence of oral health on different dimensions of quality of life among the elderly has been examined by various studies: Luo et al (2015) found that having over 16 missing teeth was associated with severe cognitive impairment among Chinese older adults [13]; Albright et al (2013) discovered a significant association between poor oral health condition and type 2 diabetes and obesity among elderly population [14]. Sischo (2011) indicated that Oral health-related quality of life (OHRQoL) was an effective approach to investigate the individual’s oral health status, functional well-being, emotional well-being, expectations and satisfaction with care and self-cognition [15]. It is also recognized by the World Health Organization as an important segment of the Global Oral Health Program (2003) [16].

There are different views about the relationship between quality of life and oral health status. Paredes-Rodríguez (2016) found that quality of life is related to the level of xerostomia but not related to the number of retained natural teeth [9]. One the contrary, Jones et al (2003) discovered that the more natural teeth retained by adults, the higher they rate
their oral health-related quality of life [17]. Tooth loss has been proved to affect the chewing ability of older adults, limiting their food choices and frequency of eating fruits and vegetables, and furthermore influencing their quality of life and general well-being [18, 19]. The authors also believed that tooth loss was associated with avoidance of certain kinds of food. A review study examined 29 papers and concluded that a significant association between number of natural teeth and OHRQoL was shown in most studies with different cutoffs regarding the number and location of retained teeth that affect OHRQoL [20]. Friedman et al (2014) raised the issue that as many older adults keep working after the traditional retirement age, maintenance of healthy dentition is important to gainful employment, especially in jobs that require interaction with the public [21]. This indicates that poor oral health status such as having missing, broken, or decayed tooth may influence older adults’ quality of life in terms of appearance and self-esteem.

Being a possible indicator for older adults’ oral health-related quality of life, it is important to understand factors associated with tooth retention, especially non-biological conditions. Studies have found that among the elderly population, the low dentition group (subjects with less than 20 natural teeth or 8 functional teeth units) was associated with less frequent use of dental floss, more common smoking habits and poor self-evaluated dental health [22, 23]. Other factors such as increasing age, level of education, employment status, frequent brushing, and regular dental check-ups (instead of when in need or pain) were found to be associated with retaining natural teeth [24]. Research on behavioral factors could contribute to formulating guidelines for the public to achieve an overall acceptable oral healthiness. Morita et al (2006) discovered that frequency of eating snacks between meals, tooth brushing frequency, having one’s own toothbrush, smoking and drinking habits were associated with retaining natural teeth [25].
Except for number of natural teeth, dental status might also be associated with OHRQoL. A study conducted in community-dwelling elders in Korea found that OHRQoL was significantly correlated with the number of chronic disease and dry mouth [26]. Another study investigated the impact of oral health status on OHRQoL in older residents of nursing homes. Sensitive teeth, toothache, bleeding gums, dry mouth and loose natural teeth among the dentate and loose or ill-fitting dentures among the edentate were strongly associated with higher prevalence of oral impacts [27]. Among these factors, oral pain can dramatically affect older people’s OHRQoL by restricting their daily activities and food choices, and compromising sleeping qualities.

Although there have been a variety of research investigating OHRQoL among the elderly population worldwide, few studies have looked at the OHRQoL in Southeast Asia where there is a significant oral health diversity among different ethnic groups. To fill in the gap and improve our understanding of oral health across ethnic groups, this study was designed to examine the potential association of number of natural teeth and oral pain with self-evaluated OHRQoL, the factors associated with number of natural teeth retained among the older population in Singapore.
2. Methods

2.1 Setting

The study was conducted during an 8-week period between May and July 2016 at the National Dental Centre of Singapore (NDCS). NDCS is the largest dental specialty centre in Singapore that attends to over 700 patients daily, including walk-in patients, appointed patients and those being referred to the centre. Most patients who come to this clinic are Singaporean citizens. Not only serving as a dental clinic, NDCS also undertakes a variety of clinical and translational research projects including animal studies, laboratory-based projects, clinical studies and trials. At the time of the study, NDCS operated three clinical departments, including Oral and Maxillofacial Surgery, Orthodontics, and Restorative Dentistry.

2.2 Participants

The study subjects were selected from patients who had appointments to NDCS. The inclusion criteria were patients over 65 years old, able to read the English questionnaire or understand the questions with reading assistance, and with provision of a signed informed consent before enrollment in the study, regardless of their reasons for the visit. The exclusion criteria were patients who were unable to complete the informed consent.

2.3 Procedures

The potential participants were pre-identified from the patient list who had appointments. During the period that a patient was waiting to be called, the study coordinator, namely myself, would approach the patient to introduce the study aims and obtain the informed consent. Upon consent, participants were requested to complete the questionnaire. If the participant could understand English but could not read in English, the questions were read to him/her by the study coordinator and the responses were recorded. After the
completion of the questionnaire, a participant’s clinical records would be retrieved from the electronic patient record system and the information of interest were extracted and recorded.

2.4 Measures

The study took a cross-sectional design to investigate the self-reported oral health-related quality of life of patients by a pre-generated survey questionnaire. The survey questionnaire included 53 questions which measured patients’ demographic information, oral hygiene care, oral health self-evaluation, dietary intake and Geriatric Oral Health Assessment Index (GOHAI) (see details in Appendix A). GOHAI was first developed by Atchison and Dolan (1990) as a self-reported measure to assess the oral health problems of older adults. It has then been applied and validated in various studies as an indicator for OHRQoL [28]. A pilot test to examine the feasibility of the questionnaire was conducted in the first few days of the study. Changes of the questionnaire after the pilot test were notified to the Duke IRB and NCDS IRB. The oral health status of the participants was measured by several variables such as number of natural teeth, dmft (decayed, missing and filled tooth), denture, and implant restoration which were extracted from their electronic dental records after participants completed the survey.

2.5 Analysis

Data from the survey questionnaire were recorded in the Redcap database. The clinical records data were entered into an Excel spreadsheet. The two sets of data were then synthesized into and analyzed by Stata statistical software (version 14.1). Descriptive statistics were used to describe the demographic and other characteristics of the sample. Non-parametric statistical tests were conducted comparing participants’ GOHAI scores and oral health status across different demographic and socio-economic variables. For continuous outcomes, the Wilcoxon Rank Sum test and Kruskal–Wallis test were used to compare the
means. For categorical outcomes, the Fisher’s exact test was used to compare proportions.

To examine the association of number of natural teeth and oral pain with self-reported OHRQoL, GOHAI total score (range from 12 to 60) served as the dependent variable and linear regression models were used to provide a general understanding of the variability of OHRQoL explained by number of natural teeth, oral pain, demographic variables, oral hygiene habits, and dietary behaviors. Logistic regression models were then used because the outcome variable was not normally distributed. According to Atchison and Dolan (1990), a GOHAI total score of 57-60 was considered as a high score, 51-56 a moderate score, and less than or equal to 50 was a low score. We thus divided our study’s GOHAI total score into two categories: 51-60 as relatively high (good, coded as “1”) and 12-50 as relative low (poor, coded as “0”). The covariates remained the same as in the linear regression models. Odds ratios were used in the logistic regression analysis to indicate the log change of the response variable, namely GOHAI total score.

To detect factors correlated with number of natural teeth, the number of natural teeth was taken as the dependent variable. Oral pain, oral hygiene variables, dietary behavior variables, demographic and socio-economic variables were used as independent variables, and linear regression models were performed.

Ethnicity was adjusted in all the regression models as an independent socio-economic variable to examine the existence of ethnic disparity. Spearman’s rank correlation test was also performed to provide additional statistical evidence for the potential associations. A conceptual analytical framework was shown in the following:
Demographic and social-economic variables
- Age
- Gender
- Education
- Health insurance
- Ethnicity

Oral hygiene behavior
- Brushing frequency
- Flossing frequency

Dietary behaviors
- Tea drinking
- Smoking
- Alcohol consumption

Oral pain

Aim 1 & 2
Linear and Logistic regression
OHRQoL

Aim 1 & 2
Linear regression
Number of natural teeth
3. Results

3.1 Description of sample

There were 262 older adults participating in the study in the one-month recruitment period. The returning percentage of questionnaires was 100% because it was an immediate survey process under supervision of the study coordinator. Among the 262 participants, 22 of them were recruited in the pilot test stage and excluded in the final data analysis. The exclusion of this subsample of participants is not likely to have a significant influence on the results since the sampling process was randomized among patients who attended the clinic.

Of the 240 participants included in the data analysis, the average age was 72.4 years (SD = 5.8). There were mainly three ethnic groups: Chinese, Indians and Malays. Beyond age and ethnicity, other demographic characteristics collected were gender and education level. Monthly income and health insurance information were collected as socio-economic status indicators.

The Geriatric Oral Health Assessment Index (GOHAI) contains 12 items demonstrating three factors: a physical health component (trouble biting and chewing, discomfort eating and swallowing, limitations in food choices, and sensitivity to temperature); a social oral health component (limitations and discomfort with social contacts and appearance and speaking problems); and a mental oral health component (worry, self-consciousness and use of pain medication) [29]. Item 4 and item 10 were designed in opposite to other items so that a higher score indicated an oral health problem to encourage active response. Thus, the total GOHAI score was calculated by summarizing each score of the 12 items after adjustment, with a higher number indicating better self-reported oral health-related quality of life.
Table 1 (below) summarizes the demographic and other characteristics of the participants by different ethnic groups.

**Table 1: Sample description**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Overall (n=240)</th>
<th>Chinese (n=197)</th>
<th>Indians (n=23)</th>
<th>Malays (n=7)</th>
<th>Others (n=13)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>72.4 (5.8)</td>
<td>72.4 (5.8)</td>
<td>71.7 (5.6)</td>
<td>71.4 (5.8)</td>
<td>74.2 (6.3)</td>
<td></td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.36</td>
</tr>
<tr>
<td>Female</td>
<td>99 (41.2)</td>
<td>84 (42.6)</td>
<td>6 (26.1)</td>
<td>4 (57.1)</td>
<td>5 (38.5)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>141 (58.8)</td>
<td>113 (57.4)</td>
<td>17 (23.9)</td>
<td>3 (42.9)</td>
<td>8 (61.5)</td>
<td></td>
</tr>
<tr>
<td>Education, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td>Primary education or less</td>
<td>30 (12.7)</td>
<td>24 (12.3)</td>
<td>3 (13.6)</td>
<td>1 (14.3)</td>
<td>2 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Secondary education</td>
<td>100 (42.2)</td>
<td>86 (44.1)</td>
<td>8 (36.4)</td>
<td>4 (57.1)</td>
<td>2 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Post-secondary education</td>
<td>107 (45.1)</td>
<td>85 (43.6)</td>
<td>11 (50)</td>
<td>2 (28.6)</td>
<td>9 (69.2)</td>
<td></td>
</tr>
<tr>
<td>Monthly income (SDG), n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>&lt;3000</td>
<td>186 (78.5)</td>
<td>157 (80.5)</td>
<td>17 (73.9)</td>
<td>6 (100)</td>
<td>6 (46.1)</td>
<td></td>
</tr>
<tr>
<td>3000-6000</td>
<td>26 (11)</td>
<td>19 (9.7)</td>
<td>4 (17.4)</td>
<td>0</td>
<td>3 (23.1)</td>
<td></td>
</tr>
<tr>
<td>&gt;6000</td>
<td>25 (10.5)</td>
<td>19 (9.7)</td>
<td>2 (8.7)</td>
<td>0</td>
<td>4 (30.8)</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>No insurance</td>
<td>8 (3.3)</td>
<td>4 (2.0)</td>
<td>1 (4.4)</td>
<td>1 (14.3)</td>
<td>2 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Private insurance</td>
<td>54 (22.5)</td>
<td>47 (23.9)</td>
<td>4 (17.4)</td>
<td>0</td>
<td>3 (23.1)</td>
<td></td>
</tr>
<tr>
<td>Governmental insurance only</td>
<td>178 (74.2)</td>
<td>146 (74.1)</td>
<td>18 (78.3)</td>
<td>6 (85.7)</td>
<td>8 (61.5)</td>
<td></td>
</tr>
<tr>
<td>GOHAI total score</td>
<td>47.7 (7.4)</td>
<td>48.1 (7.1)</td>
<td>46.9 (8.4)</td>
<td>36 (5.0)</td>
<td>49.9 (6.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Number of natural teeth</td>
<td>18.3 (8.1)</td>
<td>18.3 (7.8)</td>
<td>19.7 (9.8)</td>
<td>10.6 (8.7)</td>
<td>19.7 (8.6)</td>
<td>0.06</td>
</tr>
<tr>
<td>Oral pain, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>140 (59.6)</td>
<td>117 (60.9)</td>
<td>9 (39.1)</td>
<td>3 (42.9)</td>
<td>11 (84.6)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>95 (40.4)</td>
<td>75 (39.1)</td>
<td>14 (60.9)</td>
<td>4 (57.1)</td>
<td>2 (15.4)</td>
<td></td>
</tr>
<tr>
<td>Brushing frequency, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Twice a day or more</td>
<td>198 (84.3)</td>
<td>170 (87.6)</td>
<td>15 (65.2)</td>
<td>4 (66.7)</td>
<td>9 (75)</td>
<td></td>
</tr>
<tr>
<td>Less than twice a day</td>
<td>37 (15.7)</td>
<td>24 (12.4)</td>
<td>8 (34.8)</td>
<td>2 (33.3)</td>
<td>3 (25)</td>
<td></td>
</tr>
<tr>
<td>Flossing frequency, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Once a day or more</td>
<td>131 (58.5)</td>
<td>110 (59.5)</td>
<td>10 (47.6)</td>
<td>4 (66.7)</td>
<td>7 (58.3)</td>
<td></td>
</tr>
<tr>
<td>Less than once a day</td>
<td>93 (41.5)</td>
<td>75 (40.5)</td>
<td>11 (52.4)</td>
<td>2 (33.3)</td>
<td>5 (41.7)</td>
<td>0.76</td>
</tr>
<tr>
<td>Tea drinking, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost every day</td>
<td>82 (38.3)</td>
<td>61 (35.1)</td>
<td>11 (52.4)</td>
<td>4 (57.1)</td>
<td>6 (50)</td>
<td>0.11</td>
</tr>
<tr>
<td>Several times a week</td>
<td>42 (19.6)</td>
<td>35 (20.1)</td>
<td>2 (9.5)</td>
<td>3 (42.9)</td>
<td>2 (16.7)</td>
<td></td>
</tr>
<tr>
<td>Less than once a week</td>
<td>90 (40.1)</td>
<td>78 (44.8)</td>
<td>8 (38.1)</td>
<td>0</td>
<td>4 (33.3)</td>
<td></td>
</tr>
<tr>
<td>Smoking history, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>179 (82.1)</td>
<td>152 (85.4)</td>
<td>17 (81.0)</td>
<td>5 (71.4)</td>
<td>5 (41.7)</td>
<td>0.003</td>
</tr>
<tr>
<td>Yes</td>
<td>39 (17.9)</td>
<td>26 (14.6)</td>
<td>4 (19.0)</td>
<td>2 (18.6)</td>
<td>7 (58.3)</td>
<td></td>
</tr>
<tr>
<td>Alcohol history, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>129 (59.7)</td>
<td>106 (60.2)</td>
<td>14 (66.7)</td>
<td>6 (85.7)</td>
<td>3 (25)</td>
<td>0.04</td>
</tr>
<tr>
<td>Yes</td>
<td>87 (40.3)</td>
<td>70 (39.8)</td>
<td>7 (33.3)</td>
<td>1 (14.3)</td>
<td>7 (75)</td>
<td></td>
</tr>
</tbody>
</table>
3.2 Associate of number of natural teeth and oral pain with GOHAI total score

Following the traditional analysis, GOHAI total score was treated as a continuous variable. The mean value of GOHAI total score was 47.72 (SD = 7.45). The multiple linear regression model (Table 2) showed that increasing number of natural teeth and the absence of oral pain was significantly correlated with higher GOHAI total score (P<0.001). With demographic and socio-economic variables added into Model 2 and oral hygiene variables and dietary variables added into Model 3, the coefficients of number of natural teeth and oral pain for the association were slightly changed but it was still significant on the 1% scale. Overall, Model 3 had the highest adjusted R-squared value, which meant the covariates in Model 3 could best explain the variability of GOHAI total score. The income variable was not included in the regression due to the poor data quality that could not reflect the actual socio-economic status of the studied population.

It could be seen from the results that with per unit increase of number of natural teeth, there would be a 0.30 (95%CI: 0.17, 0.44) unit increase of GOHAI total score in the studied population, holding all other predictors constant. Compared to participants who have reported no oral pain, the GOHAI total score of those who have reported oral pain was 5.88 (95%CI: 3.91, 7.86) units lower, holding all other predictors constant. Among the ethnic groups, the Malay group was significantly associated with lower GOHAI total score compared to the other groups. Taking the Malay group as reference, the Chinese group’s GOHAI total score was 10.97 (95%CI: 5.49, 16.46) units higher, the Indian group’s GOHAI total score was 9.79 (95%CI: 3.60, 15.97) units higher, holding all other predictors constant. Age, gender, education level, health insurance, flossing frequency and dietary behaviors did not seem to be significant predictors for GOHAI total score. Brushing frequency was also shown to be significantly associated with GOHAI total score. Compared to participants who brushed teeth
less than twice a day, the GOHAI total score of those who brushed teeth at least twice a day was 2.79 (95%CI: 0.04, 5.54) units higher.

**Table 2: Association of number of natural teeth and oral pain with GOHAI total score (Multiple linear regression)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta (t)</td>
<td>Beta (t)</td>
<td>Beta (t)</td>
</tr>
<tr>
<td>Number of natural teeth</td>
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<td>0.21 (3.74)***</td>
<td>0.30 (4.47)***</td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (Ref)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
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<td>-5.74 (-6.72)***</td>
<td>-5.88 (-5.89)***</td>
</tr>
<tr>
<td>Age</td>
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<td></td>
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<td>2.79 (2.00)*</td>
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<td>Flossing frequency</td>
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</tr>
<tr>
<td>Tea drinking</td>
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<tr>
<td>Less than once a week</td>
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</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.21</td>
<td>0.24</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*p < 0.05, **p < 0.01, ***p < 0.001
However, in contrast to the assumption of linear regression that the dependent variable should be normally distributed, normality test showed that GOHAI total score was in fact not normally distributed, meaning that linear regression model was not statistically appropriate in this case. Thus, GOHAI total score was dichotomized as a binary variable (good GOHAI = 1 and poor GOHAI = 0) and logistic regression was used, adjusting for all the predictors that were used in Model 3 from the linear regression.

Results from logistic regression models were consistent: the odds ratio of GOHAI status for number of natural teeth was 1.06 (95% CI: 1.01, 1.12) (P < 0.05). It meant that for a one-unit increase in number of natural teeth, we would expect a 1.06 units increase in the odds of GOHAI status, holding all other predictors constant. The Spearman’s rank correlation coefficient was 0.22 (p < 0.001), indicating that we have sufficient evidence to reject the null hypothesis that there was no correlation between number of natural teeth and GOHAI total score on the 1% scale.

The odds ratio of GOHAI status for oral pain was 0.11 (95%CI: 0.05, 0.26) (p < 0.001), meaning that the odds ratio of GOHAI status for a participant with oral pain over a participant without oral pain was 0.11, holding all other predictors constant. The Spearman’s rank correlation coefficient was -0.40 (p < 0.001), indicating that we have sufficient evidence to reject the null hypothesis that there was no correlation between oral pain and GOHAI total score on the 1% scale. Kruskal Wallis test showed that there was a statistically significant difference between GOHAI total scores across different ethnic groups, $\chi^2(2) = 14.602$, p = 0.0022. Age, gender, education level, health insurance, oral hygiene and dietary variables did not seem to be correlated with GOHAI total score in the logistic regression model.
3.3 Factors associated with the number of natural teeth

The mean number of natural teeth of the study population was 18.27 (SD = 8.15). Linear regression models were used to examine the relationship of oral pain, demographic and socio-economic variables, oral habit variables, and dietary intake variables with number of natural teeth. Participants without any natural teeth retained were excluded from the models because they could not brush or floss. Among the three models shown in Table 3, Model 2 measured oral pain, demographic and socio-economic variables, oral hygiene variables and demonstrated the highest adjust R-squared value. The results from Model 2 suggest that age, ethnicity, and flossing frequency were significantly correlated with number of natural teeth. Specifically, for a one-unit increase of age, the expected value of number of natural teeth would decrease 0.20 (95%CI: 0.05, 0.36). In addition, compared with participants who flossed less than once a day, the expected value of number of natural teeth of those who flossed at least once a day was 4.16 (95%CI: 2.31, 6.01) units higher, holding all other variables constant. Also, compared with participants who had only governmental issued health insurance, those who had no health insurance were expected to have 7.03 (95%CI: 1.92, 12.14) units lower number of natural teeth.

Because the number of natural teeth variable was either not perfectly normally-distributed, non-regression statistical tests were performed to verify results from the linear regression model. For the association between age and number of natural teeth, the Spearman’s rank correlation coefficient was -0.15 (P < 0.05), which means we have sufficient evidence to reject the null hypothesis that there was no correlation between age and number of natural teeth among the study subjects on the 5% scale. A Wilcoxon rank-sum test indicated that number of natural teeth of the group that flossed at least once a day ranked significantly higher than the group that flossed less than once a day, Z = -5.06, p < 0.001. A
Kruskal Wallis test discovered that there was a statistically significant difference of number of natural teeth across different types of health insurance, $\chi^2(2) = 7.788$, $p = 0.02$. Another Kruskal Wallis test indicated that there was not a statistically significant difference of natural teeth across different ethnic groups, $\chi^2(2) = 7.549$, $p = 0.0563$.

Table 3: Factors associated with number of natural teeth (multiple linear regression) 
(Respondents with at least one natural tooth)

<table>
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<th>Factor</th>
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<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
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<td>Beta (t)</td>
<td>Beta (t)</td>
<td>Beta (t)</td>
</tr>
<tr>
<td>Oral pain</td>
<td></td>
<td></td>
<td></td>
</tr>
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<tr>
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<td>-0.21 (-2.42)*</td>
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<td>Primary education or less (Ref)</td>
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<td>2.58 (1.61)</td>
<td>2.97 (1.69)</td>
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<td>Chinese (Ref)</td>
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<tr>
<td>Indian</td>
<td>1.98 (1.25)</td>
<td>2.68 (1.64)</td>
<td>2.05 (1.16)</td>
</tr>
<tr>
<td>Malay</td>
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<td>-3.24 (-1.08)</td>
</tr>
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<td>Other</td>
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<td>4.04 (2.04)*</td>
<td>4.42 (2.06)*</td>
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<td>-7.03 (-2.72)**</td>
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<td>-0.72 (-0.52)</td>
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<tr>
<td>Once a day or more</td>
<td>4.16 (4.43)**</td>
<td>3.56 (3.54)**</td>
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<td>Tea drinking</td>
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<td>Almost every day (Ref)</td>
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<td>Several times a week</td>
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<td>Less than once a week</td>
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<td>-0.96 (-0.66)</td>
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*p < 0.05, **p < 0.01, ***p < 0.001
4. Discussion

4.1 Determinants of oral health-related quality of life among older adults

Assessed by GOHAI total score, the study found that the elderly people’s OHRQoL was fair. Although linear regression was not perfectly applicable in the analysis process, previous studies treated GOHAI total score as a normal-distributed variable and thus following this practice would help the comparison with other studies. Results from the analysis suggest that more number of natural teeth retained and the absence of oral pain were significantly associated with better OHRQoL among older adults. The association between a high prevalence of natural tooth loss and poor OHRQoL of older individuals has been demonstrated in other studies as well [18, 30]. A possible explanation for this would be that number of natural teeth could cause the decrease of chewing ability, which turns to be significantly affecting the OHRQoL of older adults [31]. Some scholars are interested in the potential confounding effect of age on the association between number of natural teeth and OHRQoL. Jain et al stated that age and number of natural teeth are associated with each other, but they have independent effects on OHRQoL [32]. In this study, however, age seems to be not associated with OHRQoL, which might be caused by the sampling bias that the enrolled participants inherently have poorer OHRQoL. Therefore, age is unlikely to be a confounder for the association.

Oral pain reveals a high prevalence (40.4%) among the studied population. Pain from oral diseases can restrict normal activities and daily life, it is also a sign of advanced problems with teeth or gums that require a visit to a dentist or other oral health professionals. Both general and oral health-related quality of life can be greatly affected by oral pain, suggesting that oral care should be included in general care and older adults should be aware of the consequences of oral pain [33]. However, the GOHAI measurement includes questions
related to oral pain, such as “How often did you use medication to relieve pain or discomfort from around your mouth”, which might be the reason why oral pain exhibited a significant correlation with OHRQoL.

4.2 Ethnic disparities of oral health-related quality of life

Linear regression analysis showed that the Malay group in the study sample has significantly lower OHRQoL compared to Chinese and Indian groups. Although there is an obvious limitation of this result that the sample size of Malays is too small to be included in a regression model, Table 1 showed this ethnic disparity in terms of GOHAL total score despite the similar oral hygiene habits across different ethnic groups. In addition, the non-parametric test (Kruskal Wallis test) provided evidence for this ethnic disparity of ORHQoL.

A possible reason for the poor OHRQoL status of the Malay group could be their poor oral hygiene and dietary behaviours [34]. A national adult survey in 2000 pointed out that oral hygiene instructions are required for the Malays such as the promotion of brushing teeth at least twice a day, and the consumption of sugar is high [35]. Another reason might be that elder Malays have less awareness of the importance of oral health compared to the other ethnic groups. Although not shown in this study, the relatively low socio-economic status of Malay elderly population might also contribute to this ethnic disparity. Reflected by the small sample size of the Malay group, there might be some economic barriers preventing them visiting this dental clinic. In general, very limited research has been conducted among this ethnic group and future research is warranted to examine factors related to their oral health status.

4.3 Factors correlated with number of natural teeth of older adults

Previous studies investigating the elderly population in the Southeast Asia area found that the low dentition group was more likely to be older and to exhibit low educational level
and less frequent use of dental floss [22, 36, 37]. Results from this study suggest that less number of natural teeth was associated with increasing age and less frequent use of dental floss. The non-parametric test (Kruskal Wallis test) showed that there was a significant difference in the distribution of number of natural teeth across different educational levels, implying that older adults with higher educational levels might have more number of natural teeth.

Smoking and alcohol consumption were found to be significantly correlated with tooth loss among older adults in previous studies [38, 39]. However, no such relationships were demonstrated in this study, which might be caused by measurement errors of these variables. There was no significant correlation between the frequency of tea drinking and number of natural teeth as shown in this study, conforming with a previous study conducted among Chinese older adults [40]. It was a limitation of this study that it did not measure coffee consumption frequency, which was in fact a common dietary habit of the studied population and might have an indication on number of natural teeth.

4.4 Implications for policy and practice

Given the global aging trend that the proportion of people aged 65 years and above will increase dramatically in the future, a significant challenge has been brought in front of health authorities by chronic diseases developed along the aging process due to a cumulative effect of life-long exposure to risk factors, including oral diseases. Poor oral health can cause negative impacts on daily life by reducing chewing performance, constrained food choice, weight loss, impaired communication, low self-esteem and well-being [41].

For policy makers, it is important to give higher priority to care for the elderly population and to be sufficiently aware of the need for regular dental care. Based on the research findings in this study, tooth loss and oral pain seem to be remarkable predictors for
oral health related quality of life among older adults, while frequent flossing appearing to be significantly associated with more number of natural teeth. Policy makers and health authorities should take action to strengthen preventative care and research in public health interventions that will improve oral health attitudes and healthy lifestyles among older people. Health providers should pay more attention to the elderly patients’ oral pain during the diagnosis and treatment process. Healthy oral hygiene habits such as brushing teeth at least twice a day and flossing at least once a day also need to be promoted among older adults.

As the covariates included in the regression model to predict GOHAI total score can only explain 25% of the variability, there might be other variables that are strongly correlated with OHRQoL, which could be discovered by further qualitative research. Differences in number of natural teeth across ethnic groups reflect unmet dental needs among persons with low education and the Malay population. Further research needs to be carried out to identify the extent of ethnic disparities in relation to oral diseases and dietary habits.

4.5 Study strengths and limitations

One of the study’s main strengths is that it is the first study to assess oral health-related quality of life among older adults in Singapore, taking a relatively innovative approach specifically designed to assess the elderly population. In addition, The GOHAI instrument is a reliable measurement that evaluates various dimensions of oral health-related quality of life.

On the other hand, the findings in the study are subject to at least four limitations. First, the sample was selected from a dental clinic that might not be representative of the general elderly population of Singapore. The participants were likely to have more oral health problems than the average population since most of them came to the clinic for dental treatment. Also, patients who come to this dental clinic might have different socio-economic
and demographic characteristics compared to people who prefer other dental clinics. Second, there were too few people in the Malay group, causing difficulty and inaccuracy in statistical analysis and inference. Third, some of the instruments were not designed properly to measure the variables of interest. For example, the income variable could not reflect the socio-economic status of the participants because many of the older adults were retired and did not have any income, whereas spending on housing might be a better parameter. The last limitation was the limited capacity of collecting clinical data on dental indicators, such as xerostomia, number of decayed and filled teeth, and bleeding index.
5. Conclusion

The study is the first one to measure the oral health-related quality of life of older adults in Singapore. The findings of this study highlight the association of number of natural teeth and oral pain with OHRQoL, indicating the importance of retaining more natural teeth and reducing the experience of oral pain among older adults. Ethnic disparities in OHRQoL was detected but needed further research to find out the underlying reasons. In particular, the Malay group has the worst OHRQoL compared to the other groups. It is also noteworthy that flossing at least once a day is found to be a significant predictor of more number of natural teeth among the older people, which provides implications on oral health intervention studies and policy development.
Appendix A

GOHAI (#1-12)

1. How often did you limit the kinds or amounts of food you eat because of problems with your teeth or dentures?

   Always .................................................. 1
   Often...................................................... 2
   Sometimes ............................................. 3
   Seldom.................................................... 4
   Never..................................................... 5
   Don’t know.............................................. 98
   Refused.................................................. 99

2. How often did you have trouble biting or chewing any kinds of food, such as firm meat or apples?

   Always .................................................. 1
   Often...................................................... 2
   Sometimes ............................................. 3
   Seldom.................................................... 4
   Never..................................................... 5
   Don’t know.............................................. 98
   Refused.................................................. 99

3. How often did you have trouble swallowing?

   Always .................................................. 1
   Often...................................................... 2
   Sometimes ............................................. 3
   Seldom.................................................... 4
   Never..................................................... 5
   Don’t know.............................................. 98
   Refused.................................................. 99

4. How often were you able to eat anything without discomfort?

   Always .................................................. 1
   Often...................................................... 2
   Sometimes ............................................. 3
   Seldom.................................................... 4
   Never..................................................... 5
   Don’t know.............................................. 98
   Refused.................................................. 99

5. How often did you use medication to relieve pain or discomfort from around your mouth?

   Always .................................................. 1
   Often...................................................... 2
   Sometimes ............................................. 3
   Seldom.................................................... 4
   Never..................................................... 5
   Don’t know.............................................. 98
   Refused.................................................. 99

6. How often did you worry about the problems with your teeth, gums, or dentures?

   Always .................................................. 1
   Often...................................................... 2
7. How often were your teeth or gums sensitive to hot, cold, or sweets?
   Always ........................................... 1
   Often ............................................ 2
   Sometimes ...................................... 3
   Seldom .......................................... 4
   Never ............................................ 5
   Don’t know .................................. 98
   Refused ....................................... 99

8. How often did your teeth or dentures cause problems with your speech?
   Always ........................................... 1
   Often ............................................ 2
   Sometimes ...................................... 3
   Seldom .......................................... 4
   Never ............................................ 5
   Don’t know .................................. 98
   Refused ....................................... 99

9. How often did you avoid seeing people because of the condition of your teeth or dentures?
   Always ........................................... 1
   Often ............................................ 2
   Sometimes ...................................... 3
   Seldom .......................................... 4
   Never ............................................ 5
   Don’t know .................................. 98
   Refused ....................................... 99

10. How often were you pleased or happy with the way your teeth look?
    Always ......................................... 1
    Often .......................................... 2
    Sometimes ..................................... 3
    Seldom ......................................... 4
    Never .......................................... 5
    Don’t know .................................. 98
    Refused ....................................... 99

11. How often did you feel nervous or self-conscious because of problems with your teeth, gums, or dentures?
    Always ......................................... 1
    Often .......................................... 2
    Sometimes ..................................... 3
    Seldom ......................................... 4
    Never .......................................... 5
    Don’t know .................................. 98
    Refused ....................................... 99

12. How often did you feel uncomfortable eating in front of people because of problems with your teeth or
dentures?
Always ..........................................................1
Often...........................................................2
Sometimes.....................................................3
Seldom..........................................................4
Never...........................................................5
Don’t know.....................................................98
Refused........................................................99
References


