

Development and Validation of “OHL-Ortho” Measurement Tool and Causal Model of Oral Health Behavior among Adult Orthodontic Patients

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Abstract

Aim: Oral health literacy (OHL) significantly influences oral health behavior (OHB) and plays a crucial role in effective oral health promotion and achieving improved outcomes. This research aims to develop a measurement tool for evaluating OHL, named “OHL-Ortho,” and OHB in orthodontic patients. Furthermore, the study explores the extended causal relationship model from OHL to OHB. **Materials and Methods:** A cross-sectional exploratory study was conducted between February and June 2023 among Thai working-age adults undergoing fixed orthodontic appliances. Participants were randomly selected and stratified from diverse healthcare facilities. OHL and OHB questionnaires were developed and subjected to confirmatory factor analysis (CFA). Descriptive statistics and structural equation modeling were utilized to analyze data and evaluate the causal relationship between OHL and OHB. **Results:** The sample consisted of 321 participants, with an average age of 28.44 ± 7.56 years. Regarding construct validity, the 31-item OHL Scale achieved an overall Cronbach α of 0.97, with factor loadings ranging from 0.52 to 0.85. Similarly, the 14-item OHB Scale achieved an overall Cronbach α of 0.89, displaying factor loadings ranging from 0.42 to 0.64. Additionally, the causal relationship model of OHB aligned with empirical data, indicating that OHL exhibited a highly significant positive direct effect on OHB at a level of 0.01 (effect size = 0.81), explaining 66.00% of the variance in OHB. **Conclusion:** The developed scales serve as high-quality assessment tools for healthcare providers. The study underscores the significant impact of OHL on OHB among orthodontic patients.

Keywords: Health Literacy, Oral Health, Oral Health Behavior, Oral Health Literacy, Oral Hygiene Practice, Orthodontics

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INTRODUCTION

Orthodontic treatment is essential for correcting dental misalignments and achieving both an aesthetically pleasing and healthy smile.^[1] However, orthodontic patients encounter challenges in maintaining optimal oral hygiene due to the presence of braces, wires, and other orthodontic appliances.^[2] These factors create an environment conducive to bacterial growth, increasing the risk of periodontal disease among orthodontic patients.^[3] Studies have reported a high prevalence of chronic gingivitis and periodontitis among individuals undergoing orthodontic treatment.^[4-6]

To address the risks associated with periodontal disease during orthodontic treatment, it is essential to promote

good oral health behavior (OHB). OHB encompasses personal or lifestyle actions that individuals can modify independently to enhance their health and prevent illness.^[7] Orthodontic patients must adhere to a diligent oral hygiene routine, including proper brushing techniques to clean around brackets and wires effectively. Additionally, the use of interdental brushes, superfloss, or proxabrushes can aid in removing plaque and debris from hard-to-reach areas. Emphasizing the importance of regular dental

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checkups and professional cleanings can further prevent the progression of oral diseases, ensuring optimal oral health outcomes for orthodontic patients.^[8]

Oral health literacy (OHL) plays a pivotal role in influencing OHB. Derived from the concept of Health Literacy (HL), OHL refers to the capacity to obtain, process, and comprehend basic oral health information and services needed to make informed health decisions and act on them.^[9] In Thailand, HL is a prioritized concept highlighted within the country's 20-year National Strategic Plan for Public Health. OHL has been applied in various public health areas, including oral health, and is associated with improved preventive behaviors such as regular brushing, flossing, and dental checkups.^[10-13] Conversely, low OHL is linked to a higher risk of dental issues and inadequate OHBs.^[14]

While previous studies have explored the relationship between OHL and periodontal disease, these studies primarily focused on functional literacy, relying on tools like the Rapid Estimate of Adult Literacy in Dentistry-30 (REALD-30) and Test of Functional Health Literacy in Dentistry (ToFHLiD), which mainly assess word recognition.^[15-19] However, the OHB of orthodontic patients is more complex than that of the general population, necessitating a specialized questionnaire. Although a previous study constructed an OHL tool for orthodontic patients (Ortho-30),^[20] it only covered word recognition, a component of functional literacy. To the best of our knowledge, there is no OHL tool that comprehensively assesses OHL in orthodontic patients, considering cognitive and social skills and covering all functional, interactive, and critical literacy levels. Furthermore, there are currently no OHL screening tools available for orthodontic patients from healthcare units and the Thailand Bureau of Dental Health.

Therefore, the objective of this research is to develop a specialized measurement tool for evaluating OHL, known as “OHL-Ortho,” and OHB in adult orthodontic patients undergoing fixed orthodontic appliance treatment. Additionally, this research explores a causal relationship model extending from OHL to OHB. The research hypothesis proposes that both the measurement tools are developed and proven to be of high quality, and the causal relationship model consistently aligns with empirical data.

MATERIALS AND METHODS

Setting and design

This cross-sectional exploratory study was conducted between February and June 2023. The population and sample group consisted of Thai working-age adults undergoing orthodontic treatment in Nakhon Nayok province, known for its high prevalence of periodontal disease and low OHB based on the 8th National Oral Health Survey Report in Thailand, 2017.^[21]

Ethical approval

The present study received ethical approval for research involving human subjects from Srinakharinwirot University (SWUEC-G-005/2566). All the procedures have been performed as per the ethical guidelines laid down by the Declaration of Helsinki (2013).^[22] Prior to data collection, the researchers asked for informed consent from the participants and provided detailed information about the study, including the participant selection process. Confidentiality was ensured by excluding names and sources of data, and the researchers explained the potential impact of each research step to protect participants from harm.

Sampling criteria

The sample size was determined following Schumacker and Lomax's (1996) recommendation, ensuring a 20:1 participant-to-observed variable ratio for robust data analysis.^[23] With eight observed variables, a minimum of 160 participants was considered appropriate. Additionally, factor analysis called for at least 300 participants, as suggested by Yong and Pearce (2013).^[24] Hence, the research employed stratified sampling, randomly selecting 300 participants from different healthcare facilities, with 100 participants in each group. The sample size was increased by 10% to prevent data loss, resulting in a total of 330 samples. Of these, 321 complete questionnaires were returned, representing 97.27%.

The study's inclusion criteria were as follows: 1) aged between 20 and 44 years, 2) undergoing fixed orthodontic appliance, 3) absence of non-chronic communicable diseases like diabetes mellitus, hypertension, and heart disease, and 4) ability to read, write, and consent to provide health information. The exclusion criteria encompassed: 1) reluctance or hesitation to provide information, 2) inability to complete the measurement, and 3) withdrawal from the study.

Data collection

After obtaining the Human Research Ethics Certificate from the ethical committee of Srinakharinwirot University, the researchers collaborated with health personnel in the targeted areas to gather information about the adult population undergoing fixed orthodontic appliances. Subsequently, a stratified random sampling was performed based on the selection criteria of the research participants and the specified sample size. During the questionnaire administration, participants were given the option to withdraw from the research if they felt concerned.

Instruments and quality assessment

Demographic questionnaire

This questionnaire gathered data on gender, age, marital status, education level, economic status, and the treatment duration of orthodontic treatment from the start to the present.

“OHL-Ortho” questionnaire

It was developed from HL and OHL assessments for adults.^[25,26] The 31-item scale assessed five elements of OHL: 1) access to oral health information and services, 2) understanding of oral health information and services, 3) appraisal of oral health information and services, 4) application of oral health information and services, and 5) communication of oral health information and services. The scale items were rated on a 5-point scale from lowest (1 point) to highest (5 points). Content validity was evaluated by five experts, resulting in an Item-Content Validity Index (IOC) ranging from 0.60 to 1.00, with an overall reliability score of 0.97. In the tryout phase involving 30 participants, Cronbach α values ranged from 0.80 to 0.94, leading to an overall reliability score of 0.95. Additionally, the scale demonstrated a discrimination power ranging from 0.61 to 0.87.

OHB questionnaire

It was used for the periodontal disease prevention scale. The 14-item scale assessed behavior based on three elements of OHB, 1) oral hygiene practices, 2) dietary choice, and 3) dental service utilization. The scale items were rated on a 5-point scale from never (1 point) to regularly (5 points). Five experts reviewed the content validity of the scale, and the scale achieved an IOC ranging between 0.60 and 1.00 with an overall reliability of 0.89. In tryout phase with 30 participants, Cronbach α values varied from 0.75 to 0.83, leading to an overall reliability score of 0.95. Furthermore, the scale displayed discrimination power ranging from 0.61 to 0.85.

Statistical analysis

Descriptive statistics were utilized to analyze basic data of variables, such as mean and standard deviation. In instances of missing data, such data points were excluded from analysis. The data were analyzed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA). Confirmatory factor analysis (CFA) was employed to evaluate the alignment of the measurement model with the empirical data, assessing the degree to which observed data corresponds with the anticipated relationships among variables within a theoretical framework. Structural equation model (SEM) was used to analyze the causal relationship model, ensuring it aligned with the empirical data. Model fit was assessed based on various benchmarks, including a non-statistically significant

Chi-square (χ^2), χ^2/df smaller than 2, RMSEA and SRMR values of 0.05 or smaller, CFI greater than 0.95, and GFI and AGFI greater than 0.80.^[27-29] The data analysis was conducted using LISREL version 8.72.

RESULTS

General characteristics of the sample

The sample consisted of 321 participants after excluding 9 individuals due to incomplete answers to questions. The mean age of the patients was 28.44 ± 7.56 years, and the average duration of braces placement was 2.69 ± 1.65 years. The majority of participants were female (73.60%) and single (76.80%). Most of them reported holding a bachelor’s degree as their highest level of education (64.60%) and having an adequate income with savings (51.50%).

Quality assessment of the scales

The 31-item OHL Questionnaire assessed five elements of OHL: 1) access to oral health information and services, 2) understanding of oral health information and services, 3) appraisal of oral health information and services, 4) application of oral health information and services, and 5) communication of oral health information and services. The scale items showed discriminating power ranging 0.50–0.92. The Cronbach α for each element fell 0.81 to 0.94, with an overall reliability of 0.97. In respect of construct validity, the CFA results indicated that the model fit the empirical data ($\chi^2 = 765.57$, $df = 403$, $P < 0.001$, $\chi^2/df = 1.89$, RMSEA = 0.049, SRMR = 0.046, GFI = 0.88, AGFI = 0.85, CFI = 0.99) [Table 1]. Moreover, all scale items had factor loadings ranging from 0.52 to 0.85, all of which exceeded acceptable levels as presented in Table 2.

The 14-item OHB Questionnaire assessed three elements of OHB: 1) oral hygiene practices, 2) dietary choice, and 3) dental service utilization. The scale items demonstrated discriminating power ranging 0.36–0.88. The Cronbach α for each element ranged from 0.77 to 0.88, with an overall reliability of 0.89. In respect of construct validity, the CFA results indicated that the model fit the empirical data ($\chi^2 = 97.80$, $df = 53$, $P < 0.001$, $\chi^2/df = 1.84$, RMSEA = 0.048, SRMR = 0.047, GFI = 0.96, AGFI = 0.96, CFI = 0.97) [Table 1]. Additionally, all scale items had factor loadings ranging from 0.42–0.64, all of which were above acceptable levels as presented in Table 3.

Table 1: Fit indices for confirmatory factor models

Factors	No. of items	χ^2	df	P value	χ^2/df	Goodness of fit indices				
						RMSEA	SRMR	GFI	AGFI	CFI
OHL	31	765.57	403	$P < 0.001$	1.89	0.049	0.046	0.88	0.85	0.99
OHB	14	97.80	53	$P < 0.001$	1.84	0.048	0.047	0.96	0.96	0.97

RMSEA: root mean square error of approximation, SRMR: standardized root mean square residual, GFI: goodness of fit index, AGFI: adjusted goodness of fit index, CFI: comparative fit index

Table 2: Quality assessment of “OHL-Ortho” questionnaire

Oral health literacy items	Discriminating power	Factor loading	Reliability (Cronbach's α)
Element 1: Access to oral health information and services			
1.1 I can access reliable oral health information about gum disease and its related condition called periodontal disease.	0.81	0.63	0.92
1.2 I can find accurate information on how to properly clean my teeth during orthodontic treatment	0.70	0.78	
1.3 I can find accurate information on dental cleaning tools such as toothbrushes, dental floss, and interdental brushes, which are used to clean my teeth and braces.	0.81	0.70	
1.4 I can find accurate information on the recommended foods during orthodontic treatment.	0.71	0.72	
1.5 I can seek advice from a dentist or a healthcare provider.	0.75	0.70	
1.6 I can find reliable sources to locate clinics or hospitals providing orthodontic treatment.	0.74	0.68	
1.7 I can find reliable sources when searching for orthodontic specialists.	0.71	0.69	
Element 2: Understanding of oral health information and services			
2.1 I understand information about gum and periodontal disease.	0.77	0.64	0.90
2.2 I understand the information on how to properly clean my teeth.	0.92	0.67	
2.3 I can remember important terms related to orthodontic treatment, such as elastic crossing and wire adjustment.	0.78	0.52	
2.4 I understand the information about the recommended foods during orthodontic treatment.	0.78	0.75	
2.5 I can remember the recommended foods to be consumed during orthodontic treatment.	0.65	0.65	
2.6 I understand dentists' advice on oral health care.	0.76	0.67	
2.7 I can remember the appointment dates for my orthodontic treatment and emergencies.	0.52	0.55	
Element 3: Appraisal of oral health information and services			
3.1 I can assess the condition of my gums and evaluate the presence of periodontal disease in myself.	0.78	0.57	0.94
3.2 I can identify behaviors that can increase the risk of gum and periodontal disease.	0.84	0.74	
3.3 I recognize appropriate approaches for gum and periodontal disease prevention.	0.85	0.79	
3.4 I can compare the pros and cons of oral health products while using them during orthodontic treatment.	0.83	0.73	
3.5 I can provide a list of foods that may increase the risk of gum and periodontal disease.	0.79	0.72	
3.6 I review the benefits and reliability of oral health information before trusting or using it.	0.76	0.75	
3.7 I can determine the appropriate time for scheduling checkups for my oral health.	0.77	0.63	
3.8 I can evaluate oral conditions that require a dentist's visit before the appointment.	0.71	0.68	
Element 4: Application of oral health information and services			
4.1 I can choose the methods of cleaning my teeth and braces.	0.77	0.75	0.90
4.2 I can choose the appropriate oral cleaning tools which are used to clean my teeth and braces.	0.85	0.80	
4.3 I can choose the recommended foods to be consumed during orthodontic treatment.	0.68	0.74	
4.4 I use oral health information to guide me in adjusting my behavior or lifestyle for better oral health.	0.69	0.81	
4.5 I can decide when to schedule oral health checkups.	0.78	0.70	
Element 5: Communication of oral health information and services			
5.1 I suggest others proper teeth cleaning methods based on reliable sources for oral health care.	0.79	0.85	0.81
5.2 I advise others on choosing suitable dental cleaning tools for maintaining oral health during orthodontic treatment.	0.70	0.76	
5.3 I advise others to reduce behaviors that pose risks to gum and periodontal disease to improve their oral health.	0.69	0.74	
5.4 I communicate with dentists or dental staff, expressing my dental needs and concerns.	0.50	0.60	
Overall reliability of the scale = 0.97			

Analysis of the causal relationship model of OHB

The results indicated that the causal relationship model fitted the empirical data well, with all values reaching acceptable levels ($\chi^2 = 22.71$, $df = 16$, $P = 0.12$, $\chi^2/df = 1.42$, $RMSEA = 0.034$, $SRMR = 0.023$, $GFI = 0.98$, $AGFI = 0.97$, $CFI = 1.00$). OHL exhibited a positive

direct effect on OHB with a significance level of 0.01 and an effect size of 0.81. This relationship explained 66.00% of the variation in OHB, as illustrated in Figure 1.

Considering the measurement model of OHL, it was effectively measured by five observed variables, all of which demonstrated statistically significant factor

Table 3: Quality assessment of OHB questionnaire

Oral health behavior items		Discriminating power	Factor loading	Reliability (Cronbach's α)
Element 1: Oral hygiene practices				
1.1	I brush my teeth at least twice daily.	0.85	0.62	0.88
1.2	I brush for at least 2 min each time.	0.81	0.57	
1.3	I brush my teeth by angling the bristles of the toothbrush towards the gumline. I move the brush back and forth briefly and then brush up and down until the entire mouth is covered.	0.57	0.46	
1.4	I brush with the appropriate amount of pressure.	0.61	0.53	
1.5	I use soft-bristled toothbrush.	0.69	0.64	
1.6	I use a proxabrush or superfloss to clean my braces.	0.71	0.45	
1.7	I use fluoridated toothpaste.	0.62	0.43	
Element 2: Dietary choice				
2.1	I consume sticky foods that stick to my teeth.	0.36	0.44	0.77
2.2	I consume sweet desserts.	0.64	0.56	
2.3	I drink sweetened beverages.	0.60	0.52	
2.4	I consume candies or lollipops.	0.55	0.42	
2.5	I consume crispy or hard food.	0.54	0.47	
Element 3: Dental service utilization				
3.1	In the past year, I have received dental services to prevent gum and periodontal disease while undergoing orthodontic treatment.	0.63	0.58	0.77
3.2	In the past year, I have received advice from dental professionals on how to prevent gum and periodontal disease during orthodontic treatment.	0.63	0.57	
Overall reliability of the scale = 0.89				

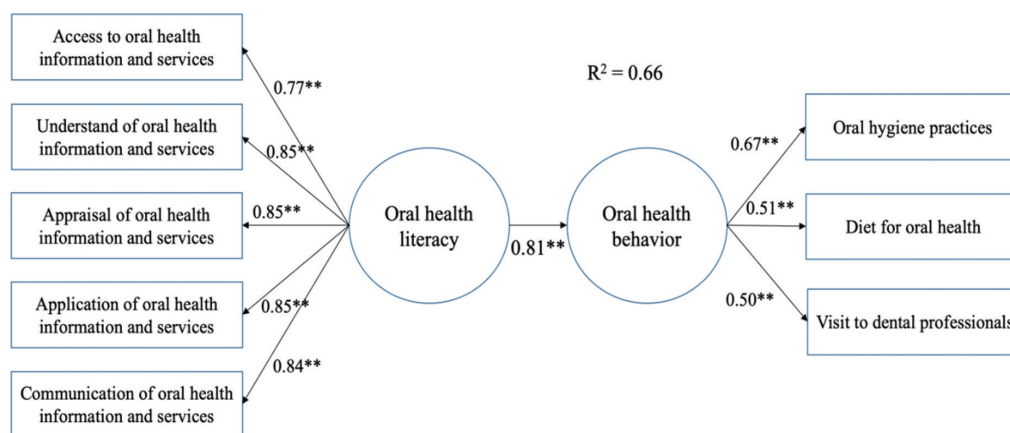


Figure 1: Causal relationship model of oral health behavior

loadings at the 0.01 level. Notably, the observed variables “understanding,” “appraisal,” and “application” of oral health information and services showed the highest factor loadings, each registering at 0.85. Following these, the observed variables “communication” and “access” to oral health information and services displayed factor loadings of 0.84 and 0.77, respectively [see Figure 1].

Furthermore, the measurement model for OHB was examined and similarly found to be measurable by three observed variables, all of which displayed statistically significant factor loadings at the 0.01 level. “Oral hygiene practices” emerged with the highest factor loading,

followed by “diet for oral health” and “visit to dental professionals,” with factor loadings of 0.67, 0.51, and 0.50, respectively [Figure 1].

DISCUSSION

In regard to the OHL questionnaire, the researchers developed the scale items based on the structural elements of HL concepts by Sorensen *et al.*[26] and Osborne *et al.*[30] and designed the item content based on oral health. A comprehensive assessment of five significant elements was undertaken, resulting in a total of 31 items. These elements have consistently demonstrated substantial reliability and validity in prior studies,[26,30] covering all

functional, interactive, and critical levels of OHL. The scale exhibited strong item reliability ranging from 0.81 to 0.94 and an overall reliability of 0.97, which aligns with the standards of excellence established by Nunnally.^[31] This underscores its status as a high-quality instrument suitable for effective data collection. Additionally, the factor loadings of the items ranged from 0.52 to 0.85, higher than the acceptable threshold of 0.30.^[32] The questionnaire’s construct validity received confirmation through CFA. The results establish that the developed OHL questionnaire is pragmatic and aptly tailored for use among orthodontic patients.

The OHB questionnaire was construct based on the definition of OHB,^[33] and the items were tailored to be most applicable for orthodontic clients. The questionnaire assessed three elements of OHB, comprising a total of 17 items. Similarly, the scale demonstrated item reliability ranging from 0.77 to 0.88 and an overall reliability of 0.89, which is considered excellent according to Nunnally,^[31] making it a high-quality instrument for data collection. The factor loadings ranged from 0.42 to 0.64 which meet Kline’s acceptable criteria.^[32] The developed scale, as confirmed by the CFA results, can effectively assess the actual levels of OHBs that possibly cause periodontal disease among working-age groups.

Consistency was found between the causal relationship model of OHB and the empirical data, with OHL showing a positive direct effect on OHB at a highly significant level of 0.01. These findings align with numerous previous studies, which revealed a significant statistical correlation between the extent of OHL and OHBs, encompassing aspects such as the duration and frequency of brushing, the use of fluoride toothpaste, regular oral checkups, and the frequency of dental service visits.^[10,12,34-37] Additionally, limited OHL was linked to poorer clinical status and OHBs, lower engagement in the oral health care system, and the utilization of dental services.^[14,38] However, this correlation is subject to ongoing debate, as alternative studies have indicated the absence of a connection between OHL and OHB.^[34,39,40]

The relationship between OHL and OHB reveals a significant causal pathway, where individuals with higher OHL possess a better understanding of oral health information, increased awareness of oral health risks, and stronger motivation to modify their behavior. Consequently, this leads to the adoption of healthier oral health practices and improved oral health outcomes.^[41] Moreover, enhanced OHL empowers individuals to make informed decisions about their oral health care, encouraging them to seek appropriate dental services, adhere to treatment plans, and implement preventive measures. Effective communication between these individuals and dental professionals further enhances oral health management, as patients can express their concerns and comprehend professional advice more effectively.^[42]

Additionally, higher OHL fosters knowledge-sharing within families and communities, promoting better oral health practices among a wider population and contributing to overall enhanced oral health outcomes.^[43]

Clinical significance

Dental Health and healthcare units can utilize these “OHL-Ortho” and OHB scales to assess the levels of OHL and OHB among adult orthodontic patients. The study’s findings highlight that increasing OHL levels through government initiatives for adult orthodontic patients could result in a significant 66% improvement in OHB. Healthcare providers and professionals can arrange educational activities designed to enhance individuals’ OHL, empowering them to actively improve their oral health.

Future scope and strength and limitation

This study demonstrates notable strengths, including the utilization of a stratified randomized sampling method and the application of an advanced statistical technique, SEM. However, it is essential to acknowledge some limitations in our approach. One potential limitation is the reliance on self-reported questionnaires to measure both OHL and OHB, which may introduce biases and subjective interpretations. Moreover, some respondents did not answer all the questions, necessitating an increase in data collection by 10% to prevent data loss and improve the completeness of the dataset. To establish a more definitive understanding of the causal relationship between OHL and OHB, future studies should consider experimental designs, which can provide more conclusive insights into the cause-and-effect dynamics between OHL and OHBs. Despite these limitations, our findings offer valuable insights into the relationship between OHL and OHB among adult orthodontic patients, paving the way for future research in this crucial field of study.

CONCLUSION

Both the “OHL-Ortho” and OHB measurement tools have been developed and proven to be high-quality assessment instruments, making them valuable resources for healthcare providers. The study also highlights the significant impact of OHL on the OHB of orthodontic patients. Promoting higher levels of OHL among these populations through government initiatives could result in a remarkable 66% improvement in OHB for this group. Therefore, healthcare providers and professionals should prioritize organizing educational activities aimed at enhancing individuals’ OHL, empowering them to improve their oral health and overall well-being.

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Conflicts of interest

The authors declare no conflict of interest.

Authors contributions

NT: conception, design of manuscript, literature search, acquisition of data, analysis of data, drafting and revising the article; UI: conception, analysis of data, final approval of the version to be published; KK: conception, analysis of data, final approval of the version to be published.

Ethical policy and institutional review board statement

The present study received ethical approval for research involving human subjects from Srinakharinwirot University (SWUEC-G-005/2566). All the procedures have been performed as per the ethical guidelines laid down by the Declaration of Helsinki (2013).

Patient declaration of consent

Prior to data collection, the researchers asked for informed consent from the participants and provided detailed information about the study, including the participant selection process.

Data availability statement

The data set used in the current study is available on request from Neeranart Thirasupa (neeranart@g.swu.ac.th).

List of Abbreviations

OHL: Oral health literacy
OHB: Oral health behavior

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