

## ORIGINAL ARTICLE OPEN ACCESS

# Assessment of Oral Health Literacy and Influencing Factors: Retrospective Analysis of Patients Treated by Dental Students

Alicia Maria Meyer-Hofmann<sup>1</sup>  | Anna Greta Barbe<sup>1</sup>  | Max von Kohout<sup>2</sup>  | Ghazal Aarabi<sup>3</sup>  | Isabel Deeg<sup>1</sup>  | Michael Jochen Wicht<sup>1</sup>  | Sonja Henny Maria Derman<sup>1</sup> 

<sup>1</sup>Faculty of Medicine and University Hospital Cologne, Polyclinic for Operative Dentistry and Periodontology, University of Cologne, Cologne, Germany | <sup>2</sup>Institute of Medical Statistics and Computational Biology, University of Cologne, Faculty of Medicine and University Hospital, Cologne, Germany | <sup>3</sup>Department of Periodontics, Preventive and Restorative Dentistry, Center for Dental and Oral Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

**Correspondence:** Alicia Maria Meyer-Hofmann ([alicia.meyer-hofmann@uk-koeln.de](mailto:alicia.meyer-hofmann@uk-koeln.de))

**Received:** 19 December 2024 | **Revised:** 19 March 2025 | **Accepted:** 27 April 2025

**Funding:** The authors received no specific funding for this work.

**Keywords:** communication skills | dental education | oral health behaviour | oral health literacy | periodontal therapy

## ABSTRACT

**Introduction:** Oral health literacy (OHL) plays a crucial role in determining oral health outcomes, particularly in preventing and managing oral health issues. It is primarily developed through communication between dentists and patients—a key focus in dental education. To enhance this training, understanding OHL in student teaching is essential. This study aimed to assess OHL among patients undergoing treatment performed by dental students and identify influencing factors.

**Materials and Methods:** This retrospective analysis evaluated the Oral Health Literacy Profile (OHLP) of patients ( $\geq 18$  years) treated by dental students in their fourth and fifth year. The OHLP measures oral health behaviour (OHB) and oral health knowledge (OHK) (scored 0–100). Patients were grouped by age and periodontal therapy status. Statistical analyses included ANOVA and linear regression modelling.

**Results:** A total of 222 questionnaires (106 females; mean age  $56.8 \pm 16.4$  years) were analysed. The mean OHLP was  $54.4 \pm 16.1$ . Significant differences ( $p < 0.05$ ) in OHB and OHK were observed between age groups: the lowest OHB was in younger adults ( $47.9 \pm 18.9$ ), while the highest OHB ( $63.4 \pm 22.9$ ) and lowest OHK ( $29.1 \pm 22.9$ ) were in older seniors; OHB scores were higher in periodontal patients. The regression model identified age, female gender, periodontal therapy, and OHK as significant predictors of OHB ( $R^2 = 0.25$ ,  $p < 0.001$ ).

**Conclusion:** Significant gaps in OHL were revealed, particularly among males, younger adults, older seniors, and those not undergoing regular periodontal therapy. Students should receive specialised training to recognise these varying levels of oral health knowledge, behaviour, and influencing factors, enabling them to effectively address these issues during counselling.

## 1 | Introduction

The concept of oral health literacy (OHL) encompasses an individual's ability to obtain, process and understand oral health information to make well-informed decisions, and the

ability to apply this information to one's own personal circumstances [1]. Oral health literacy (OHL) is becoming increasingly important within the field of dentistry [2, 3], due to the link between low levels of OHL and poor oral health outcomes [4, 5]. Individuals with inadequate OHL are more likely to

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *European Journal of Dental Education* published by John Wiley & Sons Ltd.

have poor oral health outcomes as a result of inappropriate oral health behaviours and dental care utilisation. As a consequence, they demonstrate poorer oral health behaviours, are at an increased risk of developing gingivitis and periodontitis, are more likely to cancel dental appointments, and exhibit a higher prevalence of dental caries, missing teeth, and edentulism [6–10]. These issues make the topic relevant for patients, but also for every practising dentist from a clinical and health economic point of view.

Several instruments are available to measure OHL, with most focusing on word recognition and comprehension. However, these tools often have a high administration burden, which presents a challenge in their practical application [11]. The Oral Health Literacy Profile (OHLP) [12] is a brief instrument that has been developed for the assessment of various aspects of OHL, particularly knowledge, self-reported oral hygiene practices, and dental service utilisation. The tool is designed to identify individuals in practical settings who may benefit from oral health education [13]. Gaining comprehensive understanding of OHL in specific patient groups is crucial for enhancing oral health education programmes and tailoring them to individual needs within the framework of patient-centered dentistry [14, 15]. A key research gap is the lack of clarity regarding the characterisation of patients treated in student courses in terms of OHL and influencing factors. Consequently, the optimal approach to training students to effectively address these aspects remains unclear.

Communication strategies and structured information transfer are an important part of changing health behaviour, for example with regard to nutrition or oral hygiene [16, 17]. In the context of patient-centered care, the (graduating) dentist plays a pivotal role as a communicator, with a keen understanding of the importance of communication skills and a dedicated stance as a health advocate [18–20]. Dental graduates are expected to demonstrate the capacity to identify and categorise behaviours exhibited by patients that may be healthy or risky. They are also expected to demonstrate proficiency in supporting patients through the process of behavioural change, utilising a fundamental understanding of the available counselling and therapeutic options [19, 20]. To enable students to learn patient-centered communication skills related to improving oral health status, it is essential for them to gain a comprehensive understanding of the specific and individual OHL needs of their patients during training—the patient population who will later be cared for by the graduating dentists.

Thus, the objective in this retrospective data analysis was to describe the OHL of patients undergoing dental treatment performed by fourth- and fifth-year dental students, and to identify patient-centered factors that influenced their OHL.

## 2 | Materials and Methods

### 2.1 | Ethics and Data Protection

This retrospective study was approved by the local ethics review board of the Medical Faculty of the University of Cologne. Data protection was guaranteed due to an anonymization process

before statistical analysis was performed. The data that support the findings of this study are available from the corresponding author upon reasonable request.

### 2.2 | Study Population

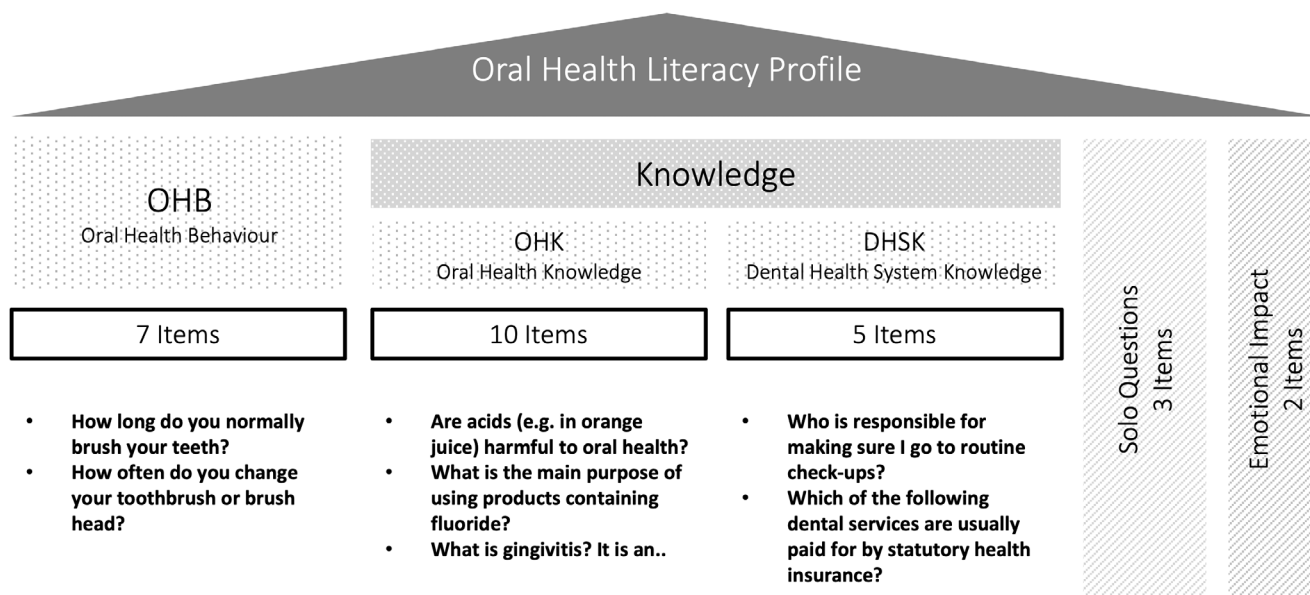
From 1st October 2023 to 1st February 2024 (corresponding to the winter semester 2023/24), all patients aged  $\geq 18$  years who were being treated by the fourth- and fifth-year dental students were routinely invited to complete a questionnaire on their OHL. All students followed the longitudinal communication curriculum that had been implemented since their first year [21]. The questionnaire was completed by each patient in writing on a voluntary basis during their introductory visit to the clinical student course in Operative Dentistry and Periodontology. Only questionnaires in which  $> 70\%$  of the questions were answered by the patient were included in the analysis. The interim pseudonymization process was implemented with the objective of identifying and deleting duplicated entries, thereby ensuring that each patient was represented only once in the database.

### 2.3 | Assessment of Oral Health Literacy

The short and validated instrument OHLP was used to assess each patient's OHL [12]. The OHLP is comprised of 28 items, with 22 core items divided into three categories: seven items that assess oral health behaviour (OHB), 10 items that assess oral health knowledge (OHK), and five items that assess Germany-specific dental health system knowledge (DHSK). The three single questions refer to the reason for the responders' last dental visit, two self-ratings of oral health knowledge and oral health status, and two questions that assess the emotional impact of costs and fear of pain. As treatment in the student course at the University of Cologne is provided only to German-speaking patients or those accompanied by an accredited interpreter, the validated German version of the OHLP questionnaire was used in this study [12]. Figure 1 provides an overview of the OHLP structure. In the categories of OHB, OHK, and DHSK, a correct answer was assigned a value of one, while an incorrect answer or a non-answer was assigned a value of zero. The total number of correct answers for each individual category was divided by the maximum number of possible points (seven for OHB, 10 for OHK, five for DHSK, and 22 in total) and multiplied by 100, resulting in a score (OHB, OHK, DHSK, total) on a scale of 0–100.

### 2.4 | Patient Parameters

The following variables were extracted from the patient's file: age, gender, general illness, active pharmaceutical ingredients and the reason for the visit (check-up, professional mechanical plaque reduction (PMPR), filling, root canal treatment, or active/supportive periodontal treatment) on the day the questionnaire was administered. In the clinical student course, a series of parameters were assessed on a routine basis during every appointment, including the number of teeth, the decayed, missing, and filled teeth (DMFT) index, and the periodontal screening index (PSI, German adaptation of the CPITN).



**FIGURE 1** | Overview of Oral Health Literacy Profile (OHL) domains.

## 2.5 | Population Grouping

The population was categorised by age. Age grouping was made in accordance with those described in the DMS V [22]. The age groups in the DMS V [22] are based on the World Health Organisation (WHO) guidelines on oral health surveys [23] and include the age groups adults (aged 35–44 years), young seniors (65–74 years) and additionally older seniors (75–100 years). Age groups comprising individuals between the ages of 18–34 (young adults), 45–54, and 55–64 years (not previously defined in the DMS V [22] or by WHO [23]) were also established. Regardless of the treatment on the day the questionnaire was completed, patients were grouped into two categories: patients under active or supportive periodontal treatment (perio patients) and patients without periodontal treatment (other patients).

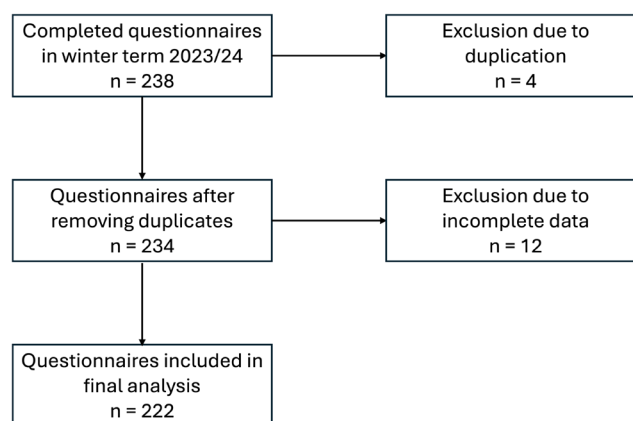
## 2.6 | Statistical Analysis

Continuous variables are displayed as mean and standard deviation [mean ( $\pm$ SD)]. Categorical variables are displayed as absolute numbers and percentages [ $n$  (%)]. ANOVA was used to explore differences in OHB and OHK scores. A linear regression model was developed to predict OHB scores, with backward selection used to refine the model by removing non-significant predictors. Significance levels were set at  $*p < 0.05$ ,  $**p < 0.01$ ,  $***p < 0.001$ . Analyses were performed using IBM SPSS Statistics (V29) and R (version 4.3.2) for visualisation purposes.

## 3 | Results

### 3.1 | Included Questionnaires

In total, 238 completed questionnaires were received at the end of the academic winter term (2023/2024). Four responses were excluded from the analysis because of duplication, and a further



**FIGURE 2** | Flow chart of included questionnaires.

12 were excluded due to incomplete data ( $\geq 30\%$  of the questions were unanswered). Therefore, questionnaires from 222 patients (116 males, 106 females; mean age  $56.8 \pm 16.4$  years) were included in the final analysis (Figure 2).

### 3.2 | Sample Description

The most frequent reasons for the initial visit were preventive consultations with PMPR ( $n = 88$ , 40%) and periodontal appointments ( $n = 73$ , 33%). Patients had  $24.4 \pm 6.1$  of their own teeth and a mean DMFT of  $20.0 \pm 5.5$  (range 1–28). Of the 222 patients, 91 (41%) were classed as perio patients. Table 1 outlines the characteristics of the patients whose questionnaires were included.

### 3.3 | Oral Health Literacy

The mean OHL total score for all patients ( $N = 222$ ) was  $54.4 \pm 16.1$ . Table 2 provides an overview of the OHL and subdomain scores subgrouped by age and periodontal therapy

**TABLE 1** | Patient and clinical dental parameters.

	<b>Patients in the student course (N=222)</b>
Age (years), mean $\pm$ SD (range)	56.8 $\pm$ 16.4 (19–87)
Sex, n (%)	
Males	116 (52.3)
Females	106 (47.7)
Comorbidities, mean $\pm$ SD (range)	n = 220 1.5 $\pm$ 1.9 (0–14)
Active Pharmaceutical Ingredients, mean $\pm$ SD (range)	n = 221 2.0 $\pm$ 3.0 (0–18)
Reason for the visit, n (%)	
Check-up	14 (6.3)
Professional mechanical plaque reduction	88 (39.6)
Filling	33 (14.9)
Root canal treatment	14 (6.3)
Perio Appointment	73 (32.9)
Subgrouping by periodontal therapy, n (%)	
Perio patients (PP)	91 (41)
Other patients (OP)	131 (59)
Number of teeth, mean $\pm$ SD (range)	24.4 $\pm$ 6.1, (0–32)
Decayed, missing, and filled teeth, mean $\pm$ SD (range)	20.0 $\pm$ 5.5 (1–28)
Max. Periodontal Screening Index, mean $\pm$ SD (range)	2.9 $\pm$ 0.9 (0–4)

Abbreviation: SD, standard deviation.

status. The OHK score was the OHL P subdomain with the lowest mean score (41.8  $\pm$  22.7). Patients aged 45–54 years showed the highest OHB scores (66.9  $\pm$  16.9). Younger seniors (65–74 years) maintained the highest OHL P and OHK scores. Perio patients had higher OHB scores (65.0  $\pm$  18.2) than other patients (57.6  $\pm$  19.6), but other patients demonstrated slightly higher OHK (43.2  $\pm$  23.3) and DSHK (71.2  $\pm$  19.6) scores.

### 3.4 | Subgrouping by Age

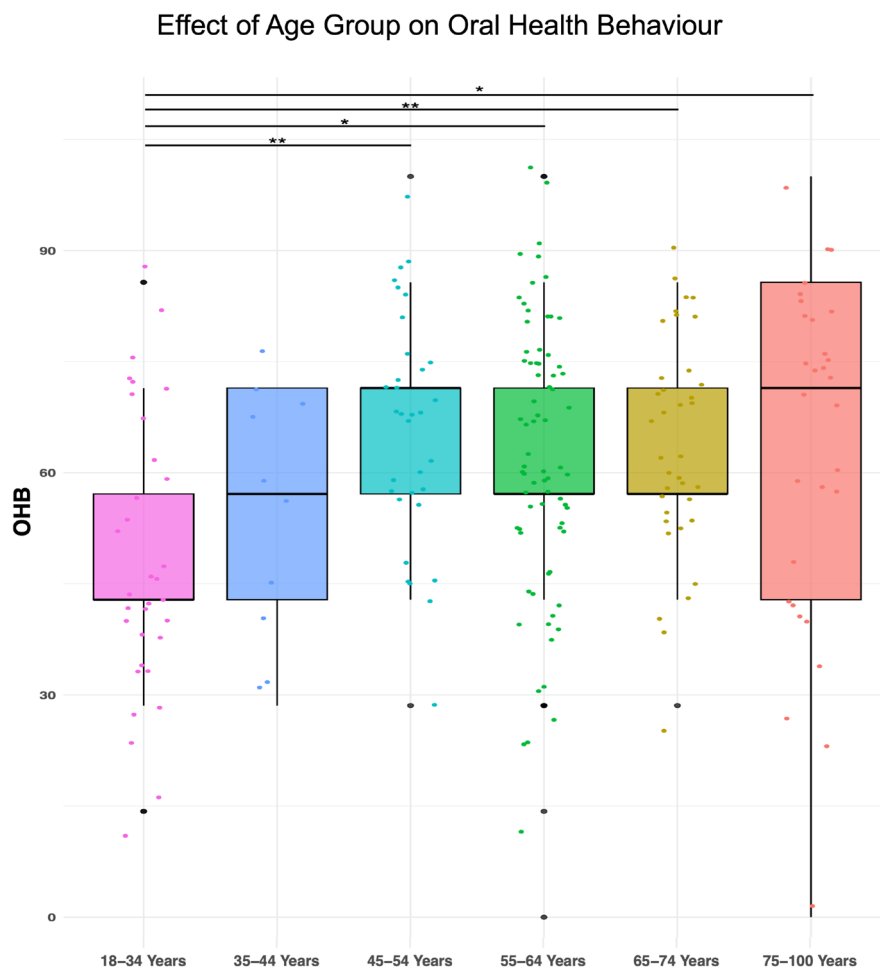
The analyses of variance (ANOVA) revealed a significant effect of age group on the OHB score ( $F(5, 211) = 4.021, p < 0.001$ ) (Figure 3). This indicates that there are statistically significant differences in the mean values of OHB across the six age groups, and a moderate proportion of variance attributed to the differences between age groups. The post hoc analysis revealed significant differences ( $p < 0.05$ ) in OHB scores between the lowest OHB in the 18–34 age group and higher OHB in the following

**TABLE 2** | OHL P Scores in patients stratified by age and periodontal therapy status.

Patients in the student course (N=222)	Subgrouping: age (years)						Periodontal therapy		
	Total (N=222)	18–34 (n=34)	35–44 (n=10)	45–54 (n=35)	55–64 (n=74)	65–74 (n=37)	75–100 (n=32)	OP (n=131)	PP (n=91)
OHL P score	54.4 $\pm$ 16.1	48.1 $\pm$ 18.3	47.3 $\pm$ 16.5	56.2 $\pm$ 15.4	57.5 $\pm$ 15.8	58.1 $\pm$ 12.3	49.6 $\pm$ 15.9	54.1 $\pm$ 16.7	54.5 $\pm$ 15.1
OHB	60.8 $\pm$ 19.5	47.9 $\pm$ 18.9	54.29 $\pm$ 17.6	66.9 $\pm$ 16.9	61.6 $\pm$ 19.3	64.9 $\pm$ 14.9	63.4 $\pm$ 22.9	57.6 $\pm$ 19.6	65.0 $\pm$ 18.2
OHK	41.8 $\pm$ 22.7	39.7 $\pm$ 24.8	36.00 $\pm$ 19.0	41.1 $\pm$ 20.7	47.6 $\pm$ 22.6	45.1 $\pm$ 19.2	29.1 $\pm$ 22.9	43.2 $\pm$ 23.3	39.6 $\pm$ 21.8
DSHK	70.5 $\pm$ 21.6	65.3 $\pm$ 24.3	60.00 $\pm$ 31.3	71.4 $\pm$ 21.9	71.6 $\pm$ 20.7	74.6 $\pm$ 21.9	71.3 $\pm$ 15.2	71.2 $\pm$ 19.6	69.5 $\pm$ 24.3

Note: Presented as mean  $\pm$  standard deviation.

Abbreviations: DSHK, dental health system knowledge; OHB, oral health behaviour; OHK, oral health knowledge; OHL P, oral health literacy profile; OP, other patient; PP, perio patient.



**FIGURE 3** | Group differences in oral health behaviour (OHB) by age. \* $p < 0.05$ , \*\* $p < 0.01$ .

age groups: 45–54 years (17.3, 95% confidence interval (CI) 4.1, 30.6), 55–64 years (13.1, 95% CI 1.84, 24.4), 65–74 years (16.4, 95% CI 3.5, 29.3), and 75–100 years (14.4, 95% CI 0.8, 27.9). The corresponding  $\eta^2$  showed a moderate effect of 0.08, according to Cohen's guidelines [24, 25].

The second one-way ANOVA revealed a significant effect of age group on the OHK score ( $F(5, 211) = 3.274$ ,  $p = 0.0072$ ) that explained a moderate amount of total variance (Figure 4). This indicates that there were statistically significant differences in the mean values of the OHK across the six age groups. Post hoc ANOVA comparisons were adjusted for multiple testing using Tukey's method. The level of OHK differed statistically significantly between the 55 and 64 age group and lower OHK in the 75–100 age group (–18.2, 95% CI –32.1, –4.4) and 65–74 and lower OHK in the 75–100 age group (–15.8, 95% CI –32.5, –0.1), with a corresponding  $\eta^2$  of 0.07, indicating a moderate effect size.

### 3.5 | Subgrouping by Periodontal Therapy

For further analysis, a one-way ANOVA was conducted to investigate whether there were any differences in OHB between the perio patient and other patient populations. The analysis indicated a significant effect of the perio patient subgroup on

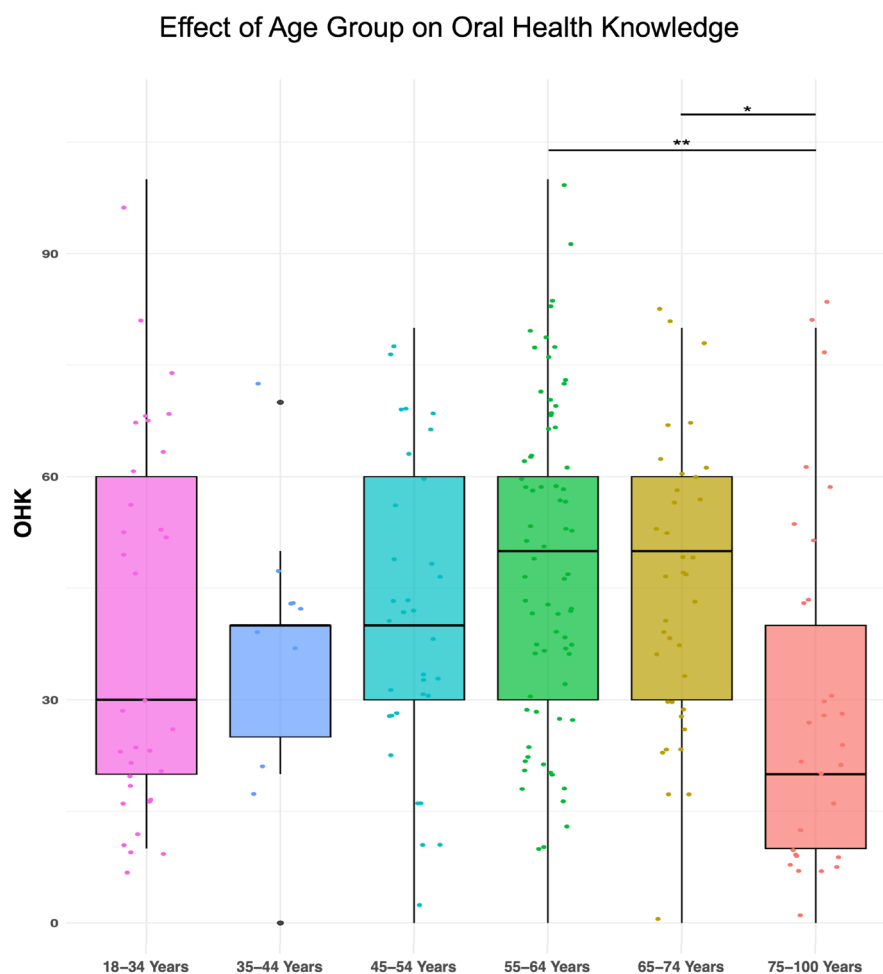
the outcome variable ( $F(1, 215) = 8.229$ ,  $p = 0.00453$ ) (Figure 5). Post hoc comparisons adjusted by the Tukey method showed a statistically significant difference in OHB levels between other patients and perio patients, with higher OHB in perio patients (difference 7.51 points, 95% CI 2.35, 12.7). This corresponds to an  $\eta^2$  of 0.037, indicating a small effect size.

### 3.6 | Predictors of Oral Health Behaviour

The linear regression model indicated a statistically significant and moderate proportion of variance in OHB ( $R^2 = 0.25$ ,  $F(5, 211) = 14.02$ ,  $p < 0.001$ , adjusted  $R^2 = 0.23$ ), with an intercept of 10.66 (95% CI –10.49, 31.81,  $t(211) = 0.99$ ,  $p = 0.321$ ). Significant positive effects were found for increasing age (beta = 0.99,  $p = 0.019$ ), female sex (beta = 7.63,  $p = 0.001$ ), active and supportive periodontal therapy (perio patient) (beta = 6.19,  $p = 0.016$ ), and higher OHK (beta = 0.30,  $p < 0.001$ ). Age squared (Age<sup>2</sup>) had a non-significant negative effect (beta = –0.007,  $p = 0.064$ ). Detailed results are in Figure 6 and Appendix 1.

## 4 | Discussion

We assessed the OHL of patients across all age groups, who had a broad range of reasons for attending the dental appointment



**FIGURE 4** | Group differences in oral health knowledge (OHK) by age. \* $p < 0.05$ , \*\* $p < 0.01$ .

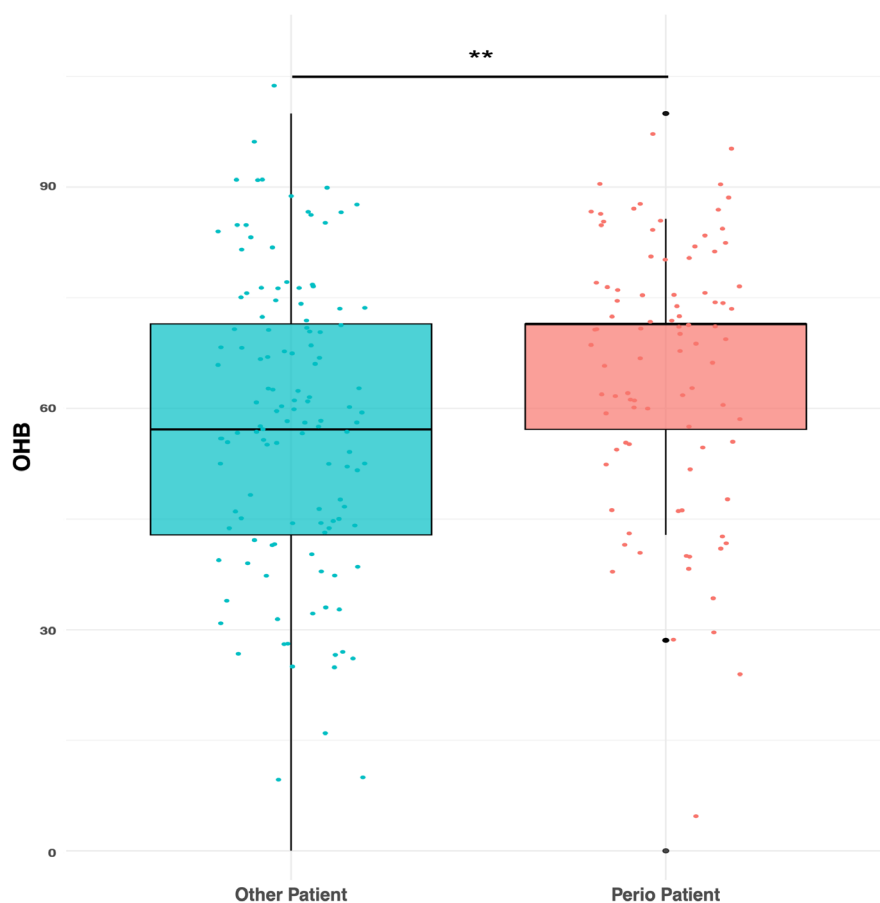
with fourth- and fifth-year dental students. This retrospective data analysis showed age-related changes in OHB and in OHK. OHB was better in patients who received regular supportive or active periodontal therapy than in those who did not. The analysis revealed that males, patients not receiving regular active or supportive periodontal therapy, younger adults, and older seniors exhibited a need for improvement in their OHL.

The objective of the underlying study design—which employed a monocentric, retrospective data analysis approach—was to provide a description of the actual state of OHL measured by the OHLP in the patient population, rather than to assess changes in OHL through the implementation of an intervention. Across all three ANOVA models, similar challenges related to the underlying assumptions were encountered, primarily due to the complex measurement and the quasi-grouping of the dependent variables. The subgroup analysis demonstrated the expected heterogeneity due to the differing conditions of treatment during the fourth and fifth years of the dental student course—patients require a greater investment of time, adhere to a schedule of appointments, and commonly make a lower financial contribution [26]. In comparison to the most extensive oral health study conducted in Germany, the patient population in this study exhibited slightly elevated DMFT values compared to the reference population [22, 27].

A linear regression model that explained 25% of the variance in OHB was developed. There were minimal differences between the  $R^2$  (0.25) and the adjusted  $R^2$  (0.23), indicating that the predictor selection was appropriate. Although some multicollinearity and non-linearity were anticipated due to the quadratic age term, the model still demonstrated an ability to capture stagnation in OHB trends for older patients, despite a marginally non-significant  $p$ -value (0.06). However, homoscedasticity was not fully met for extreme values, likely due to measurement errors in the complex dependent variable (Appendix 2) and missing socioeconomic factors. Other studies have demonstrated the influence of income and educational level on OHL [28, 29]. Nevertheless, the model exhibited an adequate fit, supported by the parsimonious selection of meaningful predictors.

The mean OHL values observed in this study were similar to the OHL values observed in other studies investigating OHL [12, 13]. In the current population, both knowledge scores were lower than those described by Spinler et al. [12]. This could be due to differences in recruitment between the cohorts—the population in Spinler et al. [12] was recruited through online questionnaires, which causes a recruitment bias where individuals who have smartphones, use social media, or have technical knowledge and skills are more likely to access and complete the questionnaire, and may also have been able to take unlimited

## Effect of Periodontal Therapy on Oral Health Behaviour



**FIGURE 5** | Group differences in oral health behaviour (OHB) by periodontal therapy.  $**p < 0.01$ .

time to complete the questionnaire and use online searches to best complete the questionnaires. Patients in this study were presented with the questionnaire in its original paper format, without the option of preparation or the use of online searches.

Most studies report lower OHL in old age, as in this population [30, 31]. Parabolic relationships between OHL and age—with low OHL among younger adults and in old age, as seen in this study with low OHB in younger adults (18–34 years) and decreasing OHK in older seniors (75–100 years)—have not been described before. The lower level of OHL observed in our population of younger adults (aged 18–34) compared to age groups 45–54 years, 55–64 years, 65–74 years, and 75–100 years may be attributed to an increasing awareness of the necessity for optimal oral health practices with age. As dental problems increase with age—as illustrated by the DMFT index, for example—awareness of oral health problems increases. This motivates individuals to improve their oral health, which results in a change in behaviour [32]. Nevertheless, a significant reduction in OHL was observed among older seniors (aged 75–100), predominantly due to lower OHK. This prompts the question of whether the observed decline in OHK can be attributed to the fact that this generation was raised in an era when formal health education was not widely available. In the mid-20th century, public health initiatives concentrated on infectious diseases to a greater extent

than on chronic conditions or oral health, which resulted in older generations acquiring limited foundational health knowledge, including oral hygiene practices [33, 34]. An alternative hypothesis is that the observed decline in knowledge may be attributed to natural age-related declines in executive function and episodic memory, or alternatively to the increased prevalence of neurodegenerative diseases [35].

Besides the previously mentioned factors of age and sociodemographic characteristics, sex also influences OHL levels [28]. A review of the existing literature indicates that women tend to demonstrate superior OHL [28, 36, 37]. Females in our study also tended to have better OHB, contributing to higher OHL than in men. This may be attributed to an increased propensity to engage in preventive oral health behaviours, such as regular dental visits and adherence to oral hygiene routines [38].

Domain Three of the Graduating European Dentist Curriculum by the Association for Dental Education in Europe (ADEE) underscores the integration of patient-centered care into dental education [18, 39]. Therefore, graduates should recognise patients' needs, values, and preferences, communicate effectively, and promote shared decision-making to enhance OHL and, consequently, improve oral health outcomes. Beyond providing an overview of patients' OHL in clinical student courses,



**FIGURE 6** | Results of a linear regression analysis examining the predictors of oral health behaviour (OHB). Coefficients were estimated using ordinary least squares regression, with 95% confidence intervals (CI) and  $p$ -values calculated via a Wald  $t$ -distribution approximation. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

the findings of this study offer valuable insights for practical applications in dental education. The focus should be on consistently addressing the individual knowledge and needs of patients, ensuring that students are trained not only to recognise patient-specific behavioural risk factors but also to identify gaps in patients' knowledge. To achieve this, students need to develop the ability to assess both behavioural and educational deficiencies, as well as the influencing contextual factors, while subsequently communicating information in an accessible, low-threshold, and patient-friendly manner. A suitable teaching format is 'situated learning' in clinical student courses as method of teaching recommended by ADEE [40]. In addition to the standard integration of the OHL into the medical history, having students directly evaluate the OHL questionnaire at the start of the treatment session would allow for an immediate, needs-based response to oral health behaviours and knowledge gaps, ensuring care is tailored to each patient's individual needs.

Communication in dentistry and dental schools plays a crucial role in patient satisfaction, concordance, and promoting behavioural changes, which individually and together promote oral health outcomes [41, 42]. Prior to its incorporation into statutory health insurance—and even before the expansion of periodontal therapy services covered by the statutory health

insurance, which is largely based on the European Federation of Periodontology guidelines—the significance of communication in dentistry was firmly established as a core element of active and supportive periodontitis therapy within the curriculum for dental students [20, 21, 43]. The emphasis on communication in dentistry, particularly in the context of periodontal therapy, may be a pivotal factor contributing to the noteworthy superior OHB observed among perio patients in our population.

Our study had limitations. The selected retrospective study design based on routine data does not permit conclusions to be drawn regarding the potential influence of socioeconomic factors, including income, marital status and level of education. Moreover, the applicability of these findings to the general population is constrained by the inherent bias associated with the monocentric study design of patients visiting the dental school and the voluntary nature of questionnaire completion. For instance, an age bias is evident, given that most patients who undergo student treatment have a considerable amount of time to spare. These individuals are predominantly pensioners or job seekers. Additionally, there is a bias in terms of wealth, with the majority of patients who are either financially constrained or reluctant to bear the costs associated with dental health issues seeking out the student course. In Western countries, contextual

factors—including those of individuals attending dental treatment in student courses—vary significantly depending on the university's location, demographics, socioeconomic status, urban–rural distribution, and the ratio of publicly to privately insured individuals. However, within Germany, student course populations are generally considered relatively homogeneous. Further research is needed to explore effective strategies for improving oral health literacy across diverse population groups. Furthermore, data regarding the correlation between oral health, as delineated by plaque and gingival indices, and OHL is lacking. This is due to the fact that a retrospective study design including only routine data from patient records were available for evaluation of these indices, and plaque and gingival indices were not consistently collected for each patient.

## 5 | Conclusion

Our study yielded valuable insights into the oral health literacy of patients undergoing dental treatment by fourth- and fifth-year students at the dental school. Males, patients not receiving regular active or supportive periodontal therapy, younger adults, and older seniors exhibited a need for improvement in their OHL. Dental students need to be aware that these groups might need greater support and education about their oral health. There was a notable discrepancy in the levels of knowledge across age groups, which was inadequate in all age groups. It is unclear whether the objective for older adults should be to enhance knowledge transfer or whether alternative strategies are required to address the discrepancy in OHL, potentially through the incorporation of supportive environments. This study highlights the importance of incorporating OHL assessment into dental education to address patients' individual needs. Training should focus on recognising individual behavioural and knowledge gaps while improving students' ability to communicate effectively within a patient-centered framework.

### Acknowledgements

The draft manuscript was edited by Deborah Nock (Medical WriteAway, Norwich, UK). We acknowledge support for the publication fee for open access articles through Project DEAL. Open Access funding enabled and organized by Projekt DEAL.

### Ethics Statement

Ethical approval was obtained from the local ethics review board of the Medical Faculty of the University of Cologne (24-1057-retro).

### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### References

1. American Dental Association (ADA), Health Literacy in Dentistry, (2025), <https://www.ada.org/resources/community-initiatives/health-literacy-in-dentistry?utm>.

2. V. Dickson-Swift, A. Kenny, J. Farmer, M. Gussy, and S. Larkins, "Measuring Oral Health Literacy: A Scoping Review of Existing Tools," *BMC Oral Health* 14 (2014): 148, <https://doi.org/10.1186/1472-6831-14-148>.
3. A. M. Horowitz and D. V. Kleinman, "Oral Health Literacy: The New Imperative to Better Oral Health," *Dental Clinics of North America* 52, no. 2 (2008): 333–344.
4. "The Invisible Barrier: Literacy and Its Relationship With Oral Health. A Report of a Workgroup Sponsored by the National Institute of Dental and Craniofacial Research, National Institute of Health, U.S. Public Health Service, Department of Health and Human Services," *Journal of Public Health Dentistry* 65, no. 3 (2005): 174–182, <https://doi.org/10.1111/j.1752-7325.2005.tb02808.x>.
5. M. J. Batista, H. P. Lawrence, and M. L. R. Sousa, "Oral Health Literacy and Oral Health Outcomes in an Adult Population in Brazil," *BMC Public Health* 18, no. 1 (2017): 60, <https://doi.org/10.1186/s12889-017-4443-0>.
6. J. R. Sukhabogi, D. Doshi, M. Vadlamani, and V. Rahul, "Association of Oral Health Literacy With Oral Health Behavior and Oral Health Outcomes Among Adult Dental Patients," *Indian Journal of Dental Research* 31, no. 6 (2020): 835–839, [https://doi.org/10.4103/ijdr.IJDR\\_337\\_19](https://doi.org/10.4103/ijdr.IJDR_337_19).
7. T. Chakraborty, M. S. Kaper, J. Almansa, A. A. Schuller, and S. A. Reijneveld, "Health Literacy, Oral Diseases, and Contributing Pathways: Results From the Lifelines Cohort Study," *Journal of Dentistry* 153 (2025): 105530, <https://doi.org/10.1016/j.jdent.2024.105530>.
8. J. S. Holtzman, K. A. Atchison, M. W. Gironda, R. Radbod, and J. Gornbein, "The Association Between Oral Health Literacy and Failed Appointments in Adults Attending a University-Based General Dental Clinic," *Community Dentistry and Oral Epidemiology* 42, no. 3 (2014): 263–270, <https://doi.org/10.1111/cdoe.12089>.
9. S. Yu, S. Huang, S. Song, J. Lin, and F. Liu, "Impact of Oral Health Literacy on Oral Health Behaviors and Outcomes Among the Older Adults: A Scoping Review," *BMC Geriatrics* 24, no. 1 (2024): 858, <https://doi.org/10.1186/s12877-024-05469-1>.
10. J. K. Baskaradoss, "Relationship Between Oral Health Literacy and Oral Health Status," *BMC Oral Health* 18, no. 1 (2018): 172, <https://doi.org/10.1186/s12903-018-0640-1>.
11. M. Ghaffari, S. Rakhshanderou, A. Ramezankhani, Y. Mehrabi, and A. Safari-Moradabadi, "Systematic Review of the Tools of Oral and Dental Health Literacy: Assessment of Conceptual Dimensions and Psychometric Properties," *BMC Oral Health* 20, no. 1 (2020): 186, <https://doi.org/10.1186/s12903-020-01170-y>.
12. K. Spinler, R. Valdez, G. Aarabi, et al., "Development of the Oral Health Literacy Profile (OHLPP)-Psychometric Properties of the Oral Health and Dental Health System Knowledge Scales," *Community Dentistry and Oral Epidemiology* 49, no. 6 (2021): 609–616, <https://doi.org/10.1111/cdoe.12688>.
13. K. Spinler, M. T. Weil, R. Valdez, et al., "Oral Health Literacy of Persons With Migration Background-First Results of the MuMi Study," *Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz* 64, no. 8 (2021): 977–985, <https://doi.org/10.1007/s00103-021-03371-4>.
14. V. Maizes, D. Raketel, and C. Niemiec, "Integrative Medicine and Patient-Centered Care," *Explore (New York, N.Y.)* 5, no. 5 (2009): 277–289, <https://doi.org/10.1016/j.explore.2009.06.008>.
15. J. T. Newton and K. Asimakopoulou, "Minimally Invasive Dentistry: Enhancing Oral Health Related Behaviour Through Behaviour Change Techniques," *British Dental Journal* 223, no. 3 (2017): 147–150, <https://doi.org/10.1038/sj.bdj.2017.659>.
16. C. Albury, A. Hall, A. Syed, et al., "Communication Practices for Delivering Health Behaviour Change Conversations in Primary Care: A Systematic Review and Thematic Synthesis," *BMC Family Practice* 20, no. 1 (2019): 111, <https://doi.org/10.1186/s12875-019-0992-x>.

17. L. Rutter, R. Duara, K. A. Vinall-Collier, et al., "Experiences of Newly Qualified Dentists in Delivering Oral Health Advice to Parents/Caregivers of Young Children-Challenges and Solutions," *Frontiers in Oral Health* 4 (2023): 1079584, <https://doi.org/10.3389/froh.2023.1079584>.
18. J. C. Field, A. Kavadella, S. Szep, J. R. Davies, E. DeLap, and M. C. Manzanara Cespedes, "The Graduating European Dentist-Domain III: Patient-Centred Care," *European Journal of Dental Education* 21, no. Suppl 1 (2017): 18–24, <https://doi.org/10.1111/eje.12310>.
19. A. Söhnel, R. Frankenberger, L. Kandsperger, and F. Wissing, "NKLZ 2.0: The Further Development of the National Competence-Based Learning Objectives Catalogue for Dentistry as a Basis for the Design of the New Licensing Regulations," *Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz* 66, no. 12 (2023): 1336–1344, <https://doi.org/10.1007/s00103-023-03794-1>.
20. A. J. Plasschaert, W. P. Holbrook, E. Delap, C. Martinez, and A. D. Walmsley, "Profile and Competences for the European Dentist," *European Journal of Dental Education* 9, no. 3 (2005): 98–107, <https://doi.org/10.1111/j.1600-0579.2005.00369.x>.
21. N. V. Lichtenstein, R. Haak, I. Ensmann, et al., "Does Teaching Social and Communicative Competences Influence Dental Students' Attitudes Towards Learning Communication Skills? A Comparison Between Two Dental Schools in Germany," *GMS Journal for Medical Education* 35, no. 2 (2018): 18, <https://doi.org/10.3205/zma001165>.
22. R. A. Jordan, C. Bodechtel, K. Hertrampf, et al., "The Fifth German Oral Health Study (Fünfte Deutsche Mundgesundheitsstudie, DMS V)–Rationale, Design, and Methods," *BMC Oral Health* 14 (2014): 161, <https://doi.org/10.1186/1472-6831-14-161>.
23. World Health Organization, ed., *Oral Health Surveys: Basic Methods*, 5th ed. (World Health Organization, 2013).
24. J. Cohen, *Statistical Power Analysis for the Behavioral Sciences* (Routledge, 2013).
25. J. Cohen, "A Power Primer," *Psychology Bulletin* 112, no. 1 (1992): 155–159.
26. S. C. Makarem and J. M. Coe, "Patient Retention at Dental School Clinics: A Marketing Perspective," *Journal of Dental Education* 78, no. 11 (2014): 1513–1520.
27. A. Jordan, W. Micheelis, C. Cholmakow-Bodechtel, et al., *Fünfte Deutsche Mundgesundheitsstudie (DMS V) [Fifth German Oral Health Study]* (Deutscher Zahnärzte Verlag DÄV, 2016).
28. F. M. V. Veladas, G. De la Torre Canales, B. B. de Souza Nobre, et al., "Do Sociodemographic Factors Influence the Levels of Health and Oral Literacy? A Cross-Sectional Study," *BMC Public Health* 23, no. 1 (2023): 2543, <https://doi.org/10.1186/s12889-023-17489-4>.
29. K. D. Vilella, S. G. Alves, J. F. de Souza, F. C. Fraiz, and L. R. Assunção, "The Association of Oral Health Literacy and Oral Health Knowledge With Social Determinants in Pregnant Brazilian Women," *Journal of Community Health* 41, no. 5 (2016): 1027–1032, <https://doi.org/10.1007/s10900-016-0186-6>.
30. K. Sørensen, S. Van den Broucke, J. Fullam, et al., "Health Literacy and Public Health: A Systematic Review and Integration of Definitions and Models," *BMC Public Health* 12, no. 1 (2012): 80, <https://doi.org/10.1186/1471-2458-12-80>.
31. M. Jones, J. Y. Lee, and R. G. Rozier, "Oral Health Literacy Among Adult Patients Seeking Dental Care," *Journal of the American Dental Association* 138, no. 9 (2007): 1199–1208, <https://doi.org/10.14219/jada.archive.2007.0344>.
32. R. Aunger, "Tooth Brushing as Routine Behaviour," *International Dental Journal* 57 (2007): 364–376, <https://doi.org/10.1111/j.1875-595X.2007.tb00163.x>.
33. P. E. Petersen, "The World Oral Health Report 2003: Continuous Improvement of Oral Health in the 21st Century—The Approach of the WHO Global Oral Health Programme," *Community Dentistry and Oral Epidemiology* 31, no. Suppl 1 (2003): 3–23, <https://doi.org/10.1046/j.2003.com122.x>.
34. R. Deinzer and A. R. Jordan, "Periodontal Health Literacy in Germany-Results of a Telephone Survey," *International Journal of Dental Hygiene* 22, no. 4 (2024): 887–896, <https://doi.org/10.1111/idh.12803>.
35. P. A. Boyle, L. Yu, R. S. Wilson, E. Segawa, A. S. Buchman, and D. A. Bennett, "Cognitive Decline Impairs Financial and Health Literacy Among Community-Based Older Persons Without Dementia," *Psychology and Aging* 28, no. 3 (2013): 614–624, <https://doi.org/10.1037/a0033103>.
36. V. W. McCarlie, Jr., M. E. Phillips, B. D. Price, P. B. Taylor, G. J. Eckert, and K. T. Stewart, "Orthodontic and Oral Health Literacy in Adults," *PLoS One* 17, no. 8 (2022): e0273328, <https://doi.org/10.1371/journal.pone.0273328>.
37. C. J. Lee, M. H. Ho, J. Y. Joo, et al., "Gender Differences in the Association Between Oral Health Literacy and Oral Health-Related Quality of Life in Older Adults," *BMC Oral Health* 22, no. 1 (2022): 205, <https://doi.org/10.1186/s12903-022-02237-8>.
38. S. Su, M. S. Lipsky, F. W. Licari, and M. Hung, "Comparing Oral Health Behaviours of Men and Women in the United States," *Journal of Dentistry* 122 (2022): 104157, <https://doi.org/10.1016/j.jdent.2022.104157>.
39. Association for Dental Education in Europe (ADEE), "Graduating European Dentist Curriculum," (2025), <https://adee.org/graduating-european-dentist/graduating-european-dentist-curriculum>.
40. Association for Dental Education in Europe (ADEE), "Methods of Teaching and Assessment," (2025), <https://adee.org/graduating-european-dentist/graduating-european-dentist-curriculum>.
41. S. Azimi, A. A. AsgharNejad Farid, M. J. Kharazi Fard, and N. Khoei, "Emotional Intelligence of Dental Students and Patient Satisfaction," *European Journal of Dental Education* 14, no. 3 (2010): 129–132, <https://doi.org/10.1111/j.1600-0579.2009.00596.x>.
42. I. Macpherson, E. Sanagustin, M. V. Roqué, and L. Giner-Tarrida, "Evaluation of Relational Factor in Patient Satisfaction With the Treatment Received by Dental Students," *European Journal of Dental Education* 28, no. 2 (2024): 548–558, <https://doi.org/10.1111/eje.12980>.
43. M. Sanz, D. Herrera, M. Kebschull, et al., "Treatment of Stage I-III Periodontitis-The EFP S3 Level Clinical Practice Guideline," *Journal of Clinical Periodontology* 47, no. Suppl 22 (2020): 4–60, <https://doi.org/10.1111/jcpe.13290>.

## Appendix 1

### Regression Analysis of Predictors of Oral Health Behaviour

Predictors	Oral Health Behaviour Score		
	Estimates	Confidence interval	<i>p</i>
Age (years)	0.99*	0.17–1.82	<b>0.019*</b>
Male	<i>Reference</i>		
Female	7.63**	3.01–12.25	<b>0.001**</b>
I (age (years) <sup>2</sup> )	–0.01	–0.01 – 0.00	0.064
OHK Score	0.30***	0.19–0.40	<b>&lt;0.001***</b>
Normal	<i>Reference</i>		
Perio Patient	6.19*	1.18–11.19	<b>0.016</b>
Observations		217	
<i>R</i> <sup>2</sup> / <i>R</i> <sup>2</sup> adjusted		0.249/0.232	

Note: \**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

Abbreviation: OHK, oral health knowledge.

#### Detailed Information About the Statistical Model

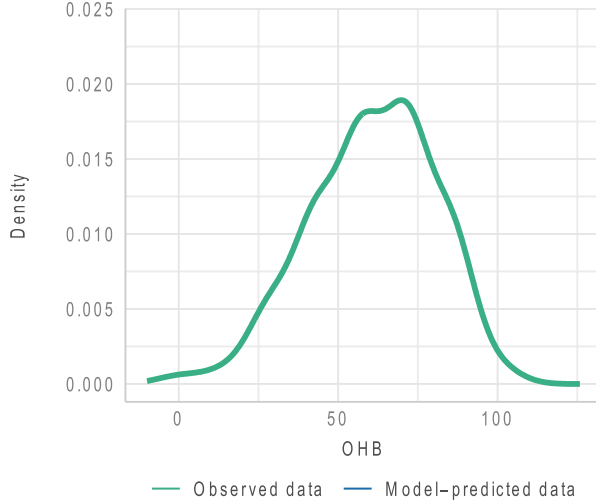
The model explains a statistically significant and moderate proportion of variance in the oral health behaviour (OHB) variable ( $R^2=0.25$ ,  $F(5,211)=14.02$ ,  $p<0.001$ , adjusted  $R^2=0.23$ ). The model's intercept, corresponding to Age = 0, Sex = male, Periodontal therapy = other patient, and OHK = 0, was at 10.66 (95% confidence interval (CI)-10.49, 31.81,  $t(211)=0.99$ ,  $p=0.321$ ). The coefficients in the regression model represent the change in the dependent variable (OHB) associated with a one-unit increase in the corresponding independent variable, holding all other variables constant. Within this model, the effect of Age was statistically significant and positive (beta = 0.99, 95% CI 0.17, 1.82,  $\eta^2=0.0649$ ,  $t(211)=2.37$ ,  $p=0.019$ ; Std. beta = 0.15, 95% CI 0.01, 0.28), the effect of Squared Age (Age<sup>2</sup>) was statistically non-significant and negative (beta = –7.20e-03, 95% CI –0.01, 4.27e-04,  $\eta^2=0.0255$ ,  $t(211)=-1.86$ ,  $p=0.064$ ; Std. beta = –0.10, 95% CI [–0.20, 5.82e-03]), the effect of Sex [female] was statistically significant and positive (beta = 7.63, 95% CI 3.01, 12.25,  $\eta^2=0.0324$ ,  $t(211)=3.25$ ,  $p=0.001$ ; Std. beta = 0.39, 95% CI 0.16, 0.63), the effect of periodontal therapy (perio patient) was statistically significant and positive (beta = 6.19, 95% CI 1.18, 11.19,  $\eta^2=0.0123$ ,  $t(211)=2.44$ ,  $p=0.016$ ; Std. beta = 0.32, 95% CI 0.06, 0.58), and the effect of oral health knowledge (OHK) was statistically significant and positive (beta = 0.30, 95% CI 0.19, 0.40,  $\eta^2=0.1143$ ,  $t(211)=5.67$ ,  $p<0.001$ ; Std. beta = 0.35, 95% CI 0.23, 0.47). The model's coefficients were estimated using ordinary least squares regression. The 95% CI and *p*-values were computed using a Wald *t*-distribution approximation (Figure 6 in the main document).

**Appendix 2**

Model Diagnostic Plots Assessing Model Fit, Assumptions, and Potential Issues Such as Collinearity, Normality, Linearity, and Influential Observations.

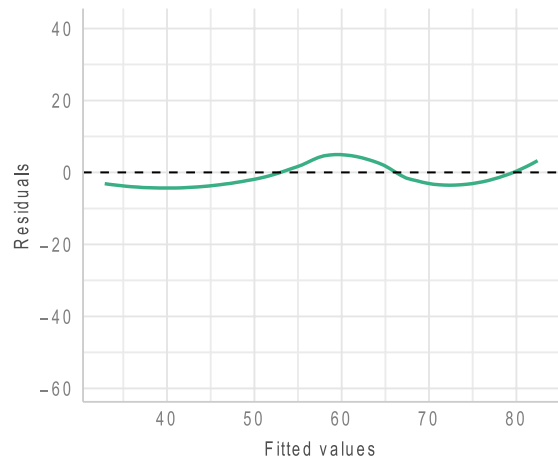
**Posterior Predictive Check**

Model-predicted lines should resemble observed data line



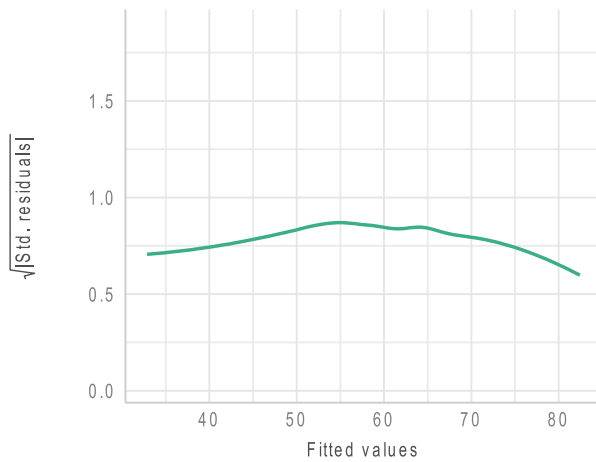
**Linearity**

Reference line should be flat and horizontal



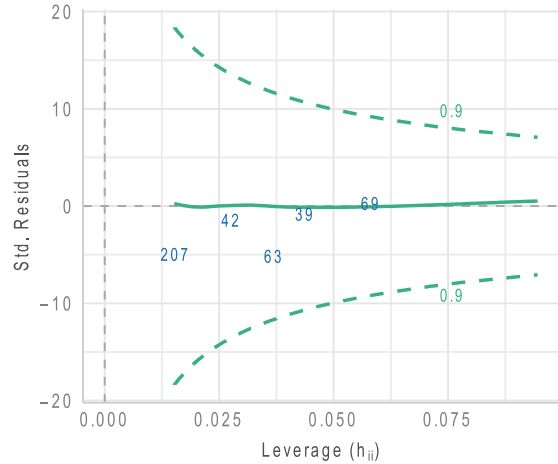
**Homogeneity of Variance**

Reference line should be flat and horizontal



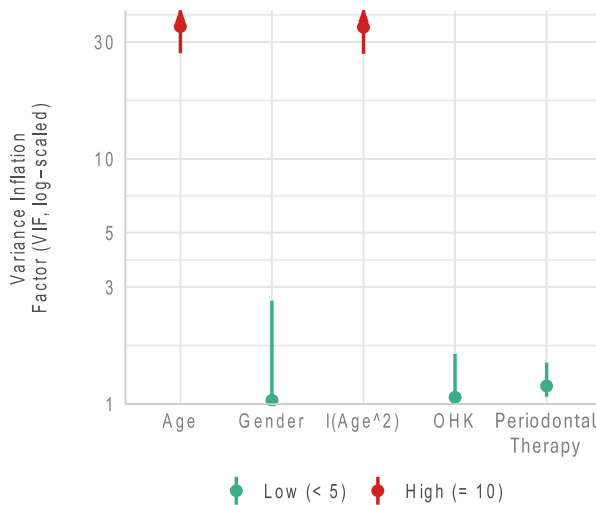
**Influential Observations**

Points should be inside the contour lines



**Collinearity**

High collinearity (VIF) may inflate parameter uncertainty



**Normality of Residuals**

Dots should fall along the line

