# INSTITUTO UNIVERSITÁRIO EGAS MONIZ

## MESTRADO INTEGRADO EM MEDICINA DENTÁRIA

# FACTORS CONFOUNDING ORAL HEALTH RELATED QUALITY OF LIFE QUESTIONNAIRES OUTCOMES IN ELDERLY PEOPLE: A SYSTEMATIC REVIEW

Trabalho submetido por

**ERIKA JUSTO MARQUES**

para a obtenção do grau de Mestre em Medicina Dentária

**setembro de 2022**

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Trabalho orientado por

**DOUTOR VITOR JOSÉ GLAZIOU TAVARES**

E coorientado por

**MESTRE PAULO SOBRAL MASCARENHAS**


**setembro de 2022**

**DEDICATION**

I dedicate this work to my beloved husband, João Frigerio.

Your love and support have been crucial in bringing me this far.

Trago dentro do meu coração,
Como num cofre que se não pode fechar de cheio,
Todos os lugares onde estive,
Todos os portos a que cheguei,
Todas as paisagens que vi através de janelas ou vigias,
Ou de tombadilhos, sonhando,
E tudo isso, que é tanto, é pouco para o que eu quero.
(Álvaro de Campos)

**AKNOWLEDGMENT**

I would like to thank my mother, Regina Justo, who walked a long and difficult path by my side, but who never let me lose hope that I would make it.

To my father, Octacílio Lima, thank you for giving me the privilege of being your daughter.

In memory of my grandparents Lidia Justo and José Justo, who are no longer with us, but who will always be in my thoughts and in my heart.

To my supervisor, Professor Vitor Glaziou Tavares, who provided me the opportunity to work in geriatrics. Thank you for your availability, attention, and thoughtfulness during the development of this project.

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## ABSTRACT

**Background:** Oral health related quality of life can be evaluated by many validated questionnaires reported in the literature. However, some confounding variables can change the results of the questionnaires. To globally address this issue, we reviewed which confounding variables influence more the Oral Health Related Quality of Life (OHRQoL) questionnaires in elderly people outcomes, specifically the Geriatric Oral Health Assessment Index (GOHAI) and the Oral Health Impact Profile (OHIP).

**Methods:** The following databases we used for data collection: PubMed, Cochrane Central Register of Controlled Trials, Scopus, B-on and Web of Science. The search strategy used was ((“GOHAI”) AND (“OHIP”)) NOT (“Review”). Studies from 1st January 2001 to 15th January 2022 were included. The risk of bias was assessed using the “Methods commentary: Risk of bias in cross-sectional surveys of attitudes and practice” (Agarwal et al., 2017) and the plots generated by the ROBVIS Tool. The results were subjected to random-effects meta-analysis using the software Open Meta Analyst. Statistical results were considered significant if $p<0.05$.

**Results:** In total, 197 articles were found. After removing duplicates, 125 articles remained. After the first screening by title and abstract, 40 articles were selected. After a second screening for inclusion criteria compliance (population over 60 years old without cognitive impairment and the use of the GOHAI and OHIP questionnaires), 8 articles including 1613 elderly patients were included. The meta-analysis revealed a substantial disparity between the results for both questionnaires. The confounding variable that had the most significant effect on OHRQoL in the elderly was xerostomia; however, the gross domestic product (the standard measure of the value added created by the production of products and services in a country over a specified period) did not appear to affect the outcomes. In addition, the questionnaires' sensitivity differs for each covariate: While the GOHAI was highly sensitive to the ratio of women to men, xerostomia, and the population human capital index, the OHIP-14 was more sensitive to edentulism, denture use, and the population poverty index.

**Conclusion:** This study demonstrated that some variables substantially affect the OHRQoL of elderly patients. Dentists and other health professionals must be aware of

these variations to minimize their impact on treatment. Thus, the clinical approach to geriatric patients requires knowledge of evaluation tools, their domains, and sensitivity.

**Keywords:** OHRQOL, GOHAI, OHIP, geriatrics

**RESUMO**

**Introdução:** A qualidade de vida relacionada à saúde bucal pode ser avaliada por diversos questionários validados e relatados na literatura. No entanto, algumas variáveis de confusão podem alterar os resultados. Para abordar globalmente essa questão, revisamos quais são as variáveis que influenciam mais os questionários de Qualidade de Vida Relacionada à Saúde Bucal (QVRSB) em idosos, especificamente o Geriatric Oral Health Assessment Index (GOHAI) e o Oral Health Impact Profile (OHIP).

**Métodos:** Utilizamos as seguintes bases de dados para coleta de dados: PubMed, Cochrane Central Register of Controlled Trials, Scopus, B-on e Web of Science. A estratégia de busca utilizada foi ((("GOHAI") AND ("OHIP")) NOT ("Review"). Foram incluídos estudos de 1º de janeiro de 2001 a 15 de janeiro de 2022. O risco de viés foi avaliado usando o "Methods commentary: Risk of bias in cross-sectional surveys of attitudes and practice" (Agarwal et al., 2017) e os gráficos gerados pela ferramenta ROBVIS. Os resultados foram submetidos à meta-análise de efeitos aleatórios utilizando o software Open Meta Analyst. Os resultados estatísticos foram considerados significativos se $p<0,05$.

Resultados: No total, foram encontrados 197 artigos. Após a remoção das duplicatas, restaram 125 artigos. Em seguida, foi feita uma primeira triagem por título e resumo, onde 40 artigos foram selecionados. Numa segunda triagem onde aplicou-se os critérios de inclusão (população acima de 60 anos sem comprometimento cognitivo e uso dos questionários GOHAI e OHIP), 8 artigos foram escolhidos, incluindo 1.613 pacientes idosos. A meta-análise revelou grande disparidade entre os resultados de ambos os questionários. A variável de confusão que teve maior efeito na QVRSB foi a xerostomia; no entanto, o Produto Interno Bruto (PIB) (a medida padrão do valor agregado criado pela produção de produtos e serviços em um país durante um período de tempo especificado) não pareceu afetar os resultados. Além disso, a sensibilidade dos questionários difere para cada covariável: enquanto o GOHAI foi altamente sensível à proporção de mulheres para homens, xerostomia e o índice de capital humano populacional, o OHIP-14 foi mais sensível ao edentulismo, uso de próteses e índice de pobreza da população.

**Conclusão:** Este estudo mostrou que algumas variáveis têm grande impacto na QVRSB em pacientes idosos. O dentista e os profissionais da saúde devem estar atentos a estas

alterações para que estas sejam minimizadas durante o tratamento. O conhecimento das ferramentas de avaliação, seus domínios e sua sensibilidade também são informações relevantes na abordagem clínica do paciente idoso.

**Palavras-chave:** QVRSB, GOHAI, OHIP, geriatria

**SUMMARY**

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## LIST OF ACRONYMS

**GOHAI** – Geriatric Oral Health Assessment Index

**OHIP-14** – Oral Health Impact Profile

**OHRQoL** – Oral Health Related Quality of Life

**Ratio F/M** – Ratio Feminine / Masculine

**SD** – Standard Deviation

**HCI** – Human Capital Index

**GDP per capita** – Gross Domestic Product per capita

# INTRODUCTION

The 20th century brought medical advances that made a significant increase in life expectancy possible. The discovery of antibiotics, vaccination campaigns and the increasing knowledge of microbiology have changed how humankind relates to diseases and their treatments. These advances have enabled us to reach the 21st century with an average life expectancy of over 70 years (World Health Organization, 2022). However, if, on the one hand, many diseases were extinguished, on the other hand, medicine has faced new challenges inherent to ageing. Thus, the higher incidence of chronic diseases and the development of increasingly effective treatment generate an important burden on health systems, which are often unprepared to meet the needs of geriatric patients.

According to data from the World Health Organization (2021), in 2030, one in six people will be over 60 years old, and the number of people over 80 years will triple between 2020 and 2050. The most common diseases resulting from ageing are, among others: immunological problems, cardiovascular diseases, hypertension, cancer, osteoporosis, osteoarthritis, dementia, and diabetes mellitus (Jaul & Barron, 2017). In addition, with senescence, physical changes such as mobility impairment, falls, muscle fragility and motor changes also occur, which may have a direct relationship with oral health due to the difficulty of efficiently performing an oral hygiene routine. Considering these facts, it is of great importance that health professionals are ready to identify the most recurrent problems and their prevalence. However, among the typical diseases of aging, oral issues such as dental caries and periodontal disease are rarely mentioned, as well the oral consequences of polypharmacy. Theses diseases can lead to tooth loss, impacting the quality of life of these patients.

Edentulism remains a significant public health issue, and multiple studies have demonstrated a considerable rise in the prevalence of edentulism from age 65 (Khanagar et al., 2020). Even though dental health is an essential component of general health maintenance, it is sometimes neglected due to a lack of knowledge, insufficient resources, or limited access to appropriate treatments. In addition, geriatric patients have different needs from other age groups, so dental treatment must be adapted. Usually, these patients arrive with many dental problems resulting from years of neglecting oral health that

culminated in progressive adaptations. In this case, it is up to the dentist to reestablish the physiological balance of the stomatognathic system.

Between 20 and 50% of the world population is affected by periodontal disease (Sanz et al., 2010). Several systematic reviews in the literature show that this disease is associated with the risk of developing and/or worsening other systemic conditions, such as coronary heart diseases, *diabetes mellitus*, chronic systemic diseases such as cancer, cardiovascular and intestinal diseases, Alzheimer's, rheumatoid arthritis and even low birth weight and preterm birth effects (Humphrey et al., 2008; Nguyen et al., 2020; Peng et al., 2022; Teshome & Yitayeh, 2016). Besides, *Streptococcus mutans* (*S. mutans*), a well-studied bacterium known as the leading cause of dental caries, may trigger infective endocarditis. This cardiac condition has been associated with brain haemorrhages, non-alcoholic steatohepatitis and inflammatory bowel disease (Ito et al., 2019).

Han-A Cho (2021) studied the relationship between tooth loss and cognitive impairment in elderly people in South Korea and concluded that oral health maintenance significantly impacts the maintenance of physical and cognitive functions. A systematic review by Farias et al. (2020) showed that institutionalized elderly have a higher rate of tooth loss and a lower rate of oral rehabilitation, significantly compromising the masticatory function. The impairment of the masticatory function can have severe consequences regarding the type of diet and nutrient absorption, considerably affecting the nutritional status of the elderly and further compromising their systemic health. Cereda et al. (2016) studied the nutritional status of institutionalized older adults according to healthcare settings and concluded that they are more susceptible to malnutrition.

Nowadays, the most common treatment among the elderly is partial or total removable dentures because it is still the cheapest option and has an acceptable aesthetic and functional prognosis. However, it has some limitations as a source of patient dissatisfaction (Doundoulakis et al., 2003). De Souza e Silva et al. (2009) showed that 66% of patients are dissatisfied with their dentures mainly due to pain and lack of retention of lower dentures. According to the author, for this type of treatment to be successful, the dentist must make good quality impressions to promote good masticatory efficiency.

In short, oral diseases lead to a loss of quality of life in elderly individuals. That is because good oral health means more than having healthy teeth and gums. It also means being healthy all over. This impact is widely studied in the literature, and the patient's point of view often measures it. The concept of Oral Health Related Quality of Life (OHRQoL) was developed to assess oral health subjective self-perception aspects, namely the satisfaction and expectations regarding one's oral condition (Adamo et al., 2020); thus, it is not directly measurable. For this reason, when these questionnaires are applied we must also observe other external variables that can influence their results, such as age, gender, social condition, cultural differences, negative affectivity, and health diseases (Bresciani et al., 2005). In short, a better OHRQoL implies a better self-perception of oral health, while a worse OHRQoL implies a worse self-perception of oral health.

Several questionnaires measure OHRQoL, but the most used is the Oral Health Impact Profile (OHIP), developed and validated by Slade & Spencer (1994) to measure and evaluate how oral diseases affect levels of disability, discomfort and dysfunctions in each individual. This questionnaire is already validated worldwide in several languages. It has demonstrated a significant correspondence between clinical, oral and socio-demographic variables that assures its validity as an important tool for OHRQoL evaluation (Adamo et al., 2020). OHIP evaluates the OHRQoL through 7 domains: physical pain, physical disability, functional limitations, psychological disability, psychological discomfort, social disability and handicap (El Osta et al., 2012). It was originally developed with 49 questions, but this number of questions often limits its use. The author then developed a shorter version with only 14 questions that assess the OHRQoL with the same reliability, validity and precision. (Slade, 1997). Later, the questionnaire gained a version adapted to edentulous patients, called OHIP-EDENT, with 19 questions that evaluate the same domains as the original OHIP-49 and OHIP-14 (David Locker & Allen, 2002). However, in this case, the questions address some problems usually found in edentulous patients, such as masticatory efficiency, pleasure in eating, comfort while wearing prothesis and social impact (Allen & Locker, 2002). To evaluate the impact of oral health in quality of life, the original questionnaire uses a Likert-type scale code, where 4 = “very often”, 3 = “fairly often”, 2 = “occasionally”, 1 = “hardly ever”, and 0 = “never”. The result is obtained by summing the score of each response.

Since the questions describe different types of oral imparments, a higher score means that the patient has a worse self-perception of oral health, thus, a worse OHRQoL.

Another questionnaire widely used in the literature is the Geriatric Oral Health Assessment Index (GOHAI), developed in the United States by Atchison & Dolan (1990) to measure OHRQoL in geriatric patients. This instrument was designed to understand the geriatric problems in dentistry better and answer the need to evolve scientific knowledge in this area (Bresciani, 2005). This questionnaire comprises 12 questions based on 3 domains: physical and functional functions, psychological aspects and pain/discomfort (de Medeiros et coll., 2020). The original questionnaire uses a three point Likert-type scale coded, from which 1 = “always, often”, 2 = “sometimes, seldom”, and 3 = “never”. The result is obtained by summing the score of each response. The questions also describe different types of oral impairments; hence, for GOHAI, a higher score means that the patient has a better self-perception of oral health, thus, a better OHRQoL. Despite the scales being standardized in the original studies, several types of scales were found in the literature.

Therefore, considering that the evaluation of OHRQoL is a subjective concept, this systematic review aims to identify the confounding variables that influence the results of the two most used questionnaires of OHRQoL, the GOHAI and OHIP.

# METHODOLOGY

## Framework and Search Protocol

This review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021) and was registered on PROSPERO (ID CRD42022323422).

To perform this systematic review, we initially defined the PICO framework to help the ground to build the inclusion and exclusion criteria:

P (population) – elderly subjects, eventually with oral health issues

I (intervention) – not applicable

C (comparison) – not applicable

O (outcome) – GOHAI/OHIP-14 scores

We searched for English, French or Portuguese studies from 1st January 2001 to 15th January 2022 on five databases: PubMed, Cochrane Central Register of Controlled Trials, Scopus, B-on and Web of Science. We applied the search time frame because the GOHAI and OHIP were created and validated in 1990 and 1994, respectively, and the first studies we found with the search strategy and that met the inclusion criteria were from 2001.

The search strategy used was: "GOHAI AND OHIP NOT review." Since GOHAI and OHIP are the two most used tools for OHRQoL assessment, the objective was to compare GOHAI/OHIP scores and evaluate how they are affected by confounding variables in the same population. Therefore studies were required to have applied both questionnaires.

## The inclusion criteria

- Older adults aged 60 years or more
- Studies that employed both questionnaires: GOHAI and OHIP.

**The exclusion criteria**

- Reviews and systematic review
- Descriptive studies
- Study protocols
- Questionnaires validations to other languages
- Older adults with cognitive impairment. But, if the study had a control group without cognitive impairment who met the inclusion criteria, it was included in the review.

**Selection Process**

For the selection process, search results were first collected from the previously mentioned databases and imported to Mendeley Desktop software, where the replicates were removed. Afterwards, articles were pre-selected through titles and abstracts review by applying the inclusion and exclusion criteria. Finally, the remaining articles were entirely read and selected for the systematic review. This phase was performed on Rayyan platform (Rayyan, n.d.).

**Data extraction**

Next, the selected articles were collected and analyzed, and the following data of each study was recorded:

- Sample size (N)
- Mean age
- Ratio F/M
- Location
- Years of education (mean)
- Edentulism (%)
- Removable dentures (%)
- Xerostomia (%)
- Perception of oral health

After the article selection and the data extraction, we performed the studies' quality assessment through the risk of bias questionnaire for cross-sectional studies (Agarwal et al., 2017).

**Meta-analysis**

We observed that, depending on the validation language and the author's convenience, different scales had been adopted for each GOHAI/OHIP question among the selected studies. Therefore, before meta-analysis, we converted (if needed) each study's GOHAI/OHIP scale distribution frequencies, for each question, to a decreasing Likert scale from 1 to 5, where 5 = always, 4 = frequently, 3 = occasionally, 2 = rarely, and 1 = never. In this case, since each question describes the frequency of different oral issues, a higher score for the questionnaires implies a worse self-perception of oral health and a worse OHRQoL. To perform the conversion, two methods were used:

- If the original scale was decreasing as well, the score conversion was performed directly by the following formula:

$$Y = \left(\frac{X - Xmin}{Xrange}\right)n$$

Where Y is the adjusted scale X is the original score, $X_{min}$ is the minimum value in the original scale, $X_{range}$ is the difference between the original maximum and minimum score, and n is the modified scale upper limit.

- If the original scale was increasing, that is, it moved in the opposite direction of the new scale chosen, standardization was performed using raw data through a weighted average of each question's score. We contacted the authors and asked for the raw data to standardize the scales, but we received no answer. As a result, three studies on the GOHAI questionnaire were removed from the meta-analysis: de Medeiros et al. (2020), Hassel et al. (2011) and Schuster et al. (2019), because a simple inversion of the scales would create a bias on the results.

Additionally, the standard deviations needed rescaling. This was performed using the following equation:

$$SDrescaled = SDoriginal \times \left(\frac{Xrange\_novo}{Xrange\_original}\right)$$

The questionnaires results were calculated by summing up the values of the scores obtained for all questions. Thus, a higher score indicated a negative view of oral health in both questionnaires, ranging from 12 to 60 points for GOHAI and 14 to 70 points for OHIP.

Meta-analyses and meta-regressions were performed using the software OpenMeta [Analyst] Yosemite 10.10. GOHAI and OHIP mean scores effect sizes and associated uncertainty were used to fit meta-analytic and meta-regression random effects models with parameters estimated by restricted maximum likelihood. Heterogeneity was evaluated by $I^2$ index and considered high every time $I^2$>50%. We correlated the confounding variables with the GOHAI/OHIP scores in the meta-regressions. The meta-regression coefficients (Pearson r) allowed us to evaluate the confusion effect of covariates. The statistic tests were performed with a 95% confidence level.

## RESULTS

The first search in the databases yielded 197 items, of which 72 replicates were deleted. The remaining 125 were selected based on titles and abstract review. This first screening eliminated 85 items, leaving a total of 40 articles for a complete reading. Among them, 4 articles could not be found as full records, so they were also left out of the study. The 36 remaining articles were evaluated according to the inclusion and exclusion criteria and, after this second screening, 8 studies were included in the systematic review.

The selection process is detailed below, according to the PRISMA Flowchart:

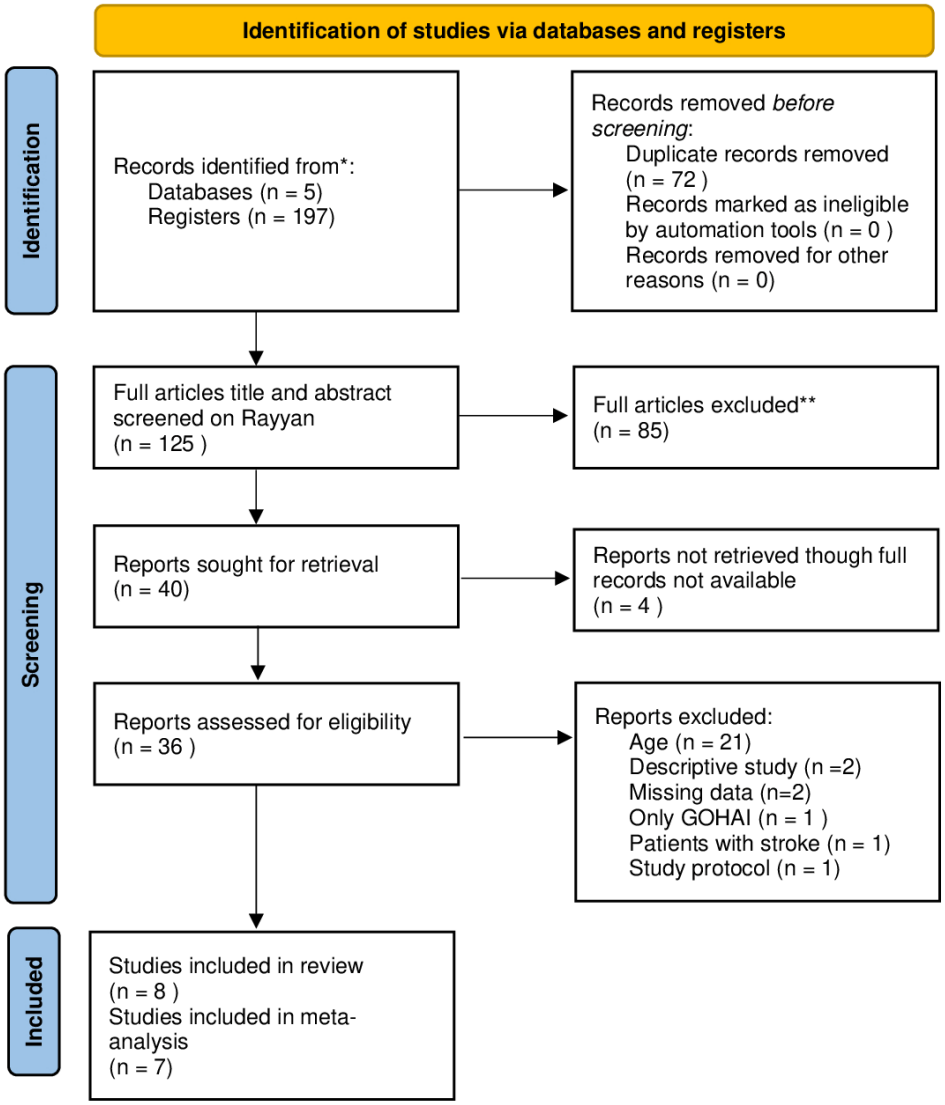


***Figure 1*** *- Research flowchart according to the PRISMA*

After the complete screening and data extraction, we proceed with the risk of bias analysis through "Methods commentary: Risk of bias in cross-sectional surveys of attitudes and practice" (Agarwal et al., 2017) and the ROBVIS tool. The Traffic Light and the Summary Plots are represented below:

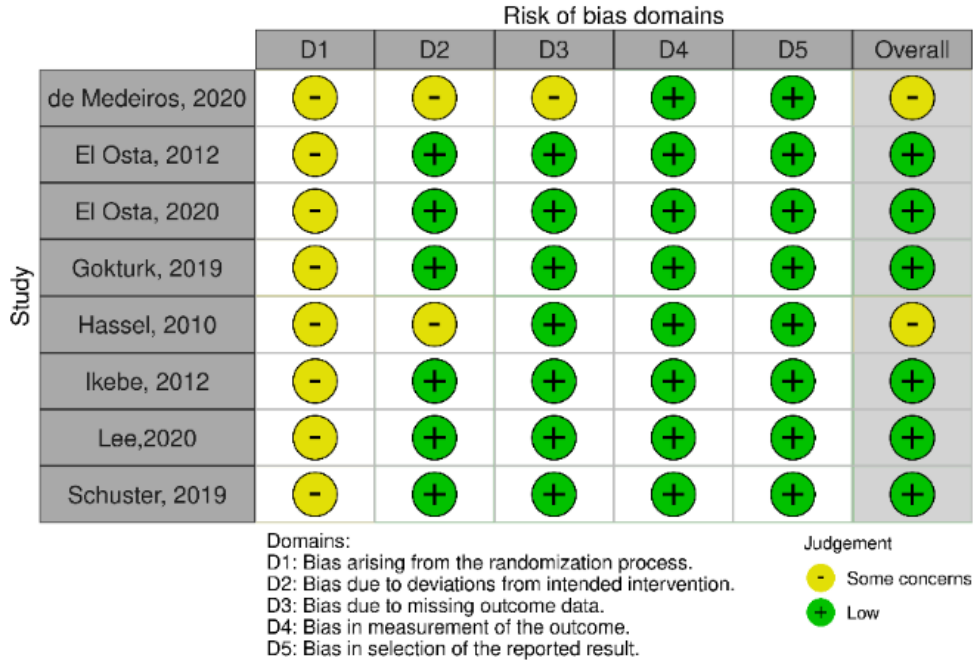


***Figure 2*** *- Traffic Light plot from ROBVIS Tool*

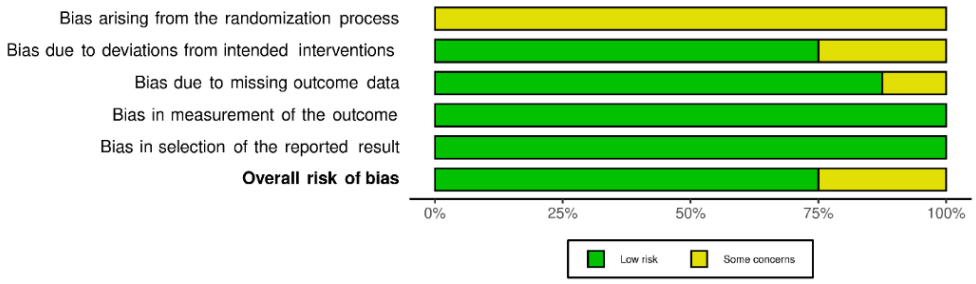


***Figure 3*** *- Summary Plot from ROBVIS Tool*

## Descriptive analysis

The converted scores for each study are shown in Tables 1 and 2:

***Table 1*** *- Table of GOHAI scores from each study*

| | ***GOHAI*** | ***SD*** |
|---|---|---|
| ***El Osta, 2020*** | 19.85 | 9.40 |
| ***El Osta, 2012*** | 24.90 | 11.20 |
| ***Lee, 2019*** | 18.13 | 7.51 |
| ***Ikebe, 2012*** | 21.36 | 6.00 |
| ***Gokturk, 2018*** | 20.65 | 9.27 |
| ***De Medeiros, 2020*** | - | - |
| ***Hassel, 2010*** | - | - |
| ***Schuster, 2019*** | - | - |

***Table 2*** *- Table of OHIP-14 scores from each study*

| | ***OHIP-14*** | ***SD*** |
|---|---|---|
| ***El Osta, 2020*** | 19.90 | 9.25 |
| ***El Osta, 2012*** | 21.94 | 9.30 |
| ***Lee, 2019*** | 20.67 | 8.14 |
| ***Ikebe, 2012*** | 24.00 | 8.40 |
| ***Gokturk, 2018*** | 27.85 | 7.59 |
| ***De Medeiros, 2020*** | 21.58 | 8.64 |
| ***Hassel, 2010*** | 18.40 | 5.70 |

The general data from each study are summarized in Table 3, while the oral status of the populations in each study is detailed in Table 4:

***Table 3*** *- Table of General Data from each study*

| | ***N*** | ***Mean age (SD)*** | ***Ratio F/M*** | ***Location*** | ***Years of Education (mean)*** |
|---|---|---|---|---|---|
| ***El Osta, 2020*** | 202 | 72.94 (7.38) | 1.04 | Lebanon (Asia) | 6.83 |
| ***El Osta, 2012*** | 206 | 72.00 (6.35) | 1.50 | Lebanon (Asia) | NA |
| ***Lee, 2019*** | 202 | NA | 2.07 | South Korea (Asia) | 6.36 |
| ***Ikebe, 2012*** | 290 | 66.3 (4.40) | 1.03 | Japan (Asia) | 12.70 |
| ***Gokturk, 2018*** | 155 | 78.48 (5.20) | 1.18 | Turkey (Europe) | 7,00 |
| ***De Medeiros, 2020*** | 344 | 77.70 (9.10) | 1.49 | Brazil (South America) | NA |
| ***Hassel, 2011*** | 197 | NA | NA | Germany (Europe) | NA |
| ***Schuster, 2019*** | 17 | NA | NA | Brazil (South America) | NA |

***Table 4*** *- Oral status of each population*

| | ***Population*** | ***Edentulism (%)*** | ***Removable dentures (%)*** | ***Xerostomia (%)*** | ***Perception of oral health*** |
|---|---|---|---|---|---|
| ***El Osta, 2020*** | Completely edentulous | 100.00% | 80.70% | 53.00% | 18.30% poor<br>21.80% moderate<br>59,9% good |
| ***El Osta, 2012*** | Old adults | 37.00% | 34.00% | 68.40% | 31.60% poor<br>34.50% dissatisfied |
| ***Lee, 2019*** | Old adults | 6.40% | NA | 40.00% | 41.60% healthy<br>50.00% moderate<br>8.40% unhealthy |
| ***Ikebe, 2012*** | Old adults | 2.90% | 32.00% | 44.50% | 13.45% very good<br>26.90% good<br>33.45% fair |
| ***Gokturk, 2018*** | Periodontal disease | 0.00% (> 15 teeth) | NA | NA | 29.10% good<br>70.90% poor |
| ***De Medeiros, 2020*** | Institutionalized elderly | 50.74% | 100.00% | NA | NA |
| ***Hassel, 2011*** | Old adults | NA | 66.20% | NA | NA |
| ***Schuster, 2019*** | Completely edentulous | 100.00% | 100.00% | NA | NA |

Table 5 describes a set of socio-demographic indicators for the countries and continents in which the research was conducted. (*The World Bank*, 2022):

***Table 5*** *- Table of socio-demographic indicators for each geographic location*

| | ***Poverty ratio (% of the population)*** | ***Life expectancy at birth (years)*** | ***Human Capital Index (HCI) (0-1)*** | ***Gross Domestic Product per capita (GDP) (annual/US$)*** |
|---|---|---|---|---|
| ***Lebanon*** | 0.00% | 79 | 0.5 | 4649.50 |
| ***South Korea*** | 0.20% | 83 | 0.8 | 31597.50 |
| ***Japan*** | 0.70% | 85 | 0.8 | 40193.30 |
| ***Turkey*** | 0.40% | 78 | 0.6 | 8536.40 |
| ***Brazil*** | 1.70% | 76 | 0.6 | 6796.80 |
| ***Germany*** | 0.00% | 81 | 0.8 | 46252.70 |

## Meta-analysis

The forest plot for the OHIP-14 questionnaire showed that the mean value of the study Gokturk (2018) was very far from the other studies. In fact, the population studied by this author was composed of older adults with periodontal disease, a variable that is not present in the other articles. To verify whether this difference would introduce a bias to the meta-analysis, a sensitivity analysis was performed. It was concluded that this result is significantly different, and its presence would generate bias in the results. Therefore, the Gokturk (2018) study was removed from the OHIP-14 questionnaire meta-analysis. On the other hand, this study did not show a significantly different mean for the GOHAI questionnaire. However, an important discrepancy was observed for El Osta (2012), but since the 'population's characteristics were in agreement with the other studies, it was not removed from the meta-analysis of this questionnaire.

## OHIP-14

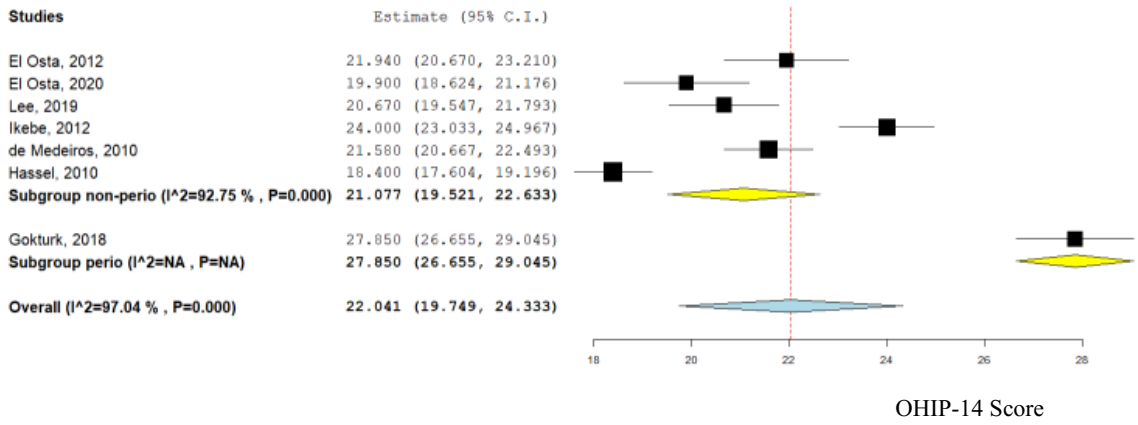


***Figure 4*** *- Forest plot for OHIP-14*

## GOHAI

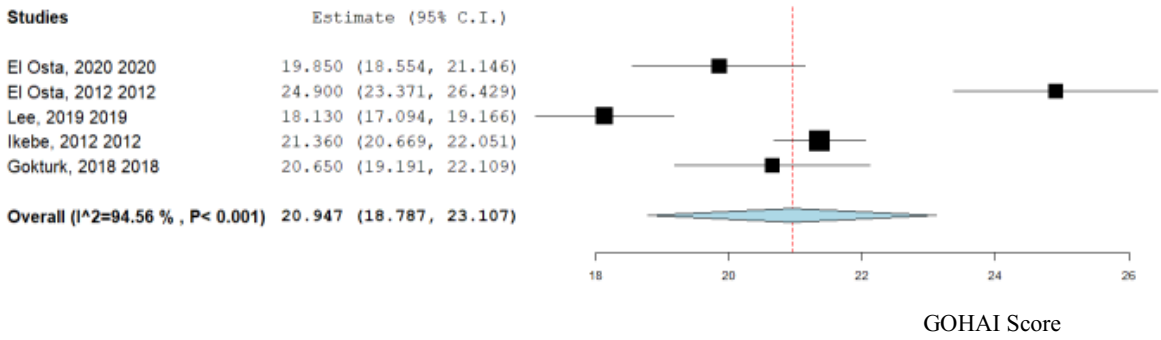


***Figure 5*** *- Forest plot for GOHAI*

Since the questionnaires are widely validated worldwide, other correlations were set up to figure out the confounding variables that most influence the results. For this study, we correlated ten confounding variables with each questionnaire scores, and one questionnaire with the other. At first, we performed a meta-regression of all confounding variables against the questionnaire scores. Then, variables that were not significant were sequentially removed from the model until reaching an entirely significant reduced model.

Even though all the studies have met the inclusion and exclusion criteria, Gokturk (2018) study was the only one that looked strictly at the elderly with periodontal disease. For this reason, this variable (having or not having periodontal disease) disrupted the meta-regression model and therefore was removed from the meta-analysis. Nevertheless, we performed a sensibility analysis for all meta-regression to evaluate if this study was a source of bias. In other words, all statistical tests were done with and without this study.

**Meta-regressions**

**Mean age**

When we performed the meta-regression for mean age, no significant relationship was found for either questionnaire. This result was already expected since age was one of the inclusion criteria, and there was no considerable variation in its values among the included study populations.

**Ratio F/M**

The meta-regression did not show a significant correlation between the F/M ratio and the OHIP-14 and GOHAI scores.

**Location**

Regarding the geographic regions, the difference in both scores was statistically significant ($p<0.001$) between Asian studies. It was not possible to perform the meta-analysis of South America and Europe subgroups since only one study from this geographic region was included. However, the overall p-value was also significant for both questionnaires, thus showing that the geographic region is not related to the results of the questionnaires for an elderly population.

$I^2$ values for the OHIP-14 questionnaire were 89.58% for the Asian subgroup and 92.75% for all subgroups, while for the GOHAI questionnaire, it was equal to 96.27% for the subgroup of Asia and 94.56% for all subgroups. These high values for $I^2$ reflect the high heterogeneity of the studies' results for both questionnaires.

## OHIP-14

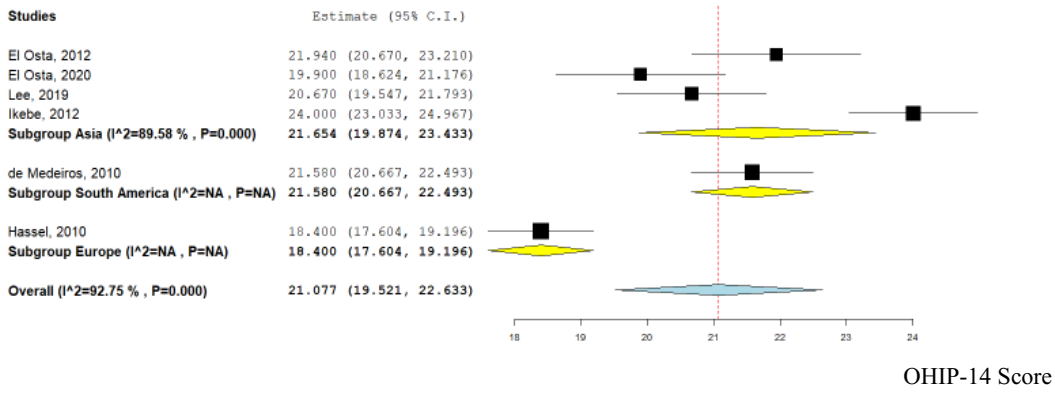


***Figure 6*** *- Forest plot for OHIP-14 by geographic region*

## GOHAI

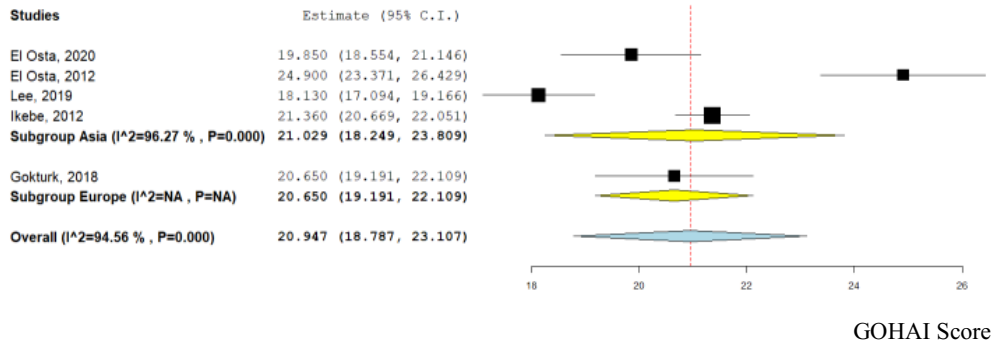


***Figure 7*** *- Forest plot for GOHAI by geographic region*

## Edentulism

We found an inverse trend between the percentage of edentulous individuals and the OHIP-14 score, although it was not significant (r = -0.026; p=0.056). The GOHAI questionnaire also showed no significant correlation.

## Removable Dentures

Conventional removable dentures showed a negative trend in both questionnaires (r = -0.062 for GOHAI and r = -0.036 for OHIP-14). Therefore, the higher the percentage

of individuals with dentures, the better the OHRQoL. However, this association was weak and without statistical support for OHIP-14 and GOHAI (p = 0.210 and 0.107, respectively).

**Xerostomia**

A positive and statistically significant correlation (0.197; p = 0.001) was found between the GOHAI score and the percentage of individuals with xerostomia. In other words, the higher the incidence of xerostomia in the studied group, the worse the perception of OHRQoL will be for this questionnaire. However, the meta-regression performed for the OHIP-14 questionnaire had no statistical support (r = -0.008; p=0.916).

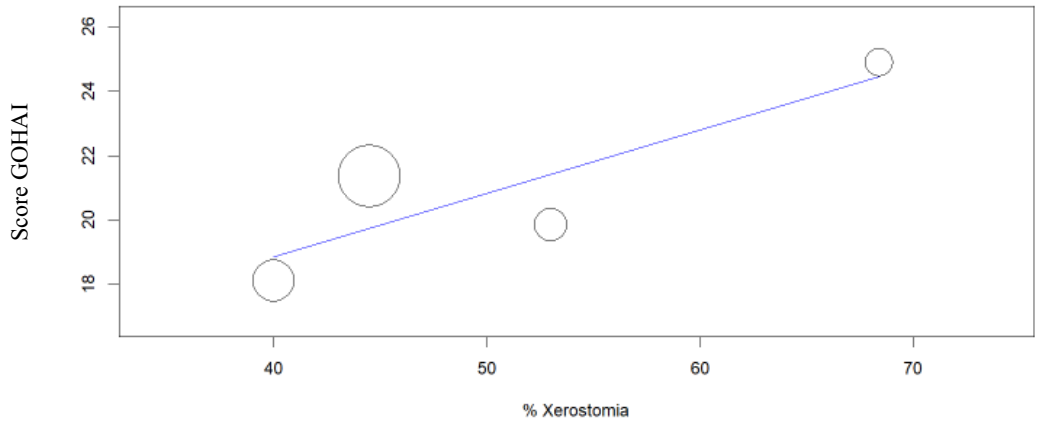


***Figure 8*** *- Meta-regression of the percentage of individuals with xerostomia in the OHRQoL*

**Life expectancy**

The meta-regression did not show a significant correlation between life expectancy and OHIP-14 and GOHAI scores.

**Human Capital Index**

The HCI assesses how much a country's economy would be worth if its citizens had access to better health care and education. The meta-regression did not reveal a significant correlation between the questionnaire scores and the HCI.

### GDP per Capita

GDP per capita is a measure of a country's economic output per person based on per capita income. No significant correlation was found between this index and the scores OHIP-14 and GOHAI.

### Poverty ratio

The poverty ratio showed no significant correlation with the OHIP-14 and GOHAI questionnaires.

### GOHAI and OHIP-14

Although the correlation between the results of the questionnaires was positive ($r = 0.193$), the meta-regression showed that it was not statistically significant ($p = 0.732$).

**Adjusted models**

**Mean Age**

**a. F/M ratio**

No significant correlation was found for the OHIP-14 questionnaire.

However, the meta-regression showed a positive and significant correlation (r = 10.148; p<0.001) between the GOHAI score and the ratio F/M. That is, the OHRQoL tends to deteriorate as the number of women in the sample grows for individuals of the same age.

**b. Location**

Regarding the OHIP-14 questionnaire, it was observed that, for individuals of the same age, South Americans tend to have significantly higher scores than Asians (r = 3.432; p=0.001), that is, a worse OHRQoL

The meta-regression for the GOHAI questionnaire also compared only two geographic regions, Europe and Asia. In this case, no significant difference was found.

**c. Edentulism**

The OHIP-14 score showed a negative (r = -0.038) and significant (p<0.001) correlation with the percentage of edentulous individuals in a population of the same age, indicating that this questionnaire identifies an improvement in OHRQoL as the number of totally edentulous persons in the sample increases.

When the model was adjusted for mean age, no statistically significant correlation was identified between the number of edentulous individuals and the GOHAI score.

**F/M ratio**

**a. Mean age**

When the statistic model is adjusted to the ratio F/M, the OHIP-14 score showed a negative and statistically significant correlation with the mean age for populations with the same F/M ratio ($r = -0.374$; $p=0.007$). The correlation between mean age and the GOHAI score also showed a negative and significant correlation ($r = -0.197$; $p=0.004$), which means that as people age, their OHRQoL improves.

**b. Location**

Comparing populations with the same F/M ratio to geographic areas, no significant correlation between Europeans and Asians was found for the GOHAI score.

The South American results did not differ significantly from Asian results for the OHIP-14 questionnaire ($p=0.995$).

**c. Edentulism**

The OHIP-14 score and the percentage of edentulous persons had a negative ($r = -0.061$) and statistically significant ($p<0.001$) correlation. This means that increasing the number of edentulous individuals leads to a higher OHRQoL.

However, no significant correlation was observed regarding the GOHAI score.

**d. Xerostomia**

The GOHAI score and the percentage of individuals with xerostomia in the sample showed a positive and significant correlation ($r = 0.187$; $p=0.001$). In other words, as the number of people reporting xerostomia increases, OHRQo decreases.

The OHIP-14 score, on the other hand, did not show a significant correlation.

**Location**

**a. Mean age**

When the mean age was adjusted for geographic location, a negative and statistically significant correlation was observed for the OHIP-14 score ($r = -0.519$; $p<0.001$). In other words, the OHIP-14 score tends to decrease with increasing age, regardless of geographic region, showing that increasing age leads to a better perception of oral health in these geographic regions.

No correlation was found between the mean age and the GOHAI score.

**b. Removable dentures**

The percentage of individuals who wore traditional removable dentures had a negative and statistically significant correlation with the OHIP-14 score ($r = -0.071$; $p<0.001$). That is, the use of traditional prostheses improves OHRQoL in the elderly in all geographic regions studied.

It was not possible to establish a correlation between studies for the GOHAI questionnaire due to a lack of data.

**c. Xerostomia**

A correlation between the percentage of individuals with xerostomia and the two questionnaires could not be established due to a lack of data.

**d. Poverty ratio**

The OHIP-14 score was statistically significant to the poverty ratio when the model was adjusted for geographic location ($r = 4.682$; $p<0.001$). This means that this variable can significantly change the score of this questionnaire, regardless of the geographic origin of the population. Furthermore, the positive correlation shows that the higher the poverty ratio of a region, the worse the OHRQoL will be.

No statistical significance was found between the GOHAI score and the poverty ratio.

**Edentulism**

**a. Location**

Meta-regression showed that the OHIP-14 score for Asia and South America was not significantly different.

Regarding the GOHAI, no difference was found between the geographic regions.

**b. % Xerostomia**

After adjusting the statistic model to the edentulism, the OHIP-14 questionnaire showed no significant correlation with xerostomia.

However, a positive and statistically significant correlation was found between GOHAI and individuals with xerostomia ($r = 0.244$; $p<0.001$). In other words, an increase in the percentage of people with xerostomia worsens the OHRQoL.

**c. Human Capital Index**

No significant correlation was found between the OHIP-14 score and the HCI.

However, a significant and negative ($r = -14.865$; $p=0.049$) correlation was obtained for the GOHAI questionnaire when the HCI was adjusted for the percentage of edentulism. This indicates that as the human capital index increases, the OHRQoL of the population in question improves.

**Removable dentures**

**a. Location**

When people with removable dentures were assessed, Asians and South Americans had significantly higher OHIP-14 scores than Europeans ($r = 2.481$; $p<0.001$ and $r = 5.686$; $p<0.001$, respectively), indicating that both have a worse OHRQoL than Europeans. There was also a significant difference between the scores of South Americans and Asians, showing that South Americans have poorer OHRQoL ($r = 3.105$; $p=0.003$).

Regarding the GOHAI questionnaire, it was not possible to perform the meta-regression due to a lack of data.

**b. Edentulism**

When the model was adjusted for the percentage of people wearing removable dentures, the number of edentulous people and the OHIP-14 score showed a negative and significant relationship ($r = -0.041$; $p<0.001$). This indicates an increase in OHRQoL as the percentage of edentulous increases.

No significant correlation was found for the GOHAI questionnaire.

**c. Poverty ratio**

The meta-regression showed a positive and statistically significant correlation between the OHIP-14 score and the poverty ratio ($r = 2.632$; $p<0.001$), indicating that the higher the poverty ratio sample, the lower the OHRQoL. There was no correlation between this variable and the GOHAI questionnaire.

However, no significant correlation was found between the poverty ratio and the GOHAI questionnaire.

**Xerostomia**

**a. Edentulism**

When the percentage of edentulous subjects was adjusted for xerostomia, the OHIP-14 questionnaire revealed no significant association with the number of edentulous individuals.

Still, a negative correlation ($r = -0.029$; $p=0.026$) was detected, indicating that, according to the GOHAI questionnaire, the OHRQoL improves as the percentage of edentulous individuals increases.

**b. Life expectancy**

The correlation between scores on the GOHAI and OHIP-14 scores and life expectancy was positive and statistically significant ($r = 0.76$; $p<0.001$ and 0.969; $p<0.001$, respectively). This result suggests that OHRQoL tends to decrease when life expectancy grows

**c. Human Capital Index**

The correlation between the Human Capital Index and the GOHAI score for the adjustment in question was positive and significant ($r = 14.967$; $p=0.002$). This result is consistent with the correlation found for the OHIP-14 questionnaire ($r = 16.406$; $p=0.010$). In other words, an increase in the Human Capital Index is associated with a decline in OHRQoL for both questionnaires.

**d. Poverty Ratio**

When the statistical model was adjusted for the number of individuals with xerostomia, the Poverty Ratio showed a positive and statistically significant correlation with the GOHAI and OHIP-14 questionnaires ($r = 4.638$; $p<0.001$ and $r = 6.418$; $p<0.001$, respectively). That means an increase in the Poverty Ratio leads to a decrease in the OHRQoL.

**e. OHIP-14**

A positive ($r = 0.742$) and significant ($p<0.001$) correlation was found between the OHIP-14 score and the GOHAI score. In this statistical model, the results of the questionnaires agree with the OHRQoL for the same population.

**f. GOHAI**

When the GOHAI index was adjusted for the xerostomia variable, it showed a positive ($r = 1.308$) and statistically significant ($p<0.001$) correlation with the OHIP-14 questionnaire. That is, for individuals with the same degree of xerostomia, the results of the questionnaires are always in agreement because they go in the same direction.

**Life expectancy**

**a. Xerostomia**

Xerostomia also showed a positive and significant correlation for both questionnaires when the model was adjusted to life expectancy ($r = 0.346$; $p<0.001$ for GOHAI and $r = 0.176$; $p<0.001$ for OHIP-14), showing an increasing percentage of people with xerostomia has a worsening OHRQoL.

**Human Capital Index**

**a. % Xerostomia**

A positive and significant correlation was found between the GOHAI and OHIP-14 scores and the percentage of individuals with xerostomia when the statistical model was adjusted for the Human Capital Index ($r = 0.380$; $p < 0.001$ and $r = 0.187$; $p = 0.036$, respectively). This result shows us that the increase in the number of subjects with xerostomia leads to an OHRQoL worsening.

## GDP per Capita

### a. % Xerostomia

The percentage of individuals with xerostomia also showed a positive and significant correlation with both scores, GOHAI and OHIP-14 ($r = 0.367$; $p < 0.001$ and $r = 0.193$; $p < 0.001$, respectively). Once again, the higher the percentage of individuals with xerostomia in the sample, the worse OHRQoL will be.

**Poverty ratio**

**a. Location**

When the model was adjusted for the poverty ratio, we found a significant difference between the OHIP-14 score between South Americans and Asians, where South Americans showed a better OHRQoL ($r = -6.929$; $p<0.001$). Regarding the meta-regression for South Americans and Europeans, we also found that Europeans tend to have a worse OHRQoL ($r = 4.679$; $p=0.007$). The OHIP-14 score was also statistically significant between Asians and Europeans, showing that Europeans have a better OHRQoL than Asians ($r = -2.150$; $p>0.001$).

On the other hand, no significant difference was found between the score GOHAI and the different locations.

**b. Xerostomia**

The percentage of individuals with xerostomia showed a positive and statistically significant correlation with both questionnaires, GOHAI and OHIP-14 ($r = 0,267$; $p<0.001$ and $r = 0.091$; $p=0.008$, respectively). This result indicates that the OHRQoL decreases as the proportion of individuals with xerostomia increases.

The findings of the meta-regressions are summarized in table 6:

***Table 6*** *- Summary data of meta-regressions*

| | | | OHIP-14 ASSOCIATION | GOHAI ASSOCIATION |
|---|---|---|---|---|
| **XEROSTOMIA** | **Not adjusted** | | POSITIVE | POSITIVE |
| **MEAN AGE** | **F/M ratio** | | not significant | POSITIVE |
| | **Location** | **Europe Asia** | lack of data | not significant |
| | | **Europe and South America** | lack of data | lack of data |
| | | **Asia and South America** | South America > Asia | lack of data |
| | **Edentulism** | | NEGATIVE | not significant |
| **F/M RATIO** | **Mean age** | | NEGATIVE | NEGATVE |
| | **Location** | **Europe and Asia** | lack of data | not significant |
| | | **Europe and South America** | not significant | lack of data |
| | | **Asia and South America** | not significant | lack of data |
| | **Edentulism** | | NEGATIVE | not significant |
| | **Xerostomia** | | not significant | POSITIVE |
| **LOCATION** | **Mean age** | | NEGATIVE | not significant |
| | **Removable dentures** | | NEGATIVE | lack of data |
| | **Xerostomia** | | lack of data | lack of data |
| | **Poverty ratio** | | POSITIVE | not significant |
| **EDENTULISM** | **Location** | **Europe and Asia** | lack of data | not significant |
| | | **Europe and South America** | lack of data | not significant |
| | | **Asia and South America** | not significant | not significant |
| | **Xerostomia** | | not significant | POSITIVE |
| | **HCI** | | not significant | NEGATIVE |
| **REMOVABLE DENTURES** | **Location** | **Europe and Asia** | Europe < Asia | lack of data |
| | | **Europe and South America** | Europe < South America | lack of data |
| | | **Asia and South America** | Asia < South America | lack of data |
| | **Edentulism** | | NEGATIVE | not significant |
| | **Poverty ratio** | | POSITIVE | not significant |
| **XEROSTOMIA** | **Edentulism** | | not significant | - |
| | **Life expectancy** | | POSITIVE | POSITIVE |
| | **HCI** | | POSITIVE | POSITIVE |
| | **Poverty ratio** | | POSITIVE | POSITIVE |
| | **OHIP-14** | | POSITIVE | POSITIVE |
| | **GOHAI** | | POSITIVE | POSITIVE |
| **LIFE EXPECTANCY** | **Mean age** | | not significant | not significant |
| | **Edentulism** | | not significant | not significant |
| | **Xerostomia** | | POSITIVE | POSITIVE |
| **HCI** | **Edentulism** | | not significant | not significant |
| | **Xerostomia** | | POSITIVE | POSITIVE |

| | | | | |
|---|---|---|---|---|
| **GDP PER CAPITA** | **Mean age** | | not significant | not significant |
| | **Edentulism** | | not significant | not significant |
| | **Xerostomia** | | POSITIVE | POSITIVE |
| **POVERTY RATIO** | **Location** | **Europe and Asia** | Europe < Asia | not significant |
| | | **Europe and South America** | Europe > South America | not significant |
| | | **Asia and South America** | Asia > South America | not significant |
| | **Edentulism** | | not significant | not significant |
| | **Xerostomia** | | POSITIVE | POSITIVE |

# DISCUSSION

## Mean age

In this study, we found that the OHRQoL improves significantly as the mean age increases, regardless of location and the ratio F/M. Khanagar et al. (2020) explained that, in elderly individuals, the enamel is more fragile and more susceptible to non-carious lesions such as attrition and abfraction. In addition, a higher rate of polymedication is also noted as mean age rises. Antihypertensive drugs, for example, can slow down saliva flow, making this population more likely to get cavities or infections, directly affecting the OHRQoL. Furthermore, according to D Locker (1992), it is true that the elderly are more likely to experience oral disorders, which would substantially impact their OHRQoL as they age. Nevertheless, other variables related to the ageing process must be examined before establishing an association between age and self-perception of oral health. Cohen-Carneiro et al. (2011), Astrøm et al. (2006) and Steele et al. (2004) stated that when these variables are standardized, elderly patients tend to have a higher OHRQoL than younger patients. In addition, despite the correlation between age and edentulism rate, these two variables have independent effects on OHRQoL. Baniasadi evaluated the association between the oral health status of the elderly and the socio-economic parameters. According to the author, there is a 22% chance that the OHRQoL is higher for those above the age of 75. McMillan et al. (2003) also studied the OHRQoL of Hong Kong's elderlies and according to the author: "They did not seem particularly bothered by their oral condition, especially when compared with other often traumatic events that had occurred in their lives. Their expectations of oral health also appeared to be low".

## F/M ratio

The GOHAI revealed a positive and statistically significant correlation with the F/M ratio. This result indicates that an increase in the proportion of women in the population leads to a decrease in OHRQoL indexes, regardless of the populations' s mean age.

According to the literature, women are more susceptible to some oral disorders. Muller et al. (2007) studied the incidence of tooth loss in Europe and concluded that the

rate of edentulism among women is significantly higher. According to Komiyama et al. (2013), another oral condition more prevalent in women, especially in menopause and post-menopause, is burning mouth syndrome, significantly affecting OHRQoL in this population. A systematic review of 13 studies regarding the prevalence of xerostomia concluded that this condition is more prevalent in women than men (Orellana et al., 2006). In addition, according to Ship (2002), in addition to xerostomia rates being higher in women, they have increased in the last decades, probably due to the polypharmacy situation in which the elderly population finds itself. Some studies claim a higher prevalence of sleep and wake bruxism in women (Wetselaar et al., 2019), but this issue is still controversial in the literature (Berger et al., 2017). According to Glaros (1981), the rate of sleep bruxism in women is significantly higher, while men are more affected by awake bruxism. However, the author states that, overall, there is no difference between the incidence of bruxism by sex. On the other hand, it is necessary to consider that there is an increased prevalence of anxiety and depression among postmenopausal women compared to men of the same age (Faravelli et al., 2013), which may negatively influence the OHRQoL in this population. Chavers et al. (2002), Gilbert et al. (1997) and D Locker (1992) investigated OHRQoL in populations where men and women had standardized clinical factors (edentulism, number of teeth, periodontal attachment) and observed that, under these conditions, women report more pain and masticatory efficiency concerns. Additionally, women appear to experience greater social and psychological impacts on OHRQL.

**Geographic location and Socio-economic factors**

The OHIP-14 questionnaire indicated that South Americans tend to have a lower OHRQoL, regardless of the population's mean age or the proportion of individuals with removable dentures. However, when we adjusted the model for the poverty ratio, the opposite was observed: South Americans had a better perception of oral health than Asians and Europeans. The divergence in the results may be attributable to the poverty ratio confounding effect, which was not previously considered. When we include this variable in the model and focus on geography, we compare individuals with the same poverty level in different countries; hence, the effect we first assumed due to the geographic location turned out to eventually be due to social differences between

demographic groups. Regarding geographic location, the GOHAI questionnaire was not sensitive to detect significant differences.

Ikebe et al., (2012) concluded that, in Japan, neither the financial status nor the education level showed a significant association with the questionnaires GOHAI and OHIP-14. However, in his work, the studied population comprised people from the middle or high economic classes.

A socio-economic, educational, and financial disadvantage determines inequality in the access and quality of health services. Therefore, the less privileged social levels generally have worse indicators of general and oral health (Marmot & Bell, 2011). Several studies have associated a higher poverty rate, a low level of education and lower social positions with worse OHRQoL (Chaffee et al., 2017; Knorst et al., 2021; Rebelo et al., 2016).

According to several authors, advanced age, low income and a lower level of education are related to a worse OHRQoL (Baniasadi et al., 2021; Jepsen et al., 2017; Sabbah & Leake, 2000). Likewise, according to Kotzer et al. (2012), individuals with a higher level of education have more access to health services and are also more concerned with prevention.

On the other hand, D Locker (1988) studied older adults in Germany and Israel and observed that individuals from lower socio-economic classes had better OHRQoL.

Baniasadi et al. (2021) conducted a systematic review and meta-analysis and found that the more negative the attitude towards tooth loss, the greater the demand for health services. In addition, the author concluded that people with less than 8 years of education tend to have a worse OHRQoL. According to John, Koepsell, et al. (2004), although the evidence indicates that a poor socio-economic status has a negative impact on OHRQoL, it is crucial to evaluate the impact of other confounding variables such as education level, income, and denture use.

Regarding the HCI, the outcomes were contradictory. After adjusting the model for the number of edentulous individuals, a negative association was identified between HCI and the GOHAI questionnaire, indicating that OHRQoL improves with an increasing HCI. However, when the model was adjusted for xerostomia, a positive correlation was

observed for both questionnaires, indicating that OHRQoL decreases with an increasing HCI.

According to Al-Rafee (2020) and Mack (2003), socio-economic factors such as per capita income, level of education, and limited social assistance for the elderly directly affect the percentage of edentulous people in a population. Mack (2003) also states that in less developed nations, tooth loss is a problem that affects people of all ages, not just the elderly. Socio-economic characteristics are also a significant predictor of edentulism, according to Eklund et al. (1994). The author concluded that the less educated and the poorer of all ages remained significantly more likely to become edentulous. Khazaei et al. (2012) concluded that the number of edentulous people has decreased in developed countries, while this rate has increased in developing countries.

Consequently, it is important to note the conflicting outcomes regarding the HCI. According to the studies, countries with a lower HCI have a greater edentulism rate. On the other hand, confounding xerostomia is associated with aging and polymedication, thus it is likely to be more prevalent in nations with better access to health care and longer life expectancies. Therefore, these results are consistent with what was previously discussed: OHRQoL tends to be higher in less developed nations with high poverty rates and poor HCI.

In this systematic review, the number of publications for each geographic region was limited. Due to this restriction, additional research should be conducted to determine how geography location influences OHRQoL in the elderly population.

**Edentulism**

In this study, the OHIP-14 questionnaire was more sensitive than the GOHAI to detect changes related to edentulism. According to the meta-regressions, an increase in the number of edentulous elderly in the sample leads to a better OHRQoL.

Despite the recent advancements in dental treatment, tooth loss remains a global public health concern. According to Khazaei et al. (2012), dental caries and periodontal disease are the main causes of edentulism. It is widely known that tooth loss leads to negative consequences on the quality of life. Several authors state that tooth loss results

in an imbalance of oral functions, leading to progressive masticatory function loss (Araújo & Lindhe, 2005; Chappuis et al., 2013). Other consequences were reported by Harris et al. (2011), such as loss of facial support and dietary restrictions, which can lead to malnutrition. In addition, edentulism is associated with significant psychological damage due to patients' aesthetic expectations, and it significantly impacts the quality of life, according to Craddock (2009). De Medeiros et al. (2020) studied the masticatory performance and the swallowing threshold in institutionalized elderly. They concluded that these factors are directly affected by the absence of teeth and that it has a negative impact on the OHRQoL. Though, the result goes in the opposite direction to the literature.

Among the studies included in this meta-analysis, there is a high prevalence of edentulous older adults rehabilitated with removable dentures. Gerritsen et al. (2010) stated that oral rehabilitation significantly improves OHRQoL in these patients. Also, according to Gotfredsen et al. (2021), even if using these prostheses does not necessarily improve masticatory efficiency, they significantly improve the OHRQoL. Yet, Kim et al. (2009) studied institutionalized older adults in South Korea and concluded that an improved masticatory capacity led to a higher OHRQoL in this population.

**Removable dentures**

A negative association was found between the OHIP-14 score and the percentage of individuals rehabilitated with conventional removable dentures. Thus, oral rehabilitation in the elderly significantly improves OHRQoL, regardless of the geographic region considered.

According to Baniasadi et al. (2021) and Gagliardi et al. (2008), removable dentures are usually associated with poor OHRQoL. Hassel et al. (2007) stated that retention is an important factor for general satisfaction and that there is a significant association between oral health and the general well-being of older adults. This type of prosthesis requires an adaptation period, which varies from 1 to 2 years. Studies showed that during this period, the OHRQoL improves continuously (John, Slade, et al., 2004; Stober et al., 2012); therefore, time must be considered when measuring satisfaction and self-perception of oral health in older adults with dental prosthetics. Komagamine et al. (2012) obtained different OHIP-EDENT questionnaire scores in different periods. They

suggested that the period of use of the prosthesis should be standardized to avoid bias. The author states that right after the prothesis placement, there is a worsening in the OHRQoL due to the retention and stability of the lower dentures. In addition, the use of poorly dentures, alcoholism, smoking, and poor hygiene can lead to complications such as traumatic ulcers and prosthetic stomatitis, hence diminishing OHRQoL (Petersen et al., 2010). Therefore, the patient's profile and habits should also be considered when assessing their self-perception of oral health.

**Xerostomia**

Both questionnaires detected a significant and positive correlation between the scores and the percentage of individuals with xerostomia, but GOHAI remained more sensitive to detecting its variations. Among the covariates analyzed by the meta-regressions, xerostomia showed the highest number of significant correlations, showing that the sensation of dry mouth negatively impacts OHRQoL in the elderly population.

According to Niklander et al. (2017), xerostomia is "a subjective sensation of dry mouth, which is usually correlated with low salivary flow rates". Several studies have evaluated xerostomia's impact on OHRQoL and shown that dry mouth significantly influences patients' quality of life. In addition, the sensation of a dry mouth affects the quality of life since it drastically modifies the taste and makes it harder to execute simple tasks like pronouncing words. (Gerdin et al., 2005; Willumsen et al., 2010). According to Wolff et al. (1990), burning mouth sensation, changes in taste, dysphagia, halitosis, oral candidiasis, angular cheilitis and cervical caries are some of the consequences of decreased salivary flow. In addition, a dry mouth makes it more challenging to retain removable dentures.

Among the causes of xerostomia, we can mention auto-immune diseases like Sjogren's Syndrome, the side effect of some drugs such as antihypertensive drugs, head and neck radiotherapy that can affect the salivary glands, and psychological conditions such as stress and anxiety. (Närhi et al., 1999; Niklander et al., 2017).

When the life expectancy model was adjusted to xerostomia, both questionnaires showed a positive relationship with life expectancy. In other words, increasing life

expectancy leads to a decrease in OHRQL. According to Hopcraft & Tan (2010), the natural ageing process has no substantial effect on salivary flow. However, xerostomia is seen to increase with age, impacting mainly older populations. Nevertheless, according to Orellana et al. (2006), the prevalence of xerostomia in the population is approximately 20%, but when considering the elderly population, this number seems to be higher.

**Periodontal disease**

The meta-analysis of this study did not analyze periodontal disease; however, during the article selection, it seems that it has a high association with a worsening of the OHRQoL. Therefore, its impact on the elderly population must be discussed.

Aging is a multifactorial process that can increase susceptibility to chronic inflammation such as periodontal disease (Hajishengallis, 2010). According to Baelum et al. (1997), there is evidence in the literature that the rate of periodontal disease increases with age.

Ferreira et al. (2017) concluded in their systematic review that periodontal disease has a negative impact on OHRQoL.

Gennai et al. (2022) evaluated the impact of oral rehabilitation in patients with stage IV periodontal disease through the OHRQoL and concluded that this treatment leads to an improvement in the general health status and well-being of these patients. However, the author states that the oral rehabilitation of patients with periodontal disease, especially those in stage IV, is always very complex because the tooth loss of more than five elements often leads to masticatory dysfunction.

**GOHAI and OHIP-14**

This study found that the OHIP-14 questionnaire seems to be more sensitive to changes in OHRQoL caused by edentulism, using removable dentures, and the poverty ratio. This questionnaire also seems to be more sensitive to changes related to periodontal disease.

The GOHAI questionnaire seems to be more sensitive in detecting alterations related to the F/M ratio, xerostomia and HCI.

The accuracy of the questionnaires in detecting changes in mean age and life expectancy was the same. The per capita GDP does not appear to affect the OHRQoL.

Due to insufficient data, it was unable to evaluate the efficiency of the GOHAI questionnaire in terms of geographic location. On the other hand, the OHIP-14 questionnaire was sensitive enough to detect disparities across geographic locations related to the use of removable dentures and the poverty rate. However, the limited number of studies in this systematic review covered only a few geographic regions. For a more accurate evaluation of its influence, additional studies from other regions are required.

A positive and significant correlation was found between the scores only when confounding xerostomia was considered. That is, this covariate seems to affect the OHRQoL for both questionnaires.

Ikebe et al. (2012) evaluated OHRQoL in the Japanese elderly and concluded that GOHAI is more sensitive than OHIP-14. Furthermore, GOHAI was strongly associated with masticatory performance and occlusal force.

El Osta et al. (2012) applied these questionnaires to older adults in Lebanon and concluded that GOHAI is a better tool for identifying dental care needs and detecting oral problems in this population.

El Osta et al., (2020) compared GOHAI, OHIP-14, and OHIP-EDENT and concluded that OHIP-EDENT is more sensitive than OHIP-14 and a better tool for detecting oral and prosthetic disorders in an edentulous population. Additionally, there was a strong correlation between the questionnaires.

Hassel et al. (2011) used GOHAI and OHIP-14 to assess OHRQoL in elderly Germans linked to depression and concluded that GOHAI is a more subjective measure of oral health, whereas OHIP-14 better reflects the social and psychological impacts of oral issues. In this regard, the author claims that using both questionnaires provides a more comprehensive view and understanding of OHRQoL. However, the author claims that OHIP performed better in terms of overall well-being.

Ikebe et al. (2012) compared GOHAI and OHIP-14 and found a strong correlation between them (Spearman's correlation = 0,728). This value is very similar to those found in Canada (=0,73) (David Locker et al., 2001) and in Germany (=0,68) (Hassel et al., 2010). The author also states that GOHAI score is less skewed and more sensitive than OHIP-14. According to Locker et al., 2001, GOHAI is also better in detecting dysfunction and pain. However, OHIP-14 showed better results in detecting psychosocial impacts. In addition, considering that GOHAI is more sensitive in detecting troubles in occlusal force masticatory performance, this tool is regarded as a better choice for longitudinal studies.

Gokturk & Yarkaç (2019) studied the impact of periodontal disease in the elderly and concluded that the GOHAI and OHIP-14 questionnaires present some differences regarding the sensitivity of the different domains: while the OHIP-14 identified an important psychological impact, the GOHAI mainly identified functional limitations.

## CONCLUSION

After performing this systematic review and meta-analysis, we concluded that the mean age significantly affects OHRQoL, even if it was standardized as one of the inclusion criteria. In other words, age is a covariate that must be properly considered in the dental treatment of elderly patients, as it can influence the therapeutic approach and the outcomes.

Despite what the literature suggests, a rise in edentulism was associated with an improvement in OHRQoL. Nonetheless, it must be emphasized that many edentulous in the studies were rehabilitated with removable dentures. For this reason, since we did not standardize the characteristics of removable dentures like type and time, it is crucial to analyze this data with caution. The time of edentulism, the anatomical characteristics of the alveolar ridge, the period of denture use, and its stability are factors that must be considered to evaluate if the transition from a precarious oral condition to a well-adapted complete denture is responsible for this improvement.

Xerostomia is the confounding condition that influences OHRQoL the most, regardless of the other confounding variables. Thus, when assessing the oral health of an elderly patient, xerostomia must be evaluated since it can affect the effectiveness of therapy. In these cases, the dentist must also adopt therapies to minimize the effect of xerostomia through salivary stimulation and replacement therapy.

The disparity between the HCI results and those adjusted for edentulism and xerostomia also catches our attention. The HCI is a variable based on the education and health of a population; thus, it is an indirect measure of a country's development. Given that edentulism is more widespread in underdeveloped countries and xerostomia is more prevalent in developed countries with high access to health services, it is assumed that there will be a difference in self-perception of oral health regarding to this covariate.

Comparing the OHIP-14 and GOHAI questionnaires is clinically relevant since, in addition to evaluating distinct domains, they also demonstrated different degrees of sensitivity for different variables. Therefore, the dentist needs to be aware of these specific details to improve the assessments.

To establish a comparison regarding the correlation and sensitivity of the OHRQoL assessment tools, only studies that used both questionnaires were included. That led to a short number of publications, which limited the findings and conclusions of this review. Consequently, more data could have been obtained if only one of the questionnaires had been considered for the assessment of the OHRQoL of the elderly population. Another limitation was the fact that only non-random cross-sectional studies were available, that is, the populations were selected by convenience and evaluated only once. In addition, investigating oral health in the elderly population is crucial to understanding the most impact elements. It can help us develop prevention and treatment strategies tailored to their needs. This meta-analysis revealed that the results of the studies for the OHIP-14 and GOHAI questionnaires are highly heterogeneous and showed which confounding variables impact OHRQoL.

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