

# UNIVERSITÄTSKLINIKUM HAMBURG-EPPENDORF

Institut für Gesundheitsökonomie und Versorgungsforschung

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Perceived oral health, anxiety and depression.  
A systematic review.

## **Dissertation**

zur Erlangung des Grades eines Doktors der Zahnmedizin  
an der Medizinischen Fakultät der Universität Hamburg.

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Hamburg 2023

**Angenommen von der  
Medizinischen Fakultät der Universität Hamburg am: 13.07.2023**

**Veröffentlicht mit Genehmigung der  
Medizinischen Fakultät der Universität Hamburg.**

**Prüfungsausschuss, der/die Vorsitzende: PD Dr. Jörg Dirmaier**

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## 1. Introduction

According to the WHO (World Health Organization), 280 million adult people worldwide suffer from depression which corresponds to 5% of the world population.

Anxiety disorders are one of the most common mental illnesses alongside depression with a worldwide prevalence of 7,3% [1].

Thus, depression and anxiety are common diseases which are often recurrent and can frequently become chronic [2]. Approximately 85% of those affected with depression are significantly anxious and 90% of those affected by anxiety have depressive disorders [3].

People with depressive disorders often suffer from a reduced quality of life, which is associated with a loss of interpersonal relationships [4], [5].

Also, depression is a main cause for poor work productivity. This shows the three-fold increase in monthly absenteeism days of depressed people after illness compared to the absenteeism days of healthy workers [6]. Furthermore, impaired cognitive function is as well associated with depressive disorders [4]. Cognitive capabilities such as perception, memory, attention, learning or problem-solving skills can be restricted.

Also, there is a widespread presence of drug abuse among people with depressive disorders (excluding alcohol and nicotine abuse). The lifetime prevalence is estimated to be 24% [7]. The comorbidity with depressive disorder and nicotine is significantly higher and lies by 38,2% [8]. The abuse of cocaine, sedative hypnotics, and opioids is greatly increased in those with depressive disorders.

Those with the highest risk to drug abuse though seem to be patients with comorbid anxiety disorder [9].

Much is already known about the determinants of depression. For example, biologic-genetic factors (e.g., serious physical illnesses, hormonal changes or disturbances in the metabolism of neurotransmitter), social factors (e.g., loss experiences, marital status) or psychological factors (e.g., lack of parental affection) [10]. Women seem to be affected more often than men [11] but depression or anxiety can occur at any age.

According to our research, there are already several studies that have dealt with the connection between oral health-related quality of life and depression/anxiety. The 2018 published article [12] “oral health condition and occurrence of depression in elderly” found out a positive relationship of depressive symptoms with DMFT (decayed missed filled teeth), MT (missed teeth) and oral dryness. Which means that greater depressive symptoms correlate with worse objective oral health.

Unfortunately, there is a lack of studies that analyze the connection between the subjective oral health (in terms of oral health-related quality of life) and depression/anxiety.

In 1995, the WHO published an international method for measuring the quality of life (WHOQOL) [13]. Quality of life is defined as „individuals' perceptions of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns” by the WHO. It is a very broad set of issues that includes physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of the individuals environment [13]. Over time, interest in

researching the influence of changes in the oral cavity and the connection with quality of life grew. Questionnaires were developed to learn about the influence of oral health on quality of life [14]. The OHIP (Oral Health Impact Profile) is a widely used and respected tool to measure the correlation of the Quality of Life and oral health [15].

Thus far, a systematic review is lacking systematically synthesizing the studies regarding oral health-related quality of life and depression/anxiety. Therefore, our aim was to fill this gap in knowledge. Knowledge about these associations may ultimately contribute to reduce these factors. This in turn is important to avoid negative consequences (such as morbidity or premature mortality). Furthermore, our systematic review may guide and inspire future research in this area.

## **2. Materials and methods**

Our current systematic review is in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. Additionally, it is registered with the international prospective register of systematic reviews (PROSPERO, registration number: CRD42021216622).

### *2.1. Search Strategy and Selection Criteria*

For this systematic review, we performed a systematic literature search based on three databases (Pubmed, PsycINFO and CINAHL). The research was conducted from March to May 2021. In Table 1, the search strategy is shown.

**Table 1. Search strategy**

#	Search Term
#1	Depres*
#2	Anxi*
#3	Oral health
#4	Dental health*
#5	Middle aged [MeSH Terms]
#6	Aged [MeSH Terms]
#7	(#1 OR #2) AND (#3 OR #4) AND (#5 OR #6)

Two reviewers (BK, AL) assessed the studies in a two-stage process according to relevance and made a decision with regard to the inclusion/exclusion of the studies.

First, a title/abstract screening was carried out. Second, a full text screening was conducted. In addition, we hand searched the list of studies selected for inclusion. In case of disagreement, we met to discuss and/or included a third party (AH) to resolve.

Our inclusion criteria were as follows:

- Cross-sectional and longitudinal observational studies investigating the association between (1) depression and perceived oral/dental health or (2) anxiety and oral/dental health
- Studies published in peer-reviewed journals (German or English language)
- Studies that take adults into account

Our exclusion criteria were as follows:

- Studies not examining the association between (1) depression and perceived oral/dental health or (2) anxiety and perceived oral/dental health
- Studies that were limited to individuals with specific disorders (e.g., individuals with cognitive impairment)
- Studies that were not in English or German language
- Studies not published in peer-reviewed journals
- Studies where important variables were not sufficiently taken into account (e.g., invalid assessment of depression)

The time and place of execution of the studies were not taken into account. A pre-testing was carried out with a set of 100 studies. The search criteria though were not modified.

## *2.2. Data extraction and analysis*

One reviewer (AL) carried out the data extraction. A second reviewer (BK) cross-checked the extracted data. If there were disagreements, we met to discuss or, if required, a third party (AH) was brought in. If necessary, the authors of the studies were contacted. Data extraction covered study type and time span, description of the sample, perceived oral health assessment, depression assessment, anxiety assessment and key results.



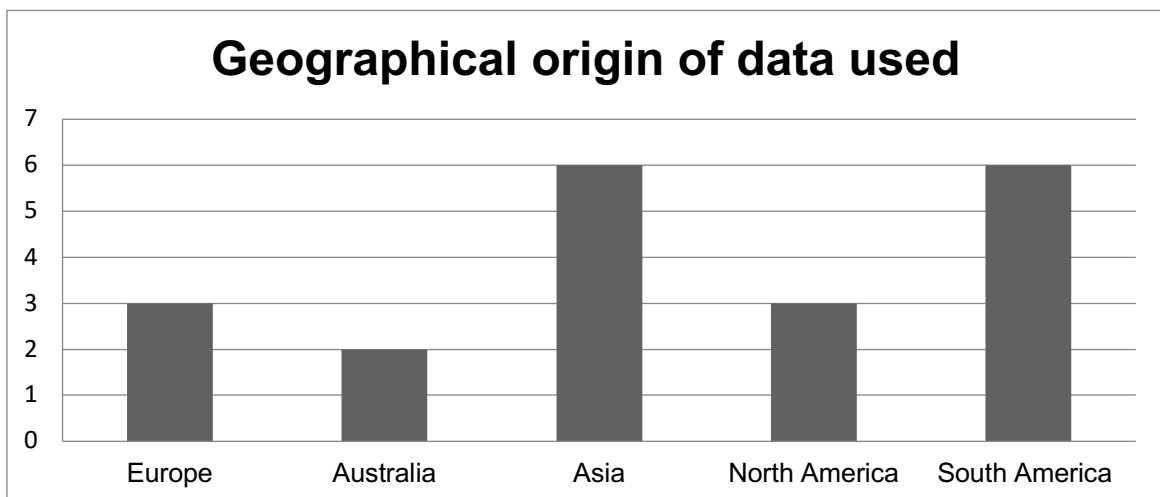
### 3. Results

This chapter has been divided into some parts dealing with the results, i.e., a brief but concise description, and the description of the results.

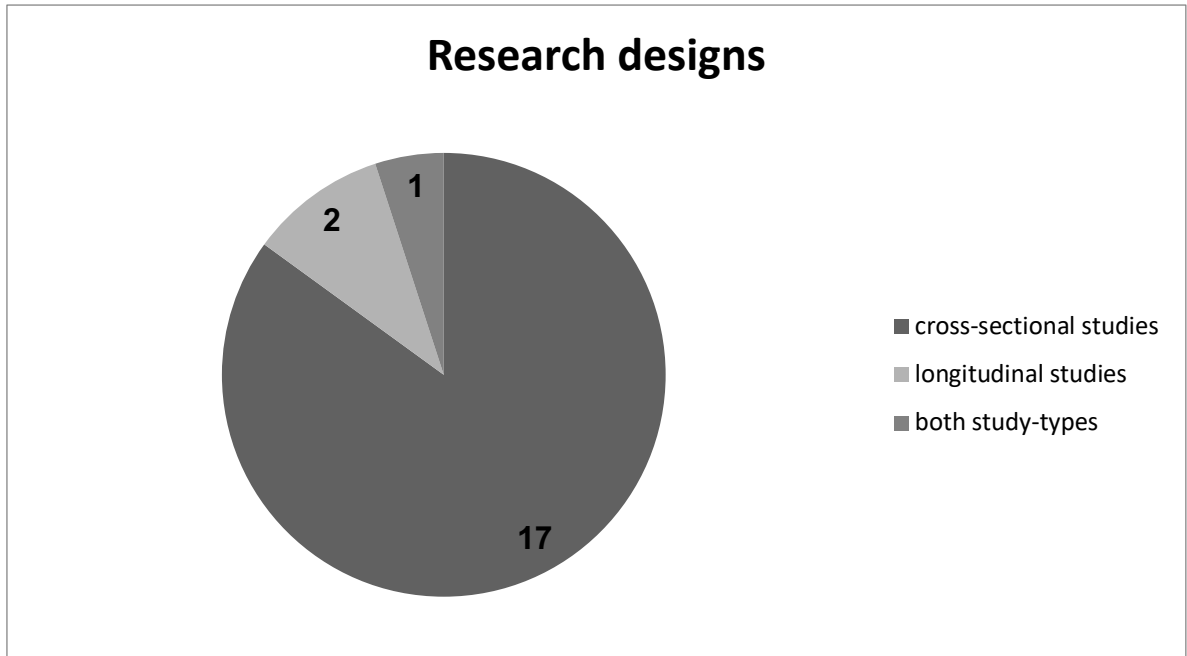
#### 3.1. Overview of included studies

The study selection process is shown in Figure 1. In sum,  $n = 20$  studies were included in the final synthesis of our review. The characteristics and the main results are summarized in Table 2. If reported, adjusted results are displayed.

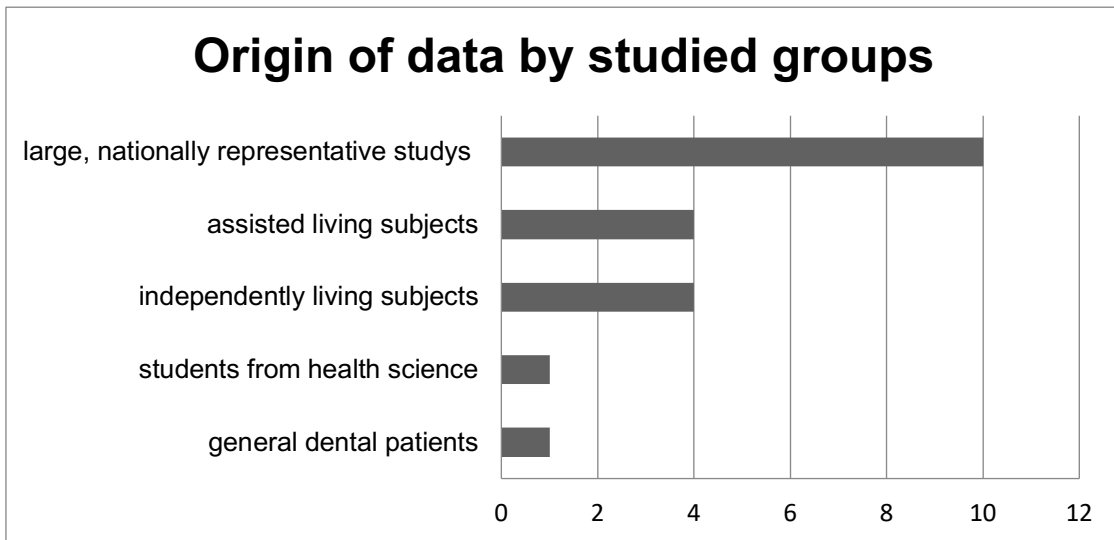
The data used is from a few different continents: Europe ( $n = 3$ , with one study each from Germany, Portugal and the UK), Australia ( $n = 2$ ), Asia ( $n = 6$ , with three studies from Korea and one each from Lebanon, Japan and India), North America ( $n = 3$ , with two studies from the USA and one from Canada) and South America with  $n = 6$  studies from Brazil.



We identified 17 cross-sectional studies and two longitudinal studies; one study used both study types [16].

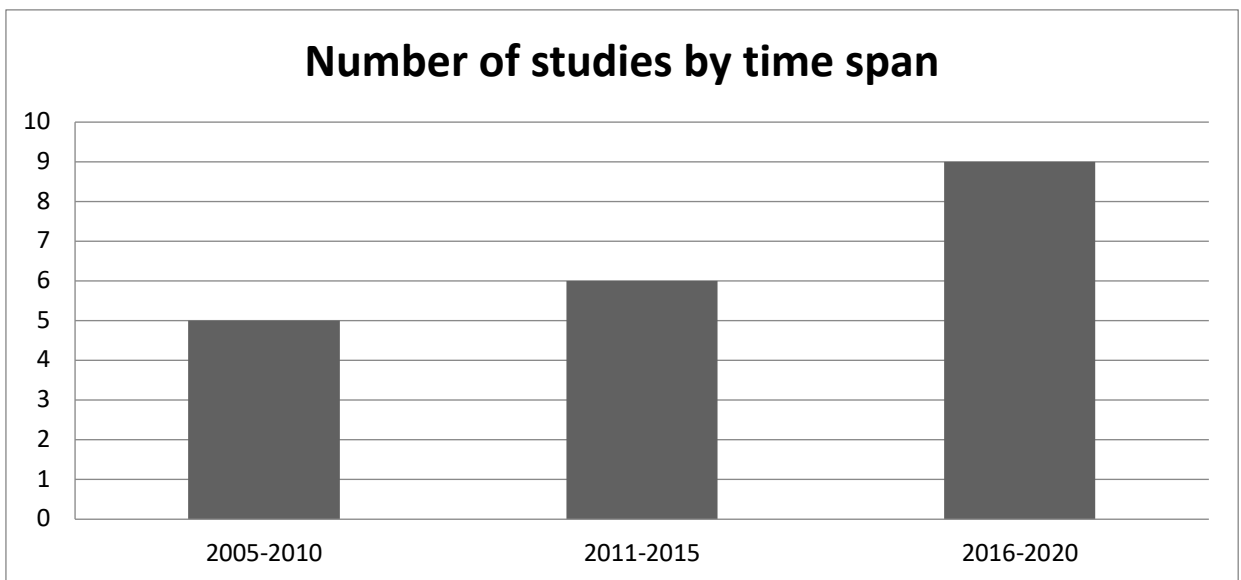


The observation period in the longitudinal studies varied from one to five years. Half of the included studies reported data from large, nationally representative studies such as the Korea National Health and Nutrition Examination Survey [17]. Some other studies ( $n = 4$ ) have looked at subjects that lived assisted [18] or lived independently ( $n = 4$ ) [19]. One study reported data on students from health science [20] and one used data from general dental patients [21].



The sample size ranged from 94 to 61,280 probands, the proportion of women mainly ranged from 30% to 75%. The average age was very different and ranged from 18 to 100 years. More details can be found in Table 2.

The time span of the publications ranged from 2006 to 2020.





# PRISMA 2009 Flow Diagram

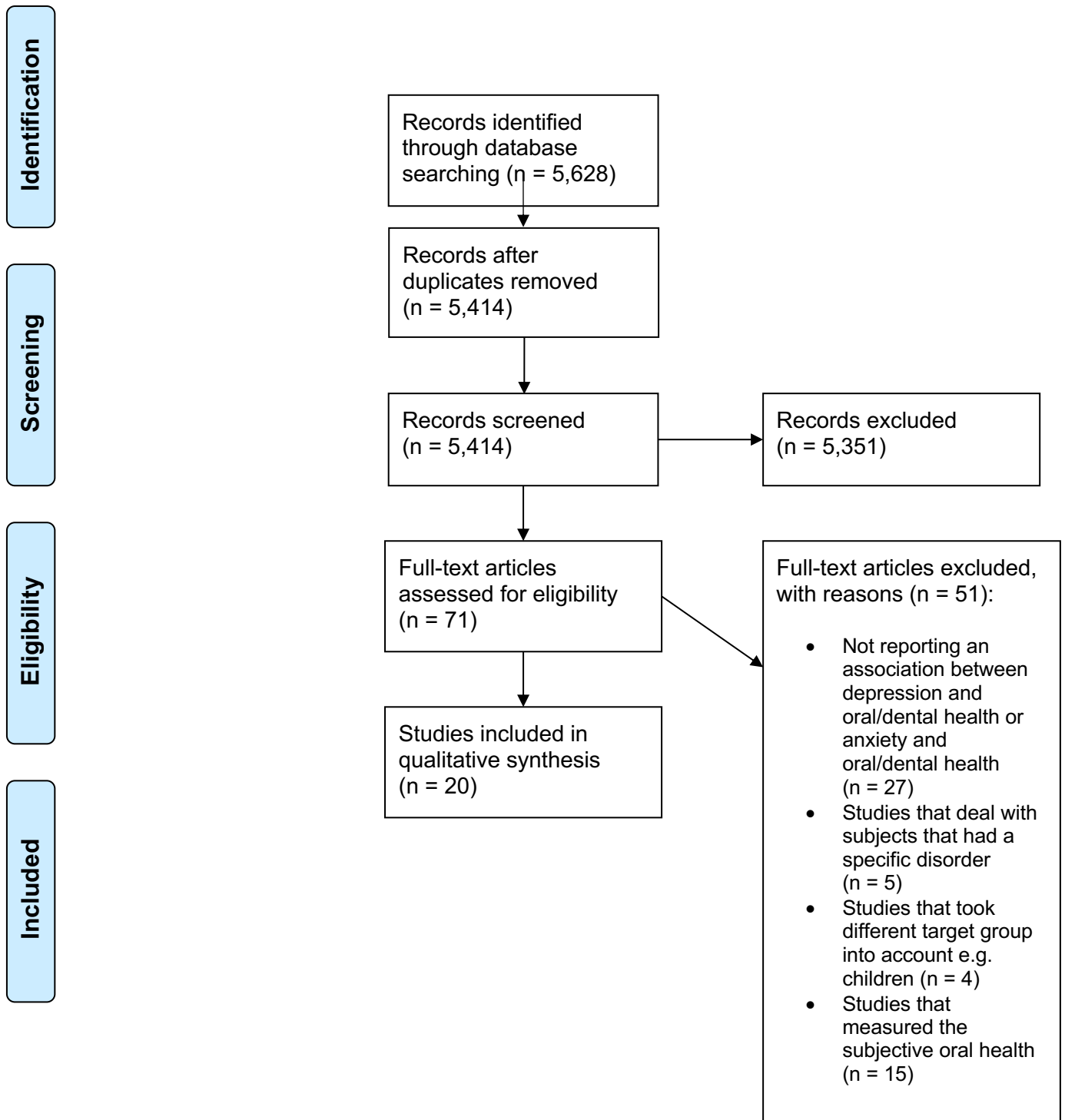


Figure 1. Flow chart.

**Table 2. Data extraction**

<b>Study</b>	<b>Study Type/ Time span</b>  <b>Age</b>	<b>Sample Source/Size</b>	<b>Oral health assessment (O)</b>  <b>Depression assessment (D)</b>  <b>Anxiety assessment (A)</b>	<b>Main result</b>	<b>Quality Assessment Score</b>
<b>Acharya, S. (2008)</b>	Cross-sectional study  Year of data collection not reported  Age: 18-80 years  M= 38,5±14,9	General dental patients who reported to the comprehensive dental care center of the department of community dentistry, Manipal College of dental science, Manipal, India  N=414 participants, (58% female)	<b>O:</b> OHIP-14 questionnaire is a tool to measure the oral health related quality of life  A 5-Point-Likert Scale was used to measure the answers with the possible scores ranging from 0-56  <b>D:</b> GHQ-12 questionnaire  A 4-Point-Likert Scale (0 to 3) was used to measure the answers with the GHQ-12 score	There was a pairwise correlation between GHQ-12 and OHIP-14 (r=.14, p<.05)	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			ranging from 0-36		
<b>AlJameel, A. H., Watt, R.G., Brunner, E. J., &amp; Tsakos, G. (2015)</b>	longitudinal, prospective closed cohort study  February until Mid-March 2011  Age:  <70: 53,8% ≥70: 39,7% Age not reported: 6,5%	random sample of 255 people from those who attended to Phase 9 of the Whitehall II study plus all participants with late onset depression  participants of the Whitehall II study were working men and women employed in London offices of the British civil	<b>O:</b> Self-reported chewing ability at Phase 10 (2011) of the Whitehall II study is used in this study  The original question was: <i>In general, how well are you able to bite or chew food that you eat nowadays?</i>  Participants were grouped into two groups: those with little, fair or great difficulties versus those with no difficulties	Depression (independent variable) in earlier adult life is significantly associated with self-reported chewing difficulties (outcome) in older adulthood (e.g., odds ratio for depression in one and/or two phases: 2.01 (95% CI: 1.06-3.82)	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
		service	<p><b>D:</b> Depression was measured using the Center for Epidemiologic Studies Depression Scale (CES-D) which consists of 20 items</p> <p>Data from Phase 7 (2003-04) and Phase 9 (2008-09) was used in this analysis</p> <p>It was calculated whether the participant had depression in any of the two phases and also the phases of depression (none, only</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			in one phase or both)  Participants taking antidepressant medications were considered as depressed even if their CES-D score indicated the absence of depression		
<b>Andrade, F. B., Lebrao, M. L., Santos, J. L. F., Teixeira, D. S. d. C., &amp; Oliveira Duarte, Y. A. d. (2012)</b>	cross sectional study  Data was taken from the second wave of the health, well-being and aging cohort-study	Community-dwelling elderly adults from the city of Sao-Paolo  N=857 participants, (60,6 % female)	<b>O:</b> self-perceived impact of oral health on quality of life was measured using the GOHAI which consists of 12 items  the GOHAI was used to assess oral-health related problems in	According to bivariate analysis (Chi <sup>2</sup> -test), individuals with depression were significantly more likely to have poor GOHAI scores (p<.001)	good



Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	(2006) which was coordinated by the Pan- American Health Organization  Age: M=72,6  SD not reported		three dimensions: physical function, psychosocial function and pain or discomfort  Questions were answered using a 5- Point Likert Scale (always, often, sometimes, seldom, never)  Final score ranged from 12-60 points, with higher scores denoting better self-rated oral health or lower degree of negative impact on quality of life  Final GOHAI Score was		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			categorized as good (57-60), moderate (51-56) or poor (<=50) indicating a low, moderate or high degree of impact on quality of life		
<b>Barbosa, A., Pinho, R. C. M., Vasconcelos, M., Magalhães, B. G., Dos Santos, M., &amp; de França Caldas Júnior, A. (2018).</b>	cross sectional study  year of data collection not reported  Age: 39.88 ± 14.34	Individuals of the urban areas of Recife (Brazil)  N= 776 participants, (84,5 % female)	<b>O:</b> Association of Research Companies and clinical exam record charts were used to establish variables related to oral health conditions (with higher values corresponding to better self-rated oral health)  <b>D:</b> Symptoms of	Worse self-perception of oral health (independent variable) was associated with an increased likelihood of depression (outcome) (OR: 1.55, 95% CI: 1.05 - 2.28)	fair

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>depression were examined by assistance of Axis II of the Research Diagnostic Criteria in Temporomandibular Disorder (RDC/TMD)</p> <p>20 items are used to evaluate depression, each item has 5 answer options and each response option corresponds to a score that ranges from 0 to 4</p> <p>The scores of the responses are added and the mean value is calculated to classify the depression according to</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			a pre-established table into: absent (<1.105), moderate (0.535-1.105) and severe (>1.105)		
<b>Esmeriz, C. E., Meneghim, M. C., &amp; Ambrosano, G. M. (2012).</b>	cross sectional, observational, randomised study  year of data collection not reported  Age: 60-87 years M= 67,35±2,8	Elderly users of health family units in Piracicaba city (Brazil) N= 371 participants, (63,3% female)	<b>O:</b> The self-assessment of oral health was held by the 12 item GOHAI  A greater GOHAI score, stands for a good self-perceived oral health  <b>D:</b> The level of Depression was analyzed by the 15 item Geriatric Depression Scale	The presence of depression (independent variable) is not associated with negative GOHAI (outcome) scores (OR: 1.65, 95% CI: 0.97–2.82)	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			Possible answers were “yes” or “no”  Cut-off used not clearly specified/described		
<b>Finlayson, T. L., Williams, D. R., Siefert, K., Jackson, J. S., &amp; Nowjack-Raymer, R. (2010)</b>	cross sectional, observational study  Participants were interviewed first in the years 1979-1980, they were recontacted after 8,9 and 10 years	Data came from the National survey of American Life which deals with self-identified Black Americans  N= 6082 participants, (53,71 % female)	<b>O:</b> A single question was asked to rate the self-rated oral health status:  ‘How would you rate the overall condition of your teeth, mouth, and gums at the present time?’  The responses were dichotomized into those who perceived their oral	Adults who met the criteria for depression (independent variable) during the previous 12 months were more than twice as likely to report fair or poor oral health (outcome) OR= 1.90*;95% CI (1.15-3.14)	fair

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	Age: 18-94 years M= 43 years  SD not reported		health to be fair or poor versus good, very good or excellent  <b>D:</b> Major depressive disorder in the past 12 months was defined by the <i>Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition</i> , criteria and was assessed with the slightly modified World Mental Health Composite International Diagnostic Interview (CIDI)		
<b>Hassel, A. J., Danner, D.,</b>	Cross-sectional	Participants were from the older	<b>O:</b> oral health and oral health related quality of	Linear regressions showed that	fair

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
Schmitt, M., Nitschke, I., Rammelsberg, P., & Wahl, H. W. (2011)	study  2007  Age: 73-75 years	cohort of the Interdisciplinary Longitudinal Study of Adult Development (ILSE)  ILSE= interdisciplinary research project comprising two cohorts, one born in the years 1930- 1932 and the other born in the years 1950–1952, conducted in the cities of Heidelberg and Leipzig, Germany	life were measured using the 12-item German version of the GOHAI and OHIP, in the German short form OHIP-14  Both instruments are based on a five category Likert-type answering format from “never” (0 for OHIP and 5 for GOHAI) to “very often” (4 for OHIP and 1 for GOHAI)  For both instruments, a summary score (SC) was calculated by addition	self-rated oral health (independent variable) is not associated with depressive symptoms (Outcome) (standardized beta: 0.08, p=.34).  Moreover, GOHAI-SC (independent variable) is not associated with depressive symptoms (Outcome) (standardized beta: -0.09, p=.46)  Additionally, OHIP-SC (independent variable) is negatively associated with depressive symptoms (Outcome) (standardized beta: -0.23, p=.04) which means that	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
		N= 197 participants	<p>Low scores mean reduced OHRQoL in GOHAI (SC 12 means highest possible impairment, SC 60 means lowest)</p> <p>In the OHIP the SC could reach values between 0=no impairment, best OHRQoL and 56=maximum impairment of OHRQoL</p> <p><b>D:</b> assessed by the 20-item German version of the internationally long-established self-rating depression scale (SDS)</p>	higher oral health-related quality of life is associated with fewer depressive symptoms	



Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>each item was measured on a 4-point scale</p> <p>the total score has a range from 20-80</p> <p>higher score indicates a greater depression</p>		
<p><b>Hayashi, K., Izumi, M., Mastuda, Y., Isobe, A., &amp; Akifusa, S. (2019)</b></p>	<p>Cross-sectional study</p> <p>April 2017- March 2018</p> <p>Age: 34-100 years</p>	<p>Inpatients of convalescent wards in Japan</p> <p>N= 94 participants (57,8% female)</p>	<p><b>O:</b> oral health and oral health related quality of life were measured using the GOHAI (Geriatric Oral Health Assessment Index)</p> <p>GOHAI assesses self-perceived oral-health using 12 questions that</p>	<p>Linear regression analysis showed that increased depressive symptoms (independent variable) are associated with lower oral-health related quality of life (Outcome) (<math>\beta=-0.25</math>, <math>p=01</math>). Linear regression</p>	<p>fair</p>

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	71.2 ± 16.2		<p>explore pain, discomfort, dysfunctions and psychosocial impacts of dental diseases</p> <p>The GOHAI was assessed using a 5-Pont-Likert Scale (1: always, 2: often, 3: sometimes, 4: rarely, and 5: never)</p> <p>A higher score indicates an improved quality of life</p> <p><b>D:</b> <i>The Hospital Anxiety and Depression Scale (HADS)</i> was used to assess emotional</p>	analysis showed that worse oral health related quality of life (independent variable) is associated with an increase in depressive symptoms (Outcome) ( $\beta=-0.28$ , $p=01$ )	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>distress. The subdomains serve as valid measures of the severity of anxiety and depressive state, they comprised seven questions with responses ranging from 0 to 3</p> <p>0 (never), 1 (rarely), 2 (often) and 3 (always)</p> <p>Scores of <math>\leq 7</math> counts as no or no significant anxiety or depression; Scores of 8-10 indicate borderline anxiety and/or depression; Scores of <math>\geq 11</math> indicative of caseness of anxiety</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>or depression</p> <p><b>A:</b> HADS was used to assess emotional distress</p> <p>The subdomains serve as valid measures of the severity of anxiety and depressive state, they comprised seven questions with responses ranging from 0 to 3: 0 (never), 1 (rarely), 2 (often) and 3 (always)</p> <p>Scores of <math>\leq 7</math> counts as no or no significant anxiety or depression; Scores of 8-10 indicate</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			borderline anxiety and/or depression; Scores of $\geq 11$ indicative of caseness of anxiety or depression		
<b>Hybels, C. F., Bennett, J. M., Landerman, L. R., Liang, J., Plassman, B. L., &amp; Wu, B. (2016)</b>	Cross-sectional study 1998-2008  Age: 65+ years  M = 75 years	Data were taken from six waves (1998-2008) from the health and retirement survey (HRS) conducted in the USA  Probands were a sample of older adults who were interviewed every 2 days	<b>O:</b> oral health was measured in 3 ways:  1.self-rated oral health (poor, fair, good, very good); the possible range of responses was 1–4, with higher scores reflecting better self- reported oral health  2.composite score measuring problems with oral health using 3	There is a longitudinal association between increased de- pressive symptoms and lower oral health among older adults  Having low ( $p = 0.0003$ ) or moderate ( $p < 0.0001$ ) depressive symptoms (independent variable) was associated with poorer self-rated oral health (outcome) in	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
		N= 944 participants (58,2% female)	questions: (Respondents were asked how often in the past year (i) they had avoided particular foods because of problems with their teeth, mouth, or dentures; (ii) their gums had been sensitive to hot, cold, or sweets; and (iii) they had their gums bleed when they brushed their teeth; the range of responses for the composite score was 3 to 15, with higher scores reflecting better oral health  3. Edentulism was	uncontrolled analyses	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>measured by self-report; Respondents were first asked if they had lost more than two natural permanent teeth (respondents who answered no were coded as dentate). Respondents who answered yes to losing more than two permanent teeth were then asked if they had lost all teeth from their upper jaw and lower jaw. Respondents who had lost all teeth in both the upper and lower jaw were coded as edentulous. Responses were coded 1 (no teeth)</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>and 0 (one or more teeth)</p> <p><b>D:</b> Depression was measured with a modified version of the Center for Epidemiologic Studies-Depression (CES-D) scale</p> <p>8 CES-D symptoms were included in the HRS: felt depressed, felt everything was an effort, sleep was restless, felt happy, felt lonely, enjoyed life, felt sad, and could not get going</p>		



Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>Each symptom was coded 1 if present much of the time in the previous week and 0 if not</p> <p>The symptoms were summed with items in the positive direction reverse coded for a possible range of 0–8</p>		
<b>Kim, Y. S., Kim, H. N., Lee, J. H., Kim, S. Y., Jun, E. J., &amp; Kim, J. B. (2017)</b>	<p>Cross-sectional study</p> <p>2010-2012</p> <p>Age: 35+ years</p> <p>35-44: 3.227</p>	<p>Participants were from the fifth KNHANES (Korea National Health and Nutrition Examination Survey), the target population was the</p>	<p><b>O:</b> The variables of subjective oral health status included self-perceived oral health including teeth and gum health (“How do you feel about your oral health related to teeth and</p>	<p>Logistic regressions showed that individuals with very poor to good self-rated oral health (independent variable) did not significantly differ in the likelihood of depression (outcome)</p>	<p>fair</p>

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	45-54: 2.773 55-64: 2.504 65-74: 1.994 75<: 849  SD not reported	total residents of the Republic of Korea  N= 11.347 participants (5.838 female)	gums, etc.?" was used directly: "very good," "good," "fair," "poor," and "very poor.")  The oral functional status variables were chewing and speaking ("Do you experience any difficulty or discomfort when pronouncing words clearly due to problems with teeth, dentures, or gums?" was used directly: "very uncomfortable," "uncomfortable," "fair," "comfortable," and "very comfortable.")	compared to individuals with very good oral health (for example, very good compared to very bad: OR=0.97, 0.53-1.78, p=.93)	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p><b>D:</b> Mental health variables were self-perceived level of stress, depression and suicidal-ideation</p> <p>“Have you experienced a continuous feeling of sadness or despair for over 2 weeks that interfered with your daily activities in the last year?” and “Have you considered committing suicide in the last year?” was used directly: “yes” or “no.”</p>		
<b>Mendes-Chiloff, C. L., Lima, M. C. P., Torres, A. R., Santos, J. L. F.,</b>	Cross-sectional (2000) and longitudinal	Elderly population of São-Paulo (Brazil)	<p><b>O:</b> Questionnaire related to general health</p> <p><b>D:</b> Geriatric Depression</p>	Elderlys who evaluated their oral health as poor (independent variable) had a higher prevalence	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
<b>Duarte, Y. O., Lebrão, M. L., &amp; Cerqueira, A. (2019)</b>	study (2006)  Age: Not reported	N= 972 participants in the cross-sectional study  N=945 participants in the longitudinal analysis	Scale (GDS) 15-item scale with cutoff from 6 to 10 points for mild depression and 11 or more for severe depression	of depressive symptoms (outcome) (OR = 1.77; 95%CI 1.08 – 2.92; p<.01))	
<b>Mesas, A. E., de Andrade, S. M., &amp; Cabrera, M. A. (2008)</b>	cross sectional study  January-April 2005  Age: 60-74 years  M=66,5±4,1	Elderly people living in the urban zone of a city in southern Brazil (Londrina)  N= 267 participants (59,9% female)	<b>O:</b> Self-perceived oral health was measured using the 12 item General Oral Health Assessment Index (GOHAI)  From the score obtained by summing the responses (1 to 3 points per question, giving a	The appearance of depressive symptoms (independent variable) is positively associated with negative self-perception of oral health (outcome) OR 2.20, 95% CI: (1,06-4,54; p=0,0340)	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			total score ranging from 12 to 36 points), self-perception was classified as 'negative' when the result was a total score of 30 points or less  <b>D:</b> Geriatric Depression scale was used (6 or more points on the GDS indicated depression)		
<b>Mitri, R., Fakhoury Sayegh, N., &amp; Boulos, C. (2020)</b>	cross sectional study 2014-2015  Age:  Men: M=72.6	Community-dwelling elderly Lebanese living in Greater Beirut  N= 905 participants	<b>O:</b> Oral health related quality of life was assessed using the 12 item Geriatric oral health assessment Index (GOHAI)	Depression (independent variable) correlates significantly with poor oral health related quality of life (outcome) OR = 2.21, 95% CI: (1.26-3.89;	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	(65-94 years)  Women: M=71 (65-92 years)  SD not reported	(41,1% female)	questionnaire  Responses for each question ranged from 1-5; the total score was obtained by adding the response codes for each question  <b>A</b> final score of 57-60 reflects satisfactory oral health, a score from 51-56 is considered as moderate and a score of 50 or less as poor oral health related quality of life  Due to the low number of participants scoring 50 or less, the	p=.006)	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>participants were dichotomized into two groups, scores <math>\geq 57</math> as satisfactory oral health and scores from 12-57 as poor oral health</p> <p><b>D:</b> Depression was assessed by the 5 item WHO well-being Index</p> <p>Depression was considered for a score of less than 13</p>		
<b>O'Neil, A., Berk, M., Venugopal, K., Kim, S. W., Williams, L. J., &amp; Jacka, F. N.</b>	<p>cross sectional study</p> <p>data was taken from the national</p>	<p>study sample was drawn from a stratified, multistage probability sample</p>	<p><b>O:</b> Participants answered an oral health questionnaire in which they were asked to rate their teeth (Poor, Fair,</p>	<p>The number of dental conditions was associated with corresponding increases in the likelihood of having</p>	<p>good</p>

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
(2014)	<p>health and nutrition examination surveys (NHANES) NHANES data are collected annually</p> <p>For this study, data from the years: 2005-2006 and 2007-2008 was taken</p> <p>Age:</p> <p>18-24: 1.528 25-34: 1.526 35-44: 1.451 45-54: 1.406</p>	<p>of non-institutionalized, United States civilians aged 20–75 years</p> <p>N= 10.214 participants (50% female)</p>	<p>Good, Very Good, Excellent) and then respond with yes/no to 7 oral specialized questions (In the past year, have you: had aching in the mouth, felt bad because of mouth, had difficulty with your job because of mouth, had your taste affected because of mouth, avoided some food because of mouth, been unable to eat because of mouth, been embarrassed because of mouth)</p> <p>the condition of tooth was classified into a</p>	<p>depression</p> <p>Compared with individuals without a dental condition, those with for example two conditions were 1.60 times as likely to have depression 1.60 (1.08–2.38),</p> <p>Those with for example four dental conditions were twice as likely to have depression 2.13 (1.46–3.11)</p> <p>those with for example six dental conditions were almost four times as likely to have depression</p>	



Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	55-64: 1.324 65+: 2.169 M and SD not reported		dichotomous variable as follows; good, very good, and excellent versus fair and poor  <b>D:</b> Depression was assessed using the Patient health questionnaire-9 (PHQ- 9)  PHQ-9= version of the prime-MD (mental diagnostic) diagnostic tool  The 9 questions are scored from 0 (not at all) to 3 (nearly every day)  Participants recording a	3.94 (2.72–5.72)	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			PHQ-9 score of 0–9 were defined as not having depression, scores of 10 and higher were defined as depression		
<b>Quine, S., &amp; Morrell, S. (2009)</b>	cross sectional study  1999-2000  Age: 65+	Community dwelling older people living independently in New South Wales, Australia  N= 8.881 participants (56,8% female)	<b>O:</b> A telephone interview was carried out in which the participant was asked 5 questions about his/her oral health in the past 12 months  The first question established whether respondents had all, some or none of their natural teeth missing. This was followed by four questions on the	Logistic regressions showed that men with toothache (independent variable) did not have a higher likelihood of depression (outcome) compared to men without toothache (OR:1.4, p>.05) Logistic regressions showed that women with toothache (independent variable) have a higher likelihood of depression (outcome) compared to	fair

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>frequency of experiencing oral health problems or concerns in the last 12 months. These were: toothache; problem with mouth or dentures;</p> <p>concern about the appearance of teeth, mouth, dentures; avoidance of eating some</p> <p>foods because of problems with teeth, mouth or dentures</p> <p><b>D:</b> A telephone interview was carried out in which the</p>	<p>women</p> <p>without toothache (OR: 2.5, p&gt;.001)</p>	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>participant was asked two questions “In the last four weeks about how often have you felt depressed?” and ‘In the last four weeks, about how often have you felt hopeless?’</p> <p>The questions had a range of frequency of occurrence during the four-week period, from ‘all of the time’ to ‘none of the time’</p>		
<b>Silva, A. E., Demarco, F. F., &amp; Feldens, C. A. (2015)</b>	cross sectional study  May 2009-	Elderly individuals treated at family health units in urban areas of the	<b>O:</b> Oral health was assessed by a structured questionnaire containing 74 questions	Appearance of depressive symptoms (independent variable) correlate with worse self-	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	September 2010  Age: 60+ years  60-69: 251(57,4%) 70-79: 138(31,6%) >80: 48 (11%)  M and SD not reported	city of Pelotas (Brazil) N=438 (68,3% female)	about demographic and socio- economic variables as well as health-related habits and behavior, use of dental services, perceived treatment needs, self-rated oral health and OHRQoL  Oral health related quality of life was assessed using the OHIP-14  Each dimension (functional limitation, physical pain, psychological discomfort, physical disability, psychological	rated oral health status (outcome) PR =  1.61, 95% CI: 1.30–1.99; p < 0.001	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>disability, social disability and handicap) has two questions, each with a score ranging from 0 to 4 points: 0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often and 4 = very often. The final score ranges from 0 to 56 points, with higher scores denoting greater impact on quality of life.</p> <p><b>D:</b> Depression was assessed using the 15 item Geriatric Depression Scale (GDS)</p> <p>Individuals with more</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			than five points were considered to exhibit depressive symptoms.		
<b>Bassim, C. W., MacEntee, M. I., Nazmul, S., Bedard, C., Liu, S., Ma, J., Griffith, L. E., &amp; Raina, P. (2020)</b>	longitudinal study 2010-2015  Data was taken from the Canadian Longitudinal Study on Aging  Age: 45-85 years  75-85 12.0% 65-74 19.4% 55-64 31.0% 45-54 37.6 %	Women and men from the 10 canadian provinces, excluded were Indigenous people living on First Nations' reserves, residents of 24-hour nursing homes and full-time members of the Canadian military  N=47.761 (51,5%)	<b>O:</b> Participants answered questions on their oral health which were adapted from the Canadian Community Health Survey 2.1, including questions on general oral health, teeth/dentures, eating problems, oral health problems and oral hygiene  <b>D:</b> Cut-off considered as depressive symptoms at $\geq 10$ on the Center for	Logistic regression showed that the presence of depression (independent variable) increases the probability of evaluating the self-perceived oral health as fair or poor (outcome) among individuals with natural teeth OR:1.5, 95% CI:1.3-1.6; $p < .001$ and among individuals without natural teeth OR:1.7 95% CI:1.2-2.3, $p < .05$	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
		female)	Epidemiology Studies- Depression scale		
<b>Marques-Vidal, P., &amp; Milagre, V. (2006)</b>	Cross sectional study  October 1998 – January 1999  Age: 21 ± 3 years	Portuguese students from the health science  N=388  (75% female)	<b>O:</b> Participants answered a questionnaire on oral health (including questions on perceived gum bleeding (yes/no), perceived toothache (yes/no), how many times had they consulted a dentist over the previous 12months, daily frequency of tooth brushing, number of tooth brushes used per year, type of dentifrice used and dental flossing (yes/no))	Logistic regressions showed that the presence of anxiety (independent variable) was associated with perceived toothache (outcome)(OR=2.90, 95% CI: 1.25 - 6.72, p<.05) Logistic regressions showed that the presence of depression (independent variable) was associated with perceived gum bleeding (outcome) (OR=4.96, 95% CI: 1.68 - 14.59,	fair



Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p><b>D:</b> Depression was assessed by the Hospital Anxiety and Depression Scale</p> <p><b>A:</b> Anxiety was assessed by the Hospital Anxiety and Depression Scale</p>	p<.05)	
<p><b>Yang, S.-E., Park, Y.-G., Han, K., Min, J.-A., &amp; Kim, S.-Y. (2016)</b></p>	<p>Cross sectional study Data was taken from the 2012 Korea National Health and Nutrition Examination study (performed since 1998)</p>	<p>non-institutionalized civilian population in Korea</p> <p>N=5.469 (50,8% female)</p>	<p><b>O:</b> Oral health behavior and the use of oral health services was assessed</p> <p>Self-perceived oral health, presence of mastication problems and the presence of speaking problems were</p>	<p>Logistic regressions showed that the presence of depression (independent variable) was associated with higher self-reported dental pain (Outcome) (OR: 1.53, 95% CI:1.07–2.19, p&lt;.05).</p>	<p>fair</p>

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
	Age: 19+ years  19-39 39,2% 40-46 46,4% >65 14,4%		determined from an oral health interview  Participants were also asked for dental pain in the last year  <b>D:</b> Depression was assessed using questionnaires  Consultation with a psychiatrist during the previous year, and diagnosis of depression during the previous year were also investigated into two categories: yes or no.		
<b>Jong-Hoon, M., Sung-Jin, H., &amp;</b>	Cross sectional	Elderly individuals	<b>O:</b> A questionnaire covering self-rated oral	Depression and anxiety (independent variable) is	good

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
Jin-Hwa, J. (2020)	<p>study</p> <p>Data was taken from the Korea Community Health Survey</p> <p>Age: &gt;65 years</p> <p>65-69 28%</p> <p>70-74 26,7%</p> <p>75-79 23,9%</p> <p>&gt;80 21,4%</p> <p>M and SD not reported</p>	<p>living in Korea</p> <p>N= 61.280 (58,7% female)</p>	<p>health (“How is your oral health including the condition of your teeth and gingiva, based on your own perception?”), coding was set to 1=good and 0=bad Oral function was studied based on mastication, pronunciation, and use of dentures. The oral health behaviors included brushing teeth after breakfast, lunch, and dinner, and before sleeping</p> <p><b>D:</b> The EQ-5D (EuroQol-5 Dimension) questionnaire measured</p>	<p>associated with lower self-rated oral health(outcome) OR = 1.162, 95% CI 1.098-1.231, p &lt; 0.001)</p>	

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			<p>the health-related quality of life which includes anxiety/depression</p> <p>The EQ-5D is divided into 5 subdomains (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) and each domain has 5 levels of response (no problems, slight problems, moderate problems, severe problems and extreme problems)</p> <p><b>A:</b> The EQ-5D</p>		

Study	Study Type/ Time span  Age	Sample Source/Size	Oral health assessment (O)  Depression assessment (D)  Anxiety assessment (A)	Main result	Quality Assessment Score
			(EuroQol-5 Dimension) questionnaire measured the health-related quality of life which includes anxiety/depression		

### *3.2. Measurement of perceived oral health*

The researchers used a variety of methods to measure the self-perceived oral health and the presence of depression.

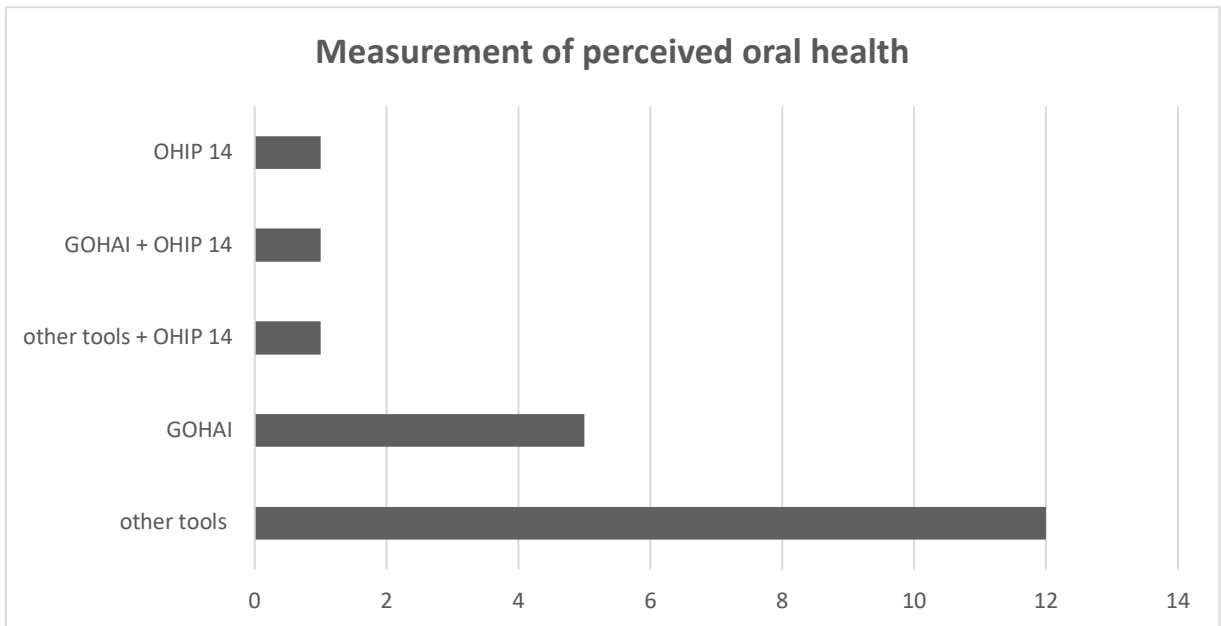
We found five studies that used only the GOHAI (Geriatric oral health assessment index) to measure the perceived oral health.

The GOHAI consists of 12 items which categorize oral health in three dimensions: physical function, psychosocial function and pain or discomfort. Questions can be answered using a 5-Point-Likert scale (always, often, sometimes, seldom, never). Final score ranged from 12-60 points, with higher scores denoting better self-rated oral health or lower degree of negative impact on quality-of-life. Final GOHAI Score can be categorized as good (57-60), moderate (51-56) or poor ( $\leq 50$ ) indicating a low, moderate or high degree of impact on quality of life.

Three other studies used the OHIP 14 whereas two of them parallelly used either the GOHAI or a questionnaire.

The OHIP 14 measures the oral health related quality of life by using a 5-Point-Likert scale. The possible score ranges from 0-56 where 0 means no limitations and 56 severe impairments.

The remaining 12 studies made use of other tools (e.g., self-developed tools such as questionnaires) on the self-perceived oral health (details can be found in Table 2).



### 3.3. Measurement of depression

Different tools were used to quantify depressive symptoms or depression.

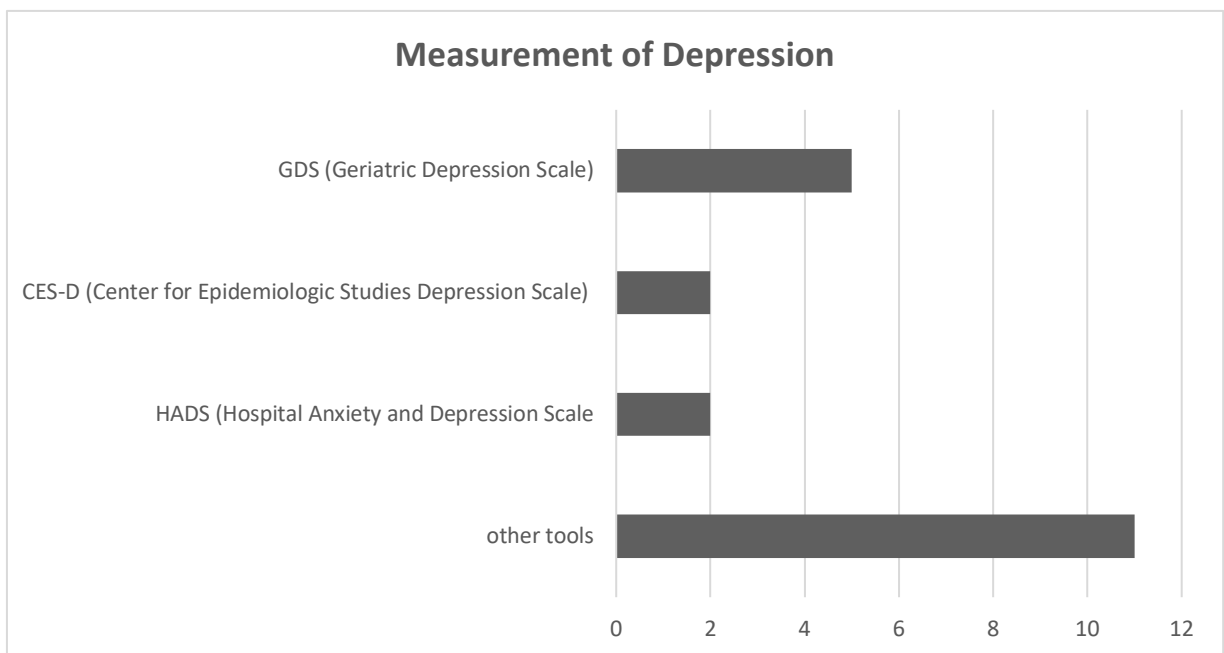
Researches have revealed that five studies used the GDS (Geriatric Depression Scale). This is a common screening measure for depression in elderly. The GDS can be used as a 15 or 30 item questionnaire. (1) In our studies, the 15-item version was used. It presents a dichotomous response format (yes/no) with lower scores indicating fewer depressive symptoms. (2)

The CES-D (Center for Epidemiologic Studies Depression Scale) was used in two studies. It consists of 20 items which can be answered with a score from 0 to 3 (0 = Rarely or None of the Time, 1 = Some or Little of the Time, 2 = Moderately or Much of the time, 3 = Most or Almost All the Time). The total score ranges from 0 to 60 with lower scores indicating lower depressive symptoms. (3)

Researches have also shown that two of the included studies made use of the HADS (Hospital Anxiety and Depression Scale) to measure if subjects had depressive symptoms. It consists of seven questions with responses ranging from 0 to 3 (0: never, 1: rarely, 2: often, and 3: always). If a proband has a score of <7

he is likely to have no significant depression or anxiety, a score of 8-10 means borderline anxiety or depression and a score of >11 indicates depression or anxiety. (4)

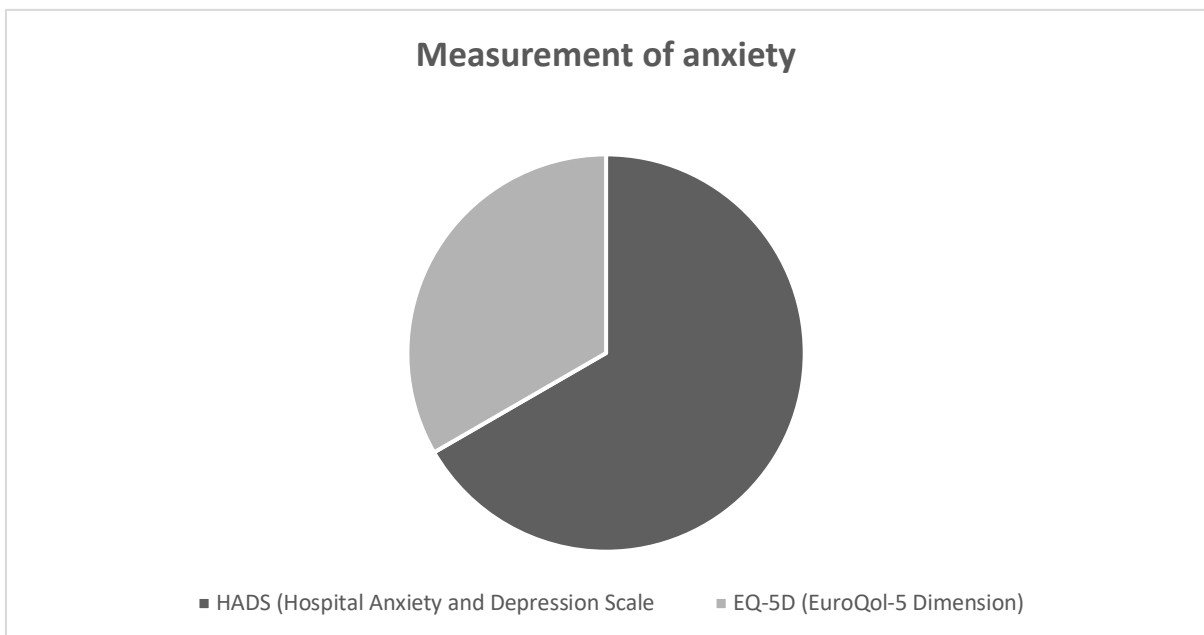
The other 11 studies used multiple different tools and questionnaires to find out the state of depression in subjects. More details can be found in Table 2.





### 3.4. Measurement of anxiety

Three of the included studies investigated anxiety. Two of those used the HADS as a tool. The other study used the EQ-5D-5L (EuroQol-5 Dimension) which is a questionnaire divided into five subdomains (mobility, self-care, usual activities, pain/discomfort and anxiety/depression). Each dimension has five possible answers (no problems, slight problems, moderate problems, severe problems and extreme problems). (5)



In the next paragraphs, the main results are presented as follows:

(1) depression and perceived oral/dental health

(2) anxiety and oral/dental health

### *3.5. Depression and perceived oral/dental health*

All 20 studies examined a link between depression and perceived oral/dental health. Most of the studies (n = 19) found a significant positive association between depression and perceived oral/dental health. Only one study [17] could not find any association between the variables of interest.

11 studies found an association between the presence of depressive symptoms (as an independent variable) and poor perceived oral health (as an outcome), another four studies took perceived oral health as an independent variable and found that poor perceived oral health is associated with a higher likelihood of depression or more depressive symptoms (outcome).

Moreover, one study found a pairwise correlation between OHRQoL and depressive symptoms (i.e., poor OHRQoL was associated with more depressive symptoms).

In sum, n = 3 studies showed that the presence of depression (independent variable) is associated with poor oral health related quality of life (OHRQoL) [21],[22],[23].

In terms of gender, there was only one study that found a difference between men and women. It was analyzed that poor oral health has an impact on the presence of depressive symptoms only in women [19].

### *3.6. Anxiety and oral/dental health*

Three studies examined a link between depression and perceived oral/dental health as well as anxiety and perceived oral/dental health. [22], [20], [24]. The presence of depressive symptoms or anxiety (independent variable) goes in all three studies along with lower OHRQoL or perceived oral health (outcome).

### *3.7. Quality Assessment*

We show the survey of the study quality of the studies included in our review in Table 3. While some assessment criteria were met in all studies (e.g., clear aim of the study or valid assessments of important variables), there were some criteria that were met only partially (were the variables of interest collected more than once) or not at all (was a sample size justification, power description, or variance and effect estimates provided). Overall, the quality of the studies was quite high (12 studies were rated "good", eight studies were rated "fair" and none were rated "poor").

**Table 3. Quality Assessment**

Questions	Studies						
	Acharya (2008)	AlJameel (2015)	Andrade (2012)	Barbosa (2018)	Esmeriz (2012)	Finlayson (2010)	Hassel (2011)
1. Was the research question or objective in this paper clearly stated?	yes	yes	yes	yes	yes	yes	yes
2. Was the study population clearly specified and defined?	yes	yes	yes	yes	yes	yes	yes
3. Was the participation rate of eligible persons at least 50%?	not reported	yes (82%)	not reported	not reported	not reported	yes (72,3%)	not reported
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	yes	yes	yes	yes	yes	yes	yes
5. Was a sample size justification, power description, or variance and effect estimates provided?	no	no	no	no	no	no	no
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? (if not prospective should be answered as 'no', even is exposure predated outcome)	no (cross-sectional)	yes	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	no (cross-sectional)	yes	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	continuous	categorical	continuous	continuous	continuous	continuous	continuous
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes	yes
10. Was the exposure(s) assessed more than once over time?	no	yes	no	no	no	no	no
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes	yes
12. Was loss to follow-up after baseline 20% or less?	not applicable	not reported	not applicable	not applicable	not applicable	not applicable	not applicable
13. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	no	yes	no	yes	yes	yes	yes
Overall quality judgement	good	good	good	fair	good	fair	fair

Questions	Studies						
	Hayashi (2019)	Hybels (2016)	Kim (2017)	Mendes-Chiloff (2019)	Mesas (2008)	Mitri (2020)	O'Neil (2014)
1. Was the research question or objective in this paper clearly stated?	yes	yes	yes	yes	yes	yes	yes
2. Was the study population clearly specified and defined?	yes	yes	yes	yes	yes	yes	yes
3. Was the participation rate of eligible persons at least 50%?	not reported	not reported	yes (77.5% in 2010, 76.1% in 2011, and 75.9% in 2012)	not reported	not reported	not reported	yes (76,4%)
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	yes	yes	yes	yes	yes	yes	yes
5. Was a sample size justification, power description, or variance and effect estimates provided?	no	no	no	no	no	no	no
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? (if not prospective should be answered as 'no', even is exposure predated outcome)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	yes	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)	yes	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	continuous	continuous	categorical	categorical	continuous	continuous	categorical
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes	yes
10. Was the exposure(s) assessed more than once over time?	no	no	no	yes	no	no	no
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes	yes
12. Was loss to follow-up after baseline 20% or less?	not applicable	not applicable	not applicable	not reported	not applicable	not applicable	not applicable
13. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	yes	yes	yes	yes	yes	yes	yes
Overall quality judgement	fair	good	fair	good	good	good	good

Questions	Studies					
	Quine (2009)	Silva (2015)	Bassim (2020)	Marques-Vidal (2006)	Yang (2016)	Jong-Hoon (2020)
1. Was the research question or objective in this paper clearly stated?	yes	yes	yes	yes	yes	yes
2. Was the study population clearly specified and defined?	yes	yes	yes	yes	yes	yes
3. Was the participation rate of eligible persons at least 50%?	yes (71%)	yes (70%)	not reported	yes (61%)	not reported	not reported
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	yes	yes	yes	yes	yes	yes
5. Was a sample size justification, power description, or variance and effect estimates provided?	no	no	no	no	no	no
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? (if not prospective should be answered as 'no', even is exposure predated outcome)	no (cross-sectional)	no (cross-sectional)	no (simultaneously)	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	no (cross-sectional)	no (cross-sectional)	yes	no (cross-sectional)	no (cross-sectional)	no (cross-sectional)
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	categorical	continuous	continuous	continuous	categorical	continuous
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes
10. Was the exposure(s) assessed more than once over time?	no	no	no	no	no	no
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	yes	yes	yes	yes	yes	yes
12. Was loss to follow-up after baseline 20% or less?	not applicable	not applicable	not reported	not applicable	Not applicable	not applicable
13. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	yes	yes	yes	yes	yes	yes
Overall quality judgement	fair	good	good	fair	fair	good

## **4. Discussion**

### *4.1. Main findings*

In total, we included 20 studies in our review. The data came from different continents (i.e., Asia, South America, North America, Europe, Australia). The overall quality of the studies can be described as good to fair.

Overall, we found that there is a clear association between a higher likelihood of depression and lower self-perceived oral health. Such knowledge about the relationship between depression and oral health-related quality of life or self-perceived oral health is of great importance for particularly dentists as well as psychiatrists. A growing number of people are affected by mental illness. It is already known that mental illnesses and especially depression have an impact on the immune system and thus also on the flare-up of inflammation [25]. The connection is therefore of great importance for the treatment of those affected.

### *4.2. Possible mechanisms*

Most of the included studies found a clear association between depression and perceived oral health or OHRQoL. The directionality in which the factors influence each other varies between the studies. We consider it important to determine the factors underlying the association between depression and OHRQoL.

As people with depressive disorders usually feel powerless, it seems plausible that this might be a significant factor for worse oral health. There may be a lack of drive to take care of their health, especially their teeth. If the teeth are not cared for regularly and the check-ups at the dentist are missed, poor oral flora and tooth decay can quickly occur.

According to studies, people with depressive symptoms often eat worse than those without depressive symptoms. They tend to turn to foods and drinks high in sugar. This factor also has a significant impact on dental health [26] [27].

What should not be neglected is that our study assessed self-perceived oral health. Since depressed people often have a negative self-image, this attitude is also transferred to how they perceive their teeth. They are more often set on preserving their natural teeth and unfairly judge their dental health to be poor [26]. It can be assumed that the self-perceived oral health is worse than the objective oral health. In a 1999 study, Anttila showed that depressive symptoms are associated with a significant increase in lactobacillus in the saliva. This is another risk factor for depressed people to suffer from poorer dental health and thus to evaluate them worse [28].

If we think the other way around and take self-perceived oral health as an independent factor (i.e., from OHRQoL to depression), it could be argued that favorable OHRQoL can have a positive impact on depressive symptoms. People with poor oral health usually feel unwell. Bad breath can develop, the appearance is no longer as desired and this can lead to isolation. Contact with people can thus gradually be lost and depression can develop.

#### *4.3. Comparability of studies*

To measure perceived oral health and depression we had several different tools used in the different studies. To determine the self-perceived oral health, studies, for example, used the OHIP-14 with 14 items or the GOHAI-12 with 12 items. For the determination of depression, studies used, for example, the GHQ-12 (General Health Questionnaire) with 12 items, the CES-D or the GDS. The use of different instruments makes it more difficult to compare the studies. It would be desirable in



the future to standardize or develop a unified instrument to measure self-perceived oral health or depression. This would ensure better comparability of studies. Also, it can be difficult to compare the results of cross-sectional and longitudinal studies. Since we have a significantly higher number of cross-sectional studies in our review, this aspect is not too relevant for us. However, this should be noted. With regard to cultural differences, we have to take into account that the dental health status is not of the same importance in every country. In parts of Asia, dental care and the demand for dental health is not as great as, for example, in Europe. From this point of view, the studies are also difficult to compare. If poor dental health influences the development of depression, this value may not be the same in every country.

#### *4.4. Research gaps and guidance for future studies*

As part of our systematic review, we have identified some research gaps. More specifically, further studies based on longitudinal data are needed to clarify the directionality between the factors of interest. The majority of studies relevant for us, are studies which have a cross-sectional design (n = 17). In cross-sectional studies, it is difficult to examine the extent to which other factors influence mental illness or self-perceived oral health. It is therefore of great importance to conduct more longitudinal studies to investigate whether there is a clear connection or if other factors influence the parameter of interest.

We also have found out that it may be necessary to conduct studies of this type in other countries or even other continents. More precisely, we could not find any studies that dealt with the variables of interest whose country of origin was Africa. Since Africa is the most populous continent after Asia, we consider the lack of these studies to be an essential research gap. We were also not able to find any studies

from Antarctica. However, it should be noted that the population is very low there (depending on season, about 1,000 to 5,000 inhabitants).

So far, research has not sufficiently investigated whether a gender-specific expression of depression is reflected in the lack of self-perceived oral health. It would therefore be of interest to find out whether this gender-specific difference is reflected in the variables of interest. Moreover, the association of OHRQoL and depressive symptoms (or anxiety symptoms) may also vary depending on the age group (e.g., children vs. oldest old). This could also be examined in future studies. Additionally, potentially mediating factors (such as shame, general self-esteem or body image) could be further explored in upcoming studies.

As we found that only three studies examined a link between anxiety and perceived oral/dental health it would be desirable to conduct more studies examining this link.

## **5. Conclusion**

In conclusion, our study showed that depression and self-perceived oral health are clearly associated cross-sectionally, whereas much more research is required to clarify the association between self-perceived oral health and anxiety symptoms. Because depression is a widespread and growing disease worldwide, we believe it is important to investigate the relationship between depression or anxiety and self-perceived oral health.

Additionally, our work may indicate how important the cooperation between dentists and mental health professionals should be. If the patient finds his teeth to be significantly worse than the dentist classifies in the physical oral examination, a targeted anamnesis should be carried out to rule out a mental illness.

Patients who are known to suffer from depression should urgently be informed about the importance of regular check-ups and, if necessary, prophylactic sessions. If the teeth are examined regularly and remain healthy, self-perception is likely to be good and cannot therefore promote depression.

## **6. Summary/Zusammenfassung**

### *6.1. Summary (english)*

With our systematic review, we wanted to find out whether there is a connection between self-perceived oral health or oral health-related quality of life and depression/anxiety. We went through 5,414 studies. In the end, there were 20 studies that dealt with our variables and that we considered usable as a result. 19 of the 20 remaining studies found a significant association between our variables of interest. Only one found no connection. The relationships are explained below. 11 studies took depressive symptoms as an independent variable and found poor perceived oral health as a result. Four other studies rotated the variables and took self-perceived oral health as an independent variable and found that poorly perceived oral health was associated with depression or more depressive symptoms. One study found a pairwise correlation between OHRQoL and depressive symptoms. This means that poor oral health-related quality of life is associated with more depressive symptoms. A total of three studies showed, with depression as an independent variable, that it is associated with poor oral health-related quality of life. Only three of our 20 studies found an association between self-perceived oral health and anxiety. All three studies found poorer oral health-related quality of life or poorer self-perceived oral health in patients with anxiety.

We therefore believe that more research is needed on anxiety and its association with self-perceived oral health and oral health-related quality of life.

## 6.2. Zusammenfassung (deutsch)

Wir wollten mit unserer systematischen Übersichtsarbeit herausfinden ob es einen Zusammenhang zwischen selbstwahrgenommener Mundgesundheit bzw. mundgesundheitsbezogener Lebensqualität und Depressionen/Angst gibt. Wir haben 5.414 Studien durchgearbeitet. Am Ende blieben 20 Studien, die sich mit unseren Variablen beschäftigten und die wir dadurch als verwertbar angesehen haben. 19 der 20 verbliebenen Studien haben einen signifikanten Zusammenhang zwischen unseren Variablen von Interesse herausgefunden. Lediglich eine fand keinen Zusammenhang. Die Zusammenhänge werden im Folgenden erläutert. Elf Studien nahmen die depressiven Symptome als unabhängige Variable und fanden als Ergebnis eine schlechte wahrgenommene Mundgesundheit heraus. vier weitere Studien drehten die Variablen und nahmen die selbstwahrgenommene Mundgesundheit als unabhängige Variable und fanden heraus, dass eine schlecht wahrgenommene Mundgesundheit mit Depressionen bzw. mehr depressiven Symptomen einhergeht. Eine Studie fand eine paarweise Korrelation zwischen mundgesundheitsbezogener Lebensqualität und depressiven Symptomen heraus. Dies bedeutet, dass eine schlechte mundgesundheitsbezogene Lebensqualität mit mehr depressiven Symptomen assoziiert ist. Insgesamt drei Studien zeigten, mit Depressionen als unabhängige Variable, dass diese mit einer schlechten mundgesundheitsbezogenen Lebensqualität einhergeht. Nur drei unserer 20 Studien fanden einen Zusammenhang zwischen selbstwahrgenommener Mundgesundheit und Angst. Bei Patienten mit Angst haben

alle drei Studien eine schlechtere mundgesundheitsbezogenen Lebensqualität bzw. schlechter selbstwahrgenommener Mundgesundheit herausgefunden.

Wir sind daher der Meinung, dass es weiterer Forschung auf dem Gebiet der Angst und dem Zusammenhang mit selbstwahrgenommener Mundgesundheit bzw. mundgesundheitsbezogener Lebensqualität bedarf.

## 7. Abkürzungsverzeichnis

<b>CES-D</b>	Center for Epidemiologic Studies Depression Scale
<b>DMFT</b>	Decayed Missed Filled Teeth
<b>EQ-5D</b>	European Quality of Life 5 Dimensions
<b>GDS</b>	Geriatric Depression Scale
<b>GHQ-12</b>	12-Item General Health Questionnaire
<b>GOHAI</b>	Geriatric Oral Health Assessment Index
<b>HADS</b>	Hospital Anxiety and Depression Scale
<b>HRS</b>	Health and Retirement Survey
<b>ILSE</b>	Interdisciplinary Longitudinal Study on Adult Development and Aging
<b>KNHANES</b>	Korea National Health and Nutrition Examination Survey
<b>MD</b>	Mental Diagnostic
<b>MeSH</b>	Medical Subject Headings
<b>MT</b>	Missed Teeth
<b>NHANES</b>	National Health and Nutrition Examination Survey
<b>OHIP</b>	Oral Health Impact Profile
<b>OHIP-SC</b>	Oral Health Impact Profile-Summary Score
<b>OHRQoL</b>	Oral Health Related Quality of Life
<b>PHQ-9</b>	9-Item Patient Health Questionnaire
<b>RDC/TMD</b>	Research Diagnostic Criteria for Temporomandibular Disorders
<b>SC</b>	Summary Score
<b>SD</b>	Standard Deviation
<b>SDS</b>	Self-Rating Depression Scale
<b>WHO</b>	World Health Organization
<b>WHOQoL</b>	World Health Organization Quality of Life

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## 9. Danksagung

Ich möchte mich hiermit bei einigen Personen bedanken, ohne die es nicht möglich gewesen wäre diese Promotionsschrift anzufertigen:

Mein Dank gilt in erster Linie meinem Doktorvater, Prof. Dr. phil. André Hajek für die Betreuung dieser Arbeit und die immer prompte und freundliche Beantwortung meiner Fragen. Ich danke Ihnen für den immer netten und konstruktiven Austausch.

Vielen Dank auch an Benedikt Kretzler, der mich beim Studien- und Daten Screening tatkräftig unterstützt hat.

Des weiteren danke ich meinem Ehemann, Hannes Labza, der mir stets den Rücken freigehalten hat und viel Verständnis aufbrachte.

Mein ganz besonderer Dank gilt meinen Eltern, Sabine und Dr. Klaus Schmitz, die mir meinen bisherigen Lebensweg ermöglicht haben und mich jederzeit maßgeblich unterstützt haben.

Zuletzt danke ich meinen Kindern, Pauline und Johanna, für ihre Geduld; ihnen widme ich diese Arbeit.

## **10. Author contributions**

In the following I list the people who contributed to the respective parts of this work.

(AL=Annika Labza; BK= Benedikt Kretzler; AH=André Hajek)

One reviewer (AL) carried out the Abstract/Title Screening, the Full text screening and the Data extraction. A second reviewer (BK) cross-checked the extracted data.

The monography (including the Graphics and figures) was written by AL. Quality rating was accomplished by AL. AH supervised the entire work and the individual work steps.

## **11. Lebenslauf**

Lebenslauf entfällt aufgrund von datenschutzrechtlichen Gründen

## **12. Eidesstattliche Versicherung**

Ich versichere ausdrücklich, dass ich die Arbeit selbständig und ohne fremde Hilfe verfasst, andere als die von mir angegebenen Quellen und Hilfsmittel nicht benutzt und die aus den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen einzeln nach Ausgabe (Auflage und Jahr des Erscheinens), Band und Seite des benutzten Werkes kenntlich gemacht habe.

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