# Oral Health and Associated Factors among Older Institution Residents: A Systematic Review

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Appendix 1. Comment protocols used in older population oral health surveys

Established epidemiological instruments are commonly used to evaluate oral conditions, in population/community studies such as the Community Periodontal Index (CPI) and Loss of Attachment (LOA) [1], the Decayed Missing Filled Teeth (DMFT) Index [1], the Denture Hygiene Index (DHI) [2], the Denture Plaque Index (DPI) [3], Gingival Bleeding Index (GBI) [4], the Gingival Index for Long-Term Care (GI-LTC) [3], Periodontal Screening and Recording (PSR) [5], the Plaque Index for Long-Term Care (PI-LTC) [3], the Revised Oral Assessment Guide (ROAG) [6], and the Visible Plaque Index (VPI) [7]. These instruments facilitate objective and comprehensive evaluation of oral health.

1.1. Oral health/hygiene examination

VPI evaluates the homecare/oral hygiene of an individual via reporting the presence and quantity of dental plaque at facial/buccal and lingual non-restored surface of all the teeth except third molars [7]. GBI is used to evaluate/categorize severity of gum inflammation/bleeding [4]. PI-LTC and GI-LTC are used to evaluate plaque control/homecare, or gingivitis (i.e. gum inflammation) in individuals under long-term care facility, respectively [3]. DPI and DHI are used to evaluate the plaque, and/or dirt/calculus accumulation on removable dentures, respectively [3].

1.2. Periodontal/gum health examination

CPI developed by the World Health Organization is used to evaluate periodontal health/disease conditions like bleeding on probing, calculus or periodontal pockets at index teeth (first and second molars and upper right/lower left central incisors) in one’s mouth where dental arches are divided into sextants [1]. CPI was evolved from an older version of the same tool: The Community Periodontal Index of Treatment Needs (CPITN) [8]. Through the CPI examination, the periodontal condition is segregated into 5 categories, excluded sextant and not recorded. The highest score of 4 indicates the most severe condition [9]. Later, modification of CPI protocol was advocated to aid general dentists to efficiently and effectively triage patients with mild versus moderate to severe periodontitis [9]. A modified/refined approach, i.e. PSR was later applied to cross-sectional surveys/epidemiological studies [10]. LOA reports history of periodontal diseases via categorization of various measurements in millimeter the destruction of periodontal support i.e. loss of periodontal attachment or the distance from cemento-enamel junction to the apical extent of the gingival sulcus/periodontal pocket upon standardized probing [9].

1.3. Dental health examination

DMFT index evaluates the dentition/dental status in terms of decayed, missing and/or filled condition due to dental caries [1].

1.4. Comprehensive oral health index

ROAG assesses saliva, swallowing, speech, caries, mucosa, gums, denture retention, denture fitting and denture conditions (0 = healthy, or 1 = treatment needed) [6].

1.5. Oral health related quality of life

GOAHI consists of 12 questions related to symptoms: physical functions (i. limit in kinds of food; ii. trouble biting or chewing; iii. able to swallow comfortably; iv. unable to speak clearly), pain/discomfort (v. able to eat without discomfort; viii. used medication to relieve pain; xii. sensitive to hot, cold or sweet foods), and psychosocial aspects (vi. limited contact with people; vii. pleased with look of teeth; ix. worried about teeth, gums or dentures; x. self-conscious of teeth, gums or dentures; xi. uncomfortable eating in front of others) with regard to an individual’s oral health [11]. A 5-point Likert scale from 1 to 5 (never, seldom, sometimes, often, very often, or always) was adopted, with total scores ranging from 12 to 60 (reverse score for items i, ii, iv, vi, viii-xii). A higher
GOHAI indicates a better OHRQoL [11]. The summary scores or the so called ADD-GOHAI was from time to time dichotomized at ≥57 or below to categorize if someone is with high vs. low/moderate perception of oral health [12].

OHIP assesses how oral problem affects seven conceptual dimensions of OHRQoL impact: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap [13]. Severity of the impact to individual items (7 under each category in full version; 2 under each category in shortened version) was recorded using a 5-point scale (0: never/not applicable; 1: hardly ever; 2: occasionally; 3: fairly often; or 4: very often) [13]. A numeric weight can be applied on subscale score which reflect both the frequency of each impact and lay judgments about the severity of the impact [14]. Higher OHIP score indicated poorer OHRQoL.

OIDP is used to assess how oral disease/problem impact upon eight daily performances: eating and enjoying food; speaking and pronouncing words clearly; cleaning teeth; sleeping and relaxing; smiling, laughing and showing teeth without embarrassment; maintaining usual emotional state without being irritable; carrying out major work or social role; and enjoying contact with people [15]. For each daily performance, frequency and severity scores were given, ranging from 0 (lowest frequency and severity) to 5 (highest frequency and severity). For OIDP scoring, each performance score was divided by the maximum possible score (8 performances × 5 frequency score × 5 severity score = 200) and multiplied by 100 to give a percentage score, ranging from 0 to 100. Higher OIDP score indicated poorer OHRQoL.

References

Appendix 2. Lists of included studies in alphabetical order of authors

2. Cocco, F.; Campus, G.; Strohmenger, L.; Ardizzone, V.C.; Cattei, M.G. The burden of tooth loss in Italian elderly population living in nursing homes. BMC Geriatrics 2018, 18, 76. [34]

The report below was referred to because it shared the same study sample:


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Appendix 3. Additional results concerning functional ability, nutritional status, health-related quality of life, and oral health

3.1. Functional ability

Functional ability of the institutionalized elderly surveyed was evaluated using various methods in five included studies [27, 30, 32, 33, 45] in this review. In brief, Barthel Index (BI) was used to assess the functional capacity or dependency of the residents surveyed in two studies [27, 30]. Only the Japanese study [27] reported 14.1% of their residents surveyed were considered functionally independent. The German study reported the mean BI score only. Saarela et al. [33] used Clinical Dementia Rating scale (CDR) personal care subscale (>2) to gauge physical functioning dependency and reported that 68.4% of the 1,369 Finish residents surveyed were functionally dependent. Niesten
et al. [45] used Gobbens’ definition of frailty scale to characterize the 126 residents in their report and identified approximate 1/3 each of their residents were medium or high care-dependent while 1/8 were of low care-dependency. Janssens et al. [32] used Activity of Daily Living (ADL) scale to gauge the functional ability of their 1,226 residents surveyed, and reported >50%, >25% and approximate 20% of the residents surveyed were of high, medium or low dependency, respectively.

One study [39] investigated the Activities of Daily Oral Hygiene (Bauer 2001) in a modified approach (mADOH) and reported slightly more than half of the 193 surveyed residents were self-oral hygiene/care disable, while around 1/5 each were partially able or able.

3.2. Nutritional status

Four included reports [21, 31, 33, 34] characterized the nutritional status of their surveyed residents using the Mini Nutritional Assessment (MNA) tool or the short form version (MNA-SF). An Indian survey [21] reported that only 1/3 of the 141 residents followed were adequately nourished while >50%, or one out of six residents were at risk of, or actually malnourished, respectively. A Finish study [33] indicated approximately 1/8, 2/3 and 1/5 of the 1,369 residents surveyed were malnourished, at risk of malnourish, or well nourished, respectively. A German study [31] reported that 51.7% of their 87 surveyed residents were ‘at risk of malnutrition’ (MNA 8-11) while 48.3% were of ‘normal’ (MNA 12-14) nutritional status and none malnourished. The data presented, however, was categorized in a way inconsistent with the standard protocol mentioned in the methods section of the same paper. An Italian national study [34] indicated 5.7%, 40.3%, 54.0% of 741 residents surveyed were malnourished, at risk of malnourish, or well nourished, respectively.

3.3. Health-related quality of life (HRQoL) and perceived social support

Only one included study from the Netherlands [45] reported the HRQoL, social support of the 126 institutionalized elderly followed using 12-Item Short Form Survey (SF-12) questionnaire, or ENRICHED Social Support Index (ESSI), respectively. Dutch age- and sex-standardized norm scores for 70-79 years (SF-12 physical component summary: 44.1; SF-12 mental component summary: 49.5) were used as reference that any score higher than the norm indicate better HRQoL. Niesten et al. [45] reported 17.5%, 50.8% of the institutionalized elderly surveyed had physical or mental HRQoL component ≥the population norm, respectively while 26.2%, 38.9% 34.1% experienced low, medium, or high social support.

3.4. Addition oral health results

3.4.1. Dental attendance

Seven studies [23, 28, 38-42] reported the frequency of dental visits of the institutionalised elderly surveyed. In six of fourteen (42.9%) nursing homes from a United States study [41], dental services were available. Similarly, high percentage of long-term care residents (75.3%) reporting <1 dental visit per year was stated in a Canadian study [40]. The other reports, however, indicated a different scenario. A Turkish study [28] reported 38% of surveyed residents had had dental visits ≤1 year driven by oral symptoms. A later report from the same country [39] indicated that only 4.4% of residents studied had visited dentist regularly and about 70% were irregular attender. An Indian study reported also <9% of their older institution residents surveyed visited a dentist in past one year [23]. An Australian study [38] reported only 25% residents had dental visit in past two years which was similar to a Brazilian report [42] indicating 21.8% residents had dental visit within past 12 months.

3.4.2. Oral mucosal conditions

Six studies [22, 25, 27, 33, 43, 44] comprehensively evaluated oral mucosal conditions of institutionalised elderly without explicitly indicate if standardized assessment tool/protocol was used.
3.4.3. Temporomandibular joint status

de Medeiros and co-workers [62] reported using the same resident sample in Piuvezam and de Lima [42], the temporomandibular joint (TMJ) status of the Brazilian surveyed. No detail was given regarding how the TMJs were assessed.

3.4.4. Salivary flow, pH and buffer capacity

Salivary flow rate, pH and buffer capacity were assessed by Brukiené et al. [44] on a cohort of Lithuanian institutionalized elderly while prevalence of dry mouth was reported in four papers [22, 25, 33, 37]. Janssens et al. [32] profiled the medications potentially causing dry mouth among the Belgian residents surveyed.

Reference

Please refer to reference list of main text.
Table S1. PRISMA checklist adopted from Moher et al. 2009.

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<td>Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.</td>
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<td>Objectives</td>
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<td>Indicate whether a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.</td>
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<td>Eligibility criteria</td>
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<td>Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.</td>
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<td>2-3</td>
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<td>Information sources</td>
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<td>Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.</td>
<td>Methods &amp; Supplementary files</td>
<td>2-4, Appendix 1-3, Table S1-4, Table 3</td>
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<td>Search</td>
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<td>Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.</td>
<td>Supplementary files</td>
<td>3-4; Appendix 2 &amp; 3, Table S1-4</td>
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<td>Study selection</td>
<td>9</td>
<td>State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).</td>
<td>Methods &amp; Supplementary files</td>
<td>2-4; Figure 1</td>
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<td>Data collection process</td>
<td>10</td>
<td>Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.</td>
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<td>2-4; Table 3</td>
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<td>List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.</td>
<td>Methods &amp; Supplementary files</td>
<td>3-4, Table 3</td>
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<td>Risk of bias in individual studies</td>
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<td>Describe methods used for assessing risk of bias of individual studies (including</td>
<td>Methods</td>
<td>4; Table 1 &amp; 2</td>
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specification of whether this was done at
the study or outcome level), and how this
information is to be used in any data
synthesis.

**Summary measures** 13
State the principal summary measures
(e.g., risk ratio, difference in means).
Methods 4, Table 1&2

**Synthesis of results** 14
Describe the methods of handling data
and combining results of studies, if done,
including measures of consistency (e.g., I^2)
for each meta-analysis.
Methods 3-4, Table 3

**Risk of bias across studies** 15
Specify any assessment of risk of bias that
may affect the cumulative evidence (e.g.,
publication bias, selective reporting within
studies).
Methods, Results 3-4; Table 1-3

**Additional analyses** 16
Describe methods of additional analyses
(e.g., sensitivity or subgroup analyses,
meta-regression), if done, indicating
which were pre-specified.
Not exist -

**RESULTS**

**Study selection** 17
Give numbers of studies screened,
assessed for eligibility, and included in the
review, with reasons for exclusions at each
stage, ideally with a flow diagram.
Methods 5, Figure 1

**Study characteristics** 18
For each study, present characteristics for
which data were extracted (e.g., study
size, PICO, follow-up period) and
provide the citations.
Results Tables 8-10; Table 3

**Risk of bias within studies** 19
Present data on risk of bias of each study
and, if available, any outcome level
assessment (see item 12).
Results 6; Table 1 & 2

**Results of individual studies** 20
For all outcomes considered (benefits or
harms), present, for each study: a) simple
summary data for each intervention group
b) effect estimates and confidence
intervals, ideally with a forest plot.
Results, Supplementary files 8-19; Table 3

**Synthesis of results** 21
Present the main results of the review. If
meta-analyses are done, include for each,
confidence intervals and measures of
consistency.
Results, Supplementary files 8-19, Table 3

**Risk of bias across studies** 22
Present results of any assessment of risk of
bias across studies (see Item 15).
Results, Supplementary files 6, Table 1 & 2

**Additional analysis** 23
Give results of additional analyses, if done
(e.g., sensitivity or subgroup analysis,
meta-regression [see Item 16]).
Not exit -

**DISCUSSION**

**Summary of evidence** 24
Summarize the main findings including
the strength of evidence for each main
outcome; consider their relevance to key
groups (e.g., healthcare providers, users,
and policy makers).
Discussion 19-23, Table 3

**Limitations** 25
Discuss limitations at study and outcome
level (e.g., risk of bias), and at review-level
(e.g., incomplete retrieval of identified
research, reporting bias).
Discussion 23

**Conclusions** 26
Provide a general interpretation of the
results in the context of other evidence,
and implications for future research.
Discussion 23
| FUNDING |  |
|---------|  |
| Funding | 27 |
| Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. |  |
| Funding | 24 |
Table S2. EMBASE (Ovid) search strategy – June 30, 2019.

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Table S3. CINAHL Complete (EBSCOhost) search strategy – June 30, 2019.

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### Table S4. MEDLINE (OvidSP) search strategy – June 30, 2019

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17 or 18 or 19 1262393

16 and 20 1185149

factor*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 4902961

precipitat*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 107049

22 and 23 24333

decayed missing filled teeth.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 231

community periodontal index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 627

community periodontal index of treatment needs.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 270

visual plaque index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 6

periodontal loss of attachment.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 15

revised oral assessment guide.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 17

plaque index for long term care.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 2

gingival index for long term care.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 2
denture plaque index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 8

periodontal screening and recording.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 38

denture hygiene index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 12

oral health impact profile.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 1027

general oral health assessment index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 65

geriatric oral health assessment index.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 102

oral impact on daily performance.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 44

people.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 126198

elderly.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 20243

resident*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 152614

47 or 48 or 49 372541

47 and 46 20243

10 and 46 371

limit 47 to year = ’2008-current’ 195

limit 52 to English language 184

limit 53 to abstracts 184

limit 54 to “all aged (65 and over)” 159
Table S5. Details of excluded studies (n=55)

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No older institution resident involved


Report focused on caregivers instead of institution residents.


A six-week prospective study on effect of dental treatment upon OHRQoL, Activities of Daily Living, and Functional Independence Measure change. No indication if randomization or CONSORT guideline was followed in the report.


Focused on dental attendance, no oral health data was collected.


A one-month prospective study on an oral health program upon body temperature of ≥37.8°C. A preliminary study, i.e. the report did not achieve the required sample size predetermined.


A descriptive study regarding oral health of older institution residents. Authors did not attempt correlation analysis, if any, between oral health and other factors recorded.


Compared oral health of older institution residents in Brazil and Spain; no correlation analysis between oral health and various factors reported.


A descriptive study regarding oral health of older institution residents. Authors did not attempt correlation analysis, if any, between oral health factors recorded.


A one-year prospective study on oral hygiene education on caregivers upon oral health and muscle strength of older institution residents. No indication if STROBE guideline was followed in the report.
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<tr>
<th>Page</th>
<th>Author(s)</th>
<th>Title</th>
<th>Journal</th>
<th>Year</th>
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<td>46</td>
<td>Sampaio, N.M.; Oliveira, M.C.; Ortega, A.O.; Santos, L.B.; Alves, T.D.</td>
<td>Temporomandibular disorders in elderly individuals: the influence of institutionalization and sociodemographic factors.</td>
<td>Commun. Disord. Audiol. Swallow.</td>
<td>2017, 6, 29, e20160114.</td>
<td>doi: 10.1590/2317-1782/20162016114.</td>
<td>A cross-sectional study looking into TMD in elderly individuals. No correlation analysis was conducted when data and focusing on association between TMD and resident status (institutionalized or not) as independent variable. No indication if STROBE guideline was followed in the report.</td>
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To justify sample size, randomization was not allowed by German Federal Ministry of Social Affairs; study was single blind.

A 12-week ‘lot’ randomized, single-blind, prospective study on professional cleaning, followed by dentist, old age home staff, or none oral hygiene education upon oral health of older institution residents.

### Table S6. Details of all included studies listed under continent of origin in chronological order.

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<thead>
<tr>
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<tr>
<td>South Korea</td>
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<td>To assess association between chewing and oral health-related quality of life (OHRQoL) in elders (&gt;60 years) in community or 3 of 18 long-term care facilities in Gyunnggi Province, South Korea</td>
<td>Cross-sectional study, cluster sampling, n = 307 community dwellers (9/25 senior centers), mean age 73.9 ± 7.3 years 197 (64.4%) female; 58 (20.4%) edentulous</td>
<td>Calibrated dentists, Number of teeth, prosthetic status, oral health impact profile short form (OHIP-14)</td>
<td>• OHIP-14 were 10.6 ± 10.7, 10.3 ± 9.9 for community-dwelling or institutionalized elderly, respectively</td>
<td>Bivariate analysis indicated inability to pay dental bill, poor oral health status, low no. of chewable food items, poor self-reported oral health, or concern of oral health were associated with worse OHRQoL.</td>
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<td></td>
<td>Kim et al. (2009) [43]</td>
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<td>Iran</td>
<td>Rabiei, et al. (2010) [24]</td>
<td>To determine the oral health status of institutionalized elders of 3 nursing homes in Rasht, Gilan</td>
<td>Cross-sectional study, convenience sample, n = 216, ≥65 years, 163 (75.5%) female; 121 (56.0%) edentulous; 57 (26.4%)</td>
<td>A specialist in oral medicine, Direct visual inspection only; no details regarding</td>
<td>• Among the 216 residents, 91 (42.1%) had dry mouth, 54 (25.0%) had atrophic tongue, 36 (16.7%) had burning mouth, 22 (10.2%) candidiasis (with 16 or 7.4% erythematous, 6 or 2.8%</td>
<td>Claimed female denture wearers had higher prevalence of denture stomatitis but related data was not presented.</td>
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</tbody>
</table>
**Province, northwest Iran**

- 71 (32.9%) had cardiovascular disease, 63 (29.6%) had hypertension and 47 (21.8%) had cerebrovascular accident,
- 36 (16.7%) had dementia,
- 31 (14.4%) had chronic obstructive pulmonary disease, 30 (13.9%) had psychiatric disease.

**Diagnostic criteria for oral conditions**

- Pseudomembranous candidiasis,
- 15 (6.9%) had traumatic ulcer, 6 (2.8%) leukoplakia (with 3 or 1.4% erythroplakia)

- In dentate residents (n = 95):
  - 49 (51.6%) had retained roots, 84 (88.4%) had caries [51 (53.7%) coronal caries, 58 (61.1%) root caries]; periodontal diseases data appeared confusing.

- Among edentulous residents (n = 121):
  - 26 (21.5%) had denture stomatitis, 19 (15.7%) had denture induced hyperplasia, 13 (10.7%) had angular cheilitis, 9 (7.4%) had epulis fissuratum.

**Cross-sectional study, convenience sample.**

- n = 202, mean age 79.6 ± 8.9 years, 155 (76.7%) female; institutionalized for mean 39.8 months, 78 (38.6%) had dementia.

- 60 (29.7%) had hypertension, 58 (28.7%) had cardiovascular disease, 50 (24.7%) had diabetes and 30 (14.9%) had cerebrovascular accident

**To assess the oral mucosal conditions of institutionalized elderslies (≥60 years) of 5 nursing homes in Mashhad, Khorasan-e Razavi Province, northeast Iran**

- 2 calibrated specialists of oral medicine

- Direct visual inspection only; no details regarding diagnostic criteria for oral conditions

- 198 (98.0%) of the surveyed residents had ≥1 oral mucosal lesion

- 98 (48.5%) had atrophic glossitis, 77 (38.1%) had dry mouth.

- 119 (58.9%) wore denture(s) for mean 19.7 years, and 109 had denture related lesion(s): 65 (54.6%) had denture stomatitis, 36 (30.2%) had epulis fissuratum, 5 (4.2%) had denture induced hyperplasia, 3 (2.5%) had angular cheilitis.

- Xerostomia was more prevalent in 70–79-year-old than in 60–69-year-old subjects.

- There was no significant difference in the prevalence of

**Mozafari et al. (2012) [25]**

- Regression analysis indicated older residents had higher gender adjusted odds for oral mucosal lesion.

- Claimed that duration of denture wearing associate with denture related/oral mucosal lesions. No details of analysis reported.
denture-related lesions between men and women (p > 0.05).

<table>
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<tr>
<th>Country</th>
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<th>OHRQoL Assessment</th>
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</table>
| India       | Cross-sectional study of all elderly homes, convenience sample of residents with no cognitive impairment. | *n* = 141, 83 (58.9%) female, mean age 72.2 ± 7.5 years, 36 (25.5%) edentulous. | Calibrated examiner DMFT Index; Geriatric Oral Health Assessment Index (GOHAI) score (continuous and dichotomized at <57: low/moderate vs. high perception of oral health) | - MNA-SF = 9.9 ± 2.4, 15.6%, 52.5%, 31.9% were malnourished, at risk of malnourish, or adequately nourished, respectively.  
- Dentate residents had 23.5 ± 8.5 teeth,  
- 56% residents had 20-32 standing teeth,  
- DMFT of 11.3 ± 8.4 for dentate group; DT = 2.7 ± 3.0  
- Mean GOHAI score = 47.0 ± 9.2, 98 (69.5%) had low perception of oral health,  
- Mean GOHAI significantly associate with mean MNA-SF score. | Female residents had worst MNA-SF scores. |
| Kshetrimayum et al. (2013) [21] | To evaluate if OHRQoL is related to malnutrition risk in institutionalized elderly in Mysore, Karnataka, south western India | | Mini Nutritional Assessment Short Form (MNA-SF) administered | | Multiple logistic regression indicated female and low/moderate perception of oral health (GOHAI <57) significantly associated with MNA-SF score. |
| Rekhi et al. (2016) [22] | To investigate association between periodontal status and OHRQoL of residents from 18 elderly homes in Delhi, India | *n* = 500, ≥60-year, 279 (55.8%) female, 112 (22.4%) edentulous | Trained, calibrated examiner Community Periodontal Index (CPI) for sextant-wise periodontal status: healthy (0), bleeding (1), calculus (2), moderate (3), or deep pocket (4), Loss of Attachment (LOA) of 0-3mm (0), 4-5mm (1), 6-8mm (2), 9-11mm | - 26, 117 or 131 (5.2%, 23.4% or 26.2%) residents had highest CPI of 4, 3, or 2, respectively; and 14, 114, 137 or 7 (2.8%, 22.8%, 27.8% or 1.4%) had highest LOA of 3, 2, 1 or 0, respectively. 226 (45.2%) sextants excluded  
- MT = 15.5 ± 12.1, DT = 1.2 ± 1.7, root caries tooth = 0.6 ± 1.2  
- 55 (11.0%) had oral mucosal lesions: 27 (5.4%) leukoplakia, 16 (3.2%) ulcersations, 11 (2.2%) candidiasis, 1 (0.2%) lichen planus | ≥80-year group had more excluded sextant than 60-69-year residents |
<p>| Rekhi et al. 2018 [46] | Cross-sectional study, convenience sample. | | | Bivariate analysis indicated residents who were female, of older age group, without formal education, poor perceived general/oral health, perceived to need dental treatment, with excluded sextants, with DT, or needing various dental prosthesis, had worst GOHAI. |  |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>Study Title</th>
<th>Study Details</th>
<th>Health Indicators</th>
<th>Findings</th>
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<tr>
<td>Shivakumar et al. (2018) [23]</td>
<td>To assess oral health status, OHRQoL and dental care utilization of 3 elderly home residents in Satara district, Maharashtra state western India</td>
<td>Cross-sectional study, systematic random sampling of 3/6 elderly home, then ‘random’ sample of 50 residents from each.</td>
<td>Cross-sectional study, systematic random sampling of 3/6 elderly home, then ‘random’ sample of 50 residents from each.</td>
<td>Goethai (dichotomized as per Kshetrimayum et al. 2013 [21]) Dentist</td>
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<tr>
<td>Hong Kong</td>
<td>Tan &amp; Lo (2014) [26]</td>
<td>To describe root caries situation of institutionalized elders from 21 homes in Hong Kong, China who had ≥5 teeth with exposed root; and to investigate the risk indicators for root caries in these elders.</td>
<td>Cross-sectional study, purposive sampling</td>
<td>Visible Plaque Index (VPI), Root caries index (RCI)</td>
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<td>Japan</td>
<td>Takeuchi et al. (2015) [27]</td>
<td>To investigate if posterior occlusion (natural/artificial) was associated with cognitive state and/or functional</td>
<td>Cross-sectional study, convenience sample</td>
<td>Trained dentist, trained nursing home care staff</td>
</tr>
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</table>
dependence of residents ≥60 years in 8 nursing home at Aso City, Kumamoto Prefecture, southern Japan

- years for women; 33/14.1% (BI ≥60, i.e. functionally independent)
- mean age 85.5 ± 7.8 years for men and mean age 89.4 ± 6.5 years for women; 109 (54.5%) edentulous.

Index (BI) for functional capacity or dependency of the residents; Mini-Mental State Examination (MMSE) scale for dementia.

- n = 200: 155 (77.5%) female; total-FTU in functionally independent residents = 10.7 ± 3.4, functionally dependent residents = 8.7 ± 4.9.
- n = 200: 168 (84.0%) with BI <60
- mean standing teeth = 4.9 ± 7.7; 73.0% dentures wearers
- total-FTUs 9.3 ± 4.6.

- MMSE = 11.0 ± 8.6

- Total-functional tooth units (FTUs)

All symptom driven dental attenders with 34.3%/38.3% residents reported dental visit ≤1 year
- 94/269 or 34.9% never clean teeth/dentures, 51 (31.9%) removed their dentures before sleep
- 42.8% reported cleaning their dentures only with water; <12% brushed teeth/dentures twice a day.
- 59/139 or 42.4% had denture stomatitis
- DMFT = 25.5 ± 3.4; from 135 of the 346 cohort, DT = 3.4 ± 2.3, MT = 20.8 ± 4.5, FT = 1.2 ± 1.7
- From 135 of the 346 cohort, 736 teeth were examined, 59

dependence and posterior teeth occlusion; more functional tooth units were associated with greater odds of independence for essential personal care; while the loss of posterior teeth occlusion was independently associated with cognitive decline.

Multivariate analyses indicated total-FTUs was positively associated with MMSE scores after adjustment against age, sex, and number of natural teeth.

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### Eurasion trans-continent

#### Turkey

- To assess the oral health status and treatment requirements of different residential homes in Istanbul, Turkey, to study the relationship between dental caries and variables factors, and to provide guidelines for different residential homes.

- Cross-sectional study, convenience sampling with cluster allocation

- Uludamar et al. (2011): n = 346 residents; 65-90 years, 201 (58.1%) females were 79.1 ± 7.0 years, males were 75.2 ± 8.3 years; 208 (60.1%) edentulous and 88 (25.4%) had complete denture; 135/117/94 residents were in fully financed/supported/subsidized residential homes, respectively.

- Calibrated dentists

- Plaque index, DMFT, probing pocket depth (PPD) >4 mm

- Denture cleanliness after plaque disclosing

- From 346 residents study:
  - Based upon distribution, denture stomatitis appeared associated with age, income, general health, denture hygiene, or overnight denture wearing.

  - Apparently the surveyed residents from homes with different levels of subsidies seemed to have different levels of DMFT.
  - The authors did not attempt post-hoc analysis to focus which group was different from the rest.

  - Reported no differences in prevalence of teeth with PPD >4 mm between surveyed residents from homes with different levels of subsidies
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<td><strong>Özkan et al. (2016) [29]</strong></td>
<td>To assess the oral health status of elderly residents of the Nursing Home of Aydin Social Services and to determine related risk factors and requirements in terms of oral health.</td>
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<tr>
<td><strong>Dentist</strong></td>
<td><strong>CPI, LOA; DMFT, decayed root</strong></td>
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<tr>
<td>• 5 (4.4%) visited dentist regularly, 78 (68.4%) irregular attenders</td>
<td>• 25 (21.9%) had ≥1 oral lesion, 12 (10.5%) denture stomatitis</td>
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<td>• 8 (13.3%), 19 (31.7%), 23 (38.3%), 7 (11.7%), 3 (5.0%) had highest CPI of 4, 3, 2, 1, or 0, respectively; 7 (11.7%), 8 (13.3%), 18 (30.0%), 14 (23.3%), 13 (21.7%), had highest LOA of 4, 3, 2, 1, or 0, respectively.</td>
<td>Bivariate analysis indicated 75-84 year-group associate with poor DT, decay roots, and FT.</td>
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<td><strong>EUROPE</strong></td>
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<td><strong>Lithuania</strong></td>
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<tr>
<td><strong>Brukené et al. (2011) [44]</strong></td>
<td>To investigate the association between salivary flow rate,</td>
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pH, buffer capacity, plaque level and health conditions plus medication in institutionalized elderlies in Vilnius, Lithuania

- pH, buffer capacity
- Plaque level
- Health conditions
- Medication

n = 25 ‘control group’, 22.3 ± 2.3 years, gender unknown, all healthy, receiving no medications
n = 50 institutionalized residents, 33 (67.3%) female, mean age 82.0 ± 9.3 years; 4.7 ± 1.9 (0-9) systemic diseases, 5.3 ± 2.6 (0-10) daily medications; 31 (62.0%) edentulous, of 49 with saliva sampled.

Salivary flow rate (aspiration by saliva ejector for elderly), pH, buffer capacity

Quantiative plaque percent index: baseline plaque/plaque formation rate index

- ‘Salivary flow rate’ (ml/min)/pH were 0.3 ± 0.2/6.3 ± 0.7 or 0.4 ± 0.4/6.9 ± 0.5 for residents or ‘control group’, respectively; 38.1%/35.7%/26.2% or 0%/16.0%/84.0% of residents or ‘control’ had low/medium/high buffer capacity
- Baseline Plaque Index: 50.7 ± 38.1%/35.7%/26.2% or 0%/16.0%/84.0% of residents or ‘control’ had low/medium/high buffer capacity

Baseline Plaque Index: 50.7 ± 35.7% and Plaque Formation Rate Index 39.4 ± 20.3% in 19 residents surveyed.

Salivary buffer capacity was significantly related to salivary pH.

**Spain**

Cornejo et al. (2013) [36]

To describe the oral health status and the factors associated with OHRQoL in ≥ 65 years, no cognitive impairment, institutionalized residents in 25 public social-health centers in Barcelona, Spain

Cross-sectional study, convenience sample.

n = 194, 138 (71.1%) female, 67 (34.5%) edentulous.

Dentist

CPI, DMFT, prosthetic need; GOHAI: dichotomized at <57: poor (negative) vs. good (positive).

- 135 (69.6%) had less than primary school education
- 15 (7.7%) attended dentists in last 12 months
- 10, 36, 54, 6 or 2 (5.2%, 18.5%, 27.1%, 3.1% or 1.9%) residents had highest CPI of 4, 3, 2, 1, or 0, respectively;
- DMFT = 22.8, MT = 20.5, DT = 2.1, FT = 0.2
- 145 (74.4%) were considered functional edentulous

Female residents had significantly poorer OHRQoL than males (p=0.042). They found that female residents had poorer dental and periodontal conditions, with a high prevalence of calculus and 4-5 mm pockets and a higher prevalence of edentulism than males.

Bivariate analysis indicated residents who perceived teeth, gums or denture problems, functional edentulous or needing upper denture were associated with poor GOHAI.

No multiple logistic regression analysis nor covariate adjustment attempted.

**Finland**

Saarela et al. (2014) [33]

To assess ≥ 65 years service housing residents’ dentition,

Cross-sectional study, convenience sample

Ward nurses evaluated dentition status interviewing,

- Mean CCI = approx. 2.9
- Mean BMI: 24.7-25.7

Dentition status appeared associate with age, gender, education or disability; Cox regression analysis adjusted for age,
(Saarela et al. 2014 [49])² eating habits, nutritional status (among 343 residents: energy, protein and vitamins intake, and to explore the prognostic value of dentition for mortality. Study conducted in Helsinki and Espoo, Finland n = 1,369, 1,081 (79.0%) female; mean age 82.7 years; 708 (51.7%) edentulous; 758 (55.4%) residents had MCI or above. Group 1: 94 (6.9%) edentulous without dentures; Group 2: 614 (44.9%) edentulous with some kind of dentures; Group 3: 661 (48.3%) with some natural teeth left. Subgroup: n = 343; 286 (83.4%) female; mean age 83 ± 7.3 years; 162 (47.2%) edentulous; 280 (81.6%) had MCI.

Observing and assessing the residents.

CCI; Clinical Dementia Rating Scale (CDR) MNA dichotomized at <17, 17 - 23.5, >23.5 as malnutrition, risk for malnutrition, or good nutritional status, respectively; body mass index (BMI)

- 295 (21.5%), 286 (20.9%), 164 (12.0%), 94 (6.9%) residents with dry mouth, chewing problem, difficulty swallowing, pain in mouth, respectively; 177 (12.9%), 884 (64.6%), 308 (22.5%) were with MNA at <17, 17-23.5, or >23.5, respectively.

74 (21.6%), 220 (64.1%), 49 (14.3%) of the 343 subgroup were with MNA at <17, 17-23.5, or >23.5, respectively.

Gender, comorbidity and MNA score indicated dentition status not predicting mortality.

Adjusted logistic regression analysis of the n = 343 data set indicated Group 1 predict low protein intake of <60 g/day.

No DMFT recorded.

No calibration of examination accuracy by ward nurses vs. dentists.

Edentulous residents without denture had poorer physical functioning and ADL performance than those who were dentate or edentulous with or without removable denture. However, no multivariate analysis was conducted.

Germany

Zenthöfer et al. (2014) [30]

To evaluate the association between oral health conditions, including prosthetic needs vs cognitive ability, general level of care needed, or OHRQoL of institutionalized eldery with or without dementia in 13 homes in Baden-Württemberg, southwest Germany

Cross-sectional study, convenience sample.

n = 268, mean age 83.1 ± 9.1 years, 189 (70.5%) female; 107 (39.9%) edentulous, 136/219 (62.1%) with dementia, 3.4 ± 2.3 systemic disease, on 6.6 ± 3.5 medications.

From 93 residents pilot study:
- MT = 20.5 ± 8.7, DT = 0.6 ± 1.4
- Plaque % = 83.2 ± 20.5, DHI% = 85.1 ± 15.7; GBI% = 42.6 ± 24.1, CPI (unconventional data presentation) = 3.2 ± 0.6

From 94 residents pilot study:
- MT = 20.3 ± 8.9
- After median split of ROAG score, the ‘unsatisfactory’ group had lower GOHAI, i.e. 48.7 ± 7.3 vs. 53.3 ± 6.2

From 268 residents study:
Spearman correlation indicated ROAG score associated with dependency (BI) and dementia (MMSE).

Zenthöfer et al. 2014 [50, 51]; 2015 [52], 2017 [53]; Klotz et al. 2017 [54]²

To evaluate the association between oral health conditions, including prosthetic needs vs cognitive ability, general level of care needed, or OHRQoL of institutionalized eldery with or without dementia in 13 homes in Baden-Württemberg, southwest Germany

CPI of treatment needs (CPITN, or an old pre-1997 version of CPI); plaque control record; Gingival Bleeding Index (GBI), Denture Hygiene Index (DHI), Yes/No denture problem, revised oral assessment guide (ROAG): median split

From 94 residents pilot study:
- MT = 20.3 ± 8.9
- After median split of ROAG score, the ‘unsatisfactory’ group had lower GOHAI, i.e. 48.7 ± 7.3 vs. 53.3 ± 6.2

From 94 residents pilot study:
linear regression indicated compromised GOHAI significantly associated with without prosthesis rehabilitation, poor oral health and high care level, while within denture wearers only, older age, number of drugs taken, higher care levels, poor oral health, and insufficient denture condition.

From 268 residents study:
Spearman correlation indicated ROAG score associated with dependency (BI) and dementia (MMSE).
were scored for CPITN, GBI, DHI and MMSE

169 [mean age 82.9 ± 8.9 years, 114 (67.5%) female, 124 (73.4%) with dementia, 3.5 ± 2.2 systemic disease, on 6.7 ± 3.4 medications] were scored for no. of teeth, denture status (n=143), ROAG, GOHAI and MMSE.

Three pilot studies of n = 93, 94 or 92 from 4, 4 or 13 elderly homes, 60 (64.5%), 61 (64.9%) or 63 (68.5%) female, 37 (39.8%), 37 (39.4%) or 31 (33.7%) edentulous, respectively; 61.3%/74.5%/unknown with dementia, 6.6 ± 3.7/6.6 ± 3.7/unknown with systemic disease, on 7.1 ± 3.6/7.2 ± 3.8/7.3 ± 3.3 medications, respectively.

for satisfactory vs. poor oral health

German version of GOHAI dichotomized at <50: compromised vs. normal perception of oral health

MMSE, BI, Pantomime test for apraxia

• DHI = 82.6 ± 14.6%; GBI = 48.5 ± 25.9%, CPITN (unconventional data presentation) = 2.9 ± 0.7
• 53 (57.6%) with apraxia
Zenthöfer et al. (2014b), from 268 residents:
• standing teeth: 6.8 ± 8.3,
• 249 (92.6%) had ≥1 oral treatment need, median ROAG = 2.0; BI = 46.9 ± 30.3.

Zenthöfer et al. (2017): From 219 residents:
• standing teeth: 7.0 ± 8.4, edentulism data confusing (n = 78 or 92?), DHI = 82.9 ± 17.9%; GBI = 51.7 ± 28.1%, CPITN (unconventional data presentation) = 2.9 ± 0.7

Klotz, et al. (2017): From 169 residents:
• standing teeth: 8.3 ± 8.9, 91 (53.8%) had denture related treatment needs, ROAG = 2.3 ± 1.3; GOHAI = 49.1 ± 8.3,

From 93 residents pilot study:
Mean CPITN was significantly worse for the dentated residents.

From 92 residents pilot study:
Bivariate analysis indicated GBI % and CPITN appeared significantly worse among individuals with ideomotor apraxia than among nonapraxic participants but not for DHI%.

Linear regression showed that each identified apraxia was associated with poor oral hygiene and health.

From 219 residents study:
Multivariate logistic regression indicated CPITN significantly associated with female, dementia and use of coagulation inhibitors while GBI was associated with the latter and older age.

From 169 residents study:
The number of natural teeth <5 and edentulism without prosthesis in the residents surveyed was significant associated with low GOHAI score.

Ziebolz et al. (2017) [31] To investigate associations between oral (dentate or edentulous) and nutritional status of 4 nursing home residents in Lower Cross-sectional study, convenience sample.

n = 87, 68 (78.2%) female; mean age 84.0 ± 8.6 years; 41 (47.1%) edentulous, BMI = 26.2 ± 5.0 kg/m², 48 (55.2%) with dementia

Dentist DMFT, Periodontal screening and recording (PSR) for 38 residents

• overall DMFT = 26.4 ± 3.1.
• residents with teeth (n=46):
  • DMFT = 25.0 ± 3.7, DT = 2.1 ± 3.1, MT = 15.0 ± 8.3, FT = 8.0 ± 7.4
  • 30 (78.9%) with PSR*/Periodontal screening index (PSI) score 3 and 4: needing

Multivariate analysis indicated residents at risk of malnutrition were associated with dementia, and edentulism
### Saxony, northwestern Germany

MNA, claimed dichotomize as per Saarela et al. (2014a) but considered at data analysis 8-11 as risk of malnutrition and 12-14 as normal nutrition.

- Median MNA = 11, 0 ‘malnourishment,’ 45 (51.7%) at risk of malnutrition of which 10 needed help with meal.

### Malta

**Santucci & Attard (2015) [35]**

To report impact of oral health status on corresponding OHRQoL in residents of 9 state residential homes, Malta.

- Cross-sectional study, convenience sample
- Examination at dental clinic

- Modified CPI, oral mucosal lesion, prosthetic status
- OHIP-14, GOHAI (243 responded), denture satisfaction questionnaire [66] (169 responded)

- 29.3% (ca. n = 817) residents reported routine dental attendance (not defined)
- Mean standing teeth = 13.7, 43.3% (ca. n = 1207) with caries, mean DMFT = 21.6; 22 (7.9%) had functional dentition, i.e. ≥21 teeth
- 64/114 edentulous residents were without denture
- 241 (86.7%), or 4 (1.3%) had highest CPI sextant of deep/shallow pockets; calculus, bleeding on probing or healthy, respectively
- Mean denture satisfaction score = 42.8; mixed reasonable satisfy and not/satisfy scores
- 35 (12.6%) had oral mucosal lesion
- OHIP-14 = 3.8, GOHAI = 54.5

### United Kingdom

**Porter et al. (2015) [37]**

To assess the association between OHRQoL and oral health condition or oral symptoms of

- Cross-sectional study, convenience sample.

- Dentist

- Standing teeth = 8.9 ± 6.4, DT = 2.0 ± 1.6, D root = 2.2 ± 2.8, FT = 4.2 ± 5.2, MT = 18.0 ± 8.3
- 139 (68.8%) had unrehabilitated anterior space

Spearman’s correlation indicated increased DT, MT or DMFT, without maxillary or mandibular denture was associated with better OHRQoL (OHIP-14/GOHAI); denture satisfaction was associated with denture age and denture type.

Adjusted multivariate logistic regression showed prevalence of oral impact (i.e. at least 1 OIDP item with a non-0 score) associated with sensitive teeth, toothache,
residents (≥65 years) in 9 nursing homes
in Islington, London, UK
n = 179 responded to survey
Oral Impacts on Daily Performances (OIDP)
to assess the impact of oral conditions on
OHRQoL.

- 73 (40.8%), 62 (34.6%) had dry mouth or dry, sore or cracked lips, respectively. 19 (34.4%) of edentulous residents had ill-fitted denture; 23.9%, 17.1%, 15.4%, 15.4% or 10.1% of dentate residents surveyed had broken teeth, toothache, sensitive teeth, loose teeth, or bleeding gum, respectively.

To investigate relationships between oral health factors and general health factors (including physical, mental, and social health domains) and OHRQoL in a care-independent and a care-dependent older population. The institutionalized elderly were from 11 residential aged care facilities in southeast Netherlands.

Calibrated final year dental/dental hygiene students.

Case-control study, Purposive sample.

n = 126, 73 (57.9%) female, mean age 85.4 ± 7.1 years; 58 (46.0%) edentulous

Tooth and position, caries, removable denture status

109 home dwellers, 52 (47.7%) female, mean age 73.1 ± 5.4 years; 43 (39.4%) edentulous

Socioeconomic status (SES), GOHAI, dental service use frequency

Gobbens' definition of frailty; Short Form health survey (SF-12: physical and mental); validated ENRICHID Social Support Index (ESSI)

- 17.5%, 50.8% of the residents surveyed had physical or mental HRQoL component ≥the population norm, respectively
- 26.2%, 38.9% 34.1% experienced low, medium, or high social support
- MT = 16.8 ± 8.2 (non-institutionalized, 10.7 ± 5.1); occluding pairs = 5.4 ± 5.0 (non-institutionalized 9.4 ± 3.5)

One-way ANOVA showed higher GOHAI score from residents was associated with absence of caries, no clinical treatment needs and no reported treatment demand.

Calibrated final year dental/dental hygiene students.

Case-control study, Purposive sample.

n = 126, 73 (57.9%) female, mean age 85.4 ± 7.1 years; 58 (46.0%) edentulous

Tooth and position, caries, removable denture status

109 home dwellers, 52 (47.7%) female, mean age 73.1 ± 5.4 years; 43 (39.4%) edentulous

Socioeconomic status (SES), GOHAI, dental service use frequency

Gobbens' definition of frailty; Short Form health survey (SF-12: physical and mental); validated ENRICHID Social Support Index (ESSI)

- 17.5%, 50.8% of the residents surveyed had physical or mental HRQoL component ≥the population norm, respectively
- 26.2%, 38.9% 34.1% experienced low, medium, or high social support
- MT = 16.8 ± 8.2 (non-institutionalized, 10.7 ± 5.1); occluding pairs = 5.4 ± 5.0 (non-institutionalized 9.4 ± 3.5)

One-way ANOVA showed higher GOHAI score from residents was associated with absence of caries, no clinical treatment needs and no reported treatment demand.

Adjusted multivariate analysis showed GOHAI score was associated with age, female gender and higher SES.

Pearson correlation indicated no correlation exist between GOHAI score of residents surveyed and any continuous variable analyzed.

Binary logistic regression indicated edentulism, difficulty in attending dentist or existence of clinical treatment need was associated with frequency or change in dental services use; while high care dependency or could not summon effort to brush was associated with change in brushing frequency. No multiple logistic
Belgium

To describe medication use in 23 nursing homes resident and corresponding oral health; to identify various parameter that associate with poor oral health, in particular the medications related to hyposalivation. Study conducted in East and West Flanders, Belgium.

Cross-sectional study, Nonrandom sample

n = 1,226; 858 (70.0%) female; mean age 83.9 ± 8.5 years; 514 (41.9%) edentulous; 81.3% had systemic disease, mean 9.0 ± 3.6 medications from 1,174 residents; 92.0%, 85.7%, 81.3%, 60.0%, or 25.5% taking medications for nervous system, alimentary tract and metabolism, cardiovascular system, blood and blood forming organs, or respiratory system, respectively.

A subgroup of n = 143 residents from 14 homes, 109 (76.2%) female; mean age 82.7 ± 7.8 years; 60.2% of low ADL level

Regression analysis was attempted for the latter.

Janssens et al. (2017) [32]

(Janssens et al. 2017 [57])

Dentists

DMFT, PI, Dutch PSR

Activity of daily living (ADL): low, medium, or high

Anatomical Therapeutic Chemical (ATC) classification system from WHO Collaborating Centre for Drug statistics Methodology.

Among 1,226 residents:
- 218 (17.9%), 328 (26.9%), 675 (55.3%) had low, medium or high ADL, respectively
- DMFT = 27.7, DT = 1.8, MT = 24.9, FT = 1.0; retained roots = 1.1
- Among all prescribed medication, 49.6% or 4.5 ± 2.2 had potential hyposalivary effect

Among dentate residents (n = 712):
- Standing teeth = 12.3 ± 8.1, 285 (40.4%) had caries, DT = 3.0 ± 4.0 including retained roots = 1.9 ± 3.4
- DMFT = 24.5 ± 7.0
- Among residents who wore removable dentures, 36.9% needed repair, rebase or renewal.

Among 143 residents:
- Standing teeth = 13.6 ± 7.0, DT = 1.4 ± 2.2, FT = 2.3 ± 3.3, DMFT = 19.8 ± 6.8; retained root = 1.8 ± 3.1
- PI = 2.1 ± 0.7; approx. 15%, 53%, 5%, 24%, or 2% had highest Dutch PSR score of 4, 3*, 3, 2, or 1, respectively.

Mixed-effect logistic regression analysis indicated male and age associated with proportion of DT in dentate residents while 10-13 medications used and the count of medications used potentially induce dry mouth negatively associate with the latter.

Mixed-effect logistic regression analysis indicated female, 10-13 medication used, count of medications used potentially induce dry mouth associated with higher treatment index in dentate residents while high dependency negatively associated with the latter.

General linear mixed-model analysis indicated:
- male and older dentate residents were associated with DT or retained roots or total treatment need
- female, younger dentate residents, no preferential tariff were associated with FT or restorative index
- male, older dentate and high dependency residents were associated with extraction need
**General linear logistic mixed analyses** showed that residents with medium care dependency, increasing age and the possession of a preferential tariff were significantly associated with a higher risk of wearing a full denture.

No regression analysis attempted for interrelationship between periodontal and other socioeconomic/medical parameters of residents.

### Italy

**Cocco et al. (2018) [34]**

To evaluate the prevalence and severity of tooth loss in 23 nursing home residents in 5 areas (northwest, northeast, center, south and islands) of Italy.

<table>
<thead>
<tr>
<th>Study Details</th>
<th>Prevalence</th>
<th>Functional Dental Units</th>
<th>Prosthetic Status</th>
<th>Nutritional Status</th>
<th>Cognitive Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional study, convenience sample.</td>
<td>n = 1,976, 1,462 (74.0%) female; mean age 84.1 ± 9.7 years, 814 (41.2%) edentulous</td>
<td>1,326 (67.1%), 1,289 (65.2%), or 741 (35.5%) residents, respectively.</td>
<td>One examiner; not specified</td>
<td>BMI, MMSE, or MNA scores were collected from 1,326 (67.1%), 1,289 (65.2%), or 741 (35.5%) residents, respectively.</td>
<td>Only breakdown or per age group data available, no overall dental, SES, MMSE, BMI or MNA data presented</td>
</tr>
<tr>
<td>Multinomial logistic regression analysis showed reduced functional dental units was associated with severe MMSE (mental state), older age group of ≥80 years, and female.</td>
<td>1,688 (86.3%), 121 (6.2%), 147 (7.5%) of the 1,956 residents</td>
<td>Functional units (good, sufficient or insufficient for chewing; lacking clear definition), prosthetic status</td>
<td>SES, MMSE, BMI, MNA</td>
<td>Did not collect/report DMFT/CPI data.</td>
<td></td>
</tr>
</tbody>
</table>
surveyed had insufficient, sufficient, or good functional units for chewing, respectively.

OCEANIA

Australia

Cross-sectional study, convenience sample

n = 510/1,345 surveyed; 351 (68.8%) female, women 85.7 ± 9.4 years, men 77.8 ± 13.9 years; 235 (46.1%) edentulous; 242 (47.5%) had ≥5 chronic medical conditions; 401 (78.6%) took ≥5 medications, 194 (38.0%) had dementia, 92 (18.0%) had stroke; 75 (14.7%) had diabetes (DM).

Reported 273/275 dental condition.

Reported 263/275 dentate residents' periodontal conditions: n = 263, >75 years, 171 (65.0%) female; 84 (35.6%) with dementia; 37 (14.1%) had stroke; exact number of residents examined not clear.

Dental status of 273 residents:
- Mean standing teeth = 14.4, DT = 2.7 with 82 (30.0%) DT = 0, and 7 (2.6%) D root, 69 (25.3%) with retained root(s)

Periodontal status of 263 residents:
- Only 25% residents had dental visit in past 2 years,
- <1/3 residents reported cleaning their teeth ≥2×/day;
- 50% of residents reported cleaning their teeth 1×/day,
- >25% residents had plaque covering >1/3 of at least one index tooth (upper first and second molars, upper right central incisor; lower first and second molars, lower left central incisor),
- All residents had visible plaque on any one index tooth
- Periodontal health was extremely poor;
- >50% of residents had calculus

Male gender or residents ≤65 years old had significantly more DT and fewer FT; residents claimed that needing dental treatment had more DT; those who attended dentists ≤1 year had higher DMFT; residents attended dentist for check-up had more FT; dentated DM residents had less standing teeth, less FT and more DT; no association detectable between DT and number of medications taken nor number of chronic medical conditions; no post-hoc test nor regression analysis attempted.

Female residents had increased visual plaque; 75-84 years group had increased visual plaque and periodontal disease

Logistic regression analysis indicated CPI score 3 or above (i.e. periodontal pocket 3.5-5.5 mm [35.6% participants] or periodontal pocket >6 mm [10.2%]) in any one sextant of a participant was associated with inadequate or poor plaque control, >9 teeth present, male gender and aged 75-84 years; no covariate adjustment attempted.

Residents who required total assistance with oral hygiene had more decayed teeth and fewer filled teeth.
To investigate oral hygiene, gum conditions and caries experience of institutionalized, aged, dentate residents in Perth, Western Australia, with or without dementia

Cross-sectional study, convenience sample.

Philip et al. (2012) [39]

Dentist

Full mouth examination:

O’Leary’s plaque score (Pl%); visual detection of gingival redness (categories of minimal, light, moderate or heavy inflammation).

DMFT, retained root

- 21% residents were mADOH able, 22% as partially disabled, and 51% disabled
- DMFT ≈ 26, DT ≈ 3, MT ≈ 18, FT ≈ 5; D root = 0.05, retained root = 1.3.

DMF, retained root

To investigate oral health status and OHRQoL of pre-seniors (45-64 years), seniors (≥65 years), and residents in 31 (4 private, 28 public; 15 rural, 16 urban) long term care (LTC) facilities in urban and rural Nova Scotia, maritime province, eastern Canada.

Cross-sectional study, random sampling

Kotzer et al. (2012) [40]

Oral health survey:

LTC residents: n = 335, 248 (74.0%) female; mean age 80.8 ± 11.6 years; 137 (40.9%) edentulous; 112/329 (34.0%) perceived fair/poor general health.

OHRQoL study:

Community dwellers: pre-seniors n = 629, seniors n = 501, 711 (62.9%) female

pre-senior LTC residents n = 33, elderly LTC residents n = 297; 246 (74.5%) female

6 calibrated dentists

Modified WHO protocol: mucosal and denture status, DMFT, gingival index (GI), debris index, calculus index, PPD, probing attachment level (PAL)

OHIP-14

- 244 (75.3%) LTC residents reported dental visit <1×/year; 64.6%/28.6%/10.5%/6.5%/1.5%/1.8% reported oral healthcare provider as none, dentist, dental hygienist, denturist, physician, or others, respectively.
- 155 (48.7%) residents brush <2×/day, 158 (83.2%) of 190 dentate residents did not use floss daily.
- 79/324 (24.4%) perceived fair/poor oral health

Logistic regression indicated that perceived need for oral treatment and smoking years were associated with ≥1 D/F roots, while debris index ≥2 and smoking years were associated with ≥1 DC crown, or residents ≥65 years; brush <1×/day, and smoking years were associated with DMFT in dentate residents.

NORTH AMERICA

Canada

To investigate oral health status and OHRQoL of pre-seniors (45-64 years), seniors (≥65 years), and residents in 31 (4 private, 28 public; 15 rural, 16 urban) long term care (LTC) facilities in urban and rural Nova Scotia, maritime province, eastern Canada.

Cross-sectional study, random sampling

Matthews et al. (2012 [60])

Oral health survey:

Community dwellers: pre-seniors n = 629, seniors n = 501, 711 (62.9%) female

pre-senior LTC residents n = 33, elderly LTC residents n = 297; 246 (74.5%) female

6 calibrated dentists

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OHIP-14

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- 155 (48.7%) residents brush <2×/day, 158 (83.2%) of 190 dentate residents did not use floss daily.
- 79/324 (24.4%) perceived fair/poor oral health

Logistic regression indicated that residents ≥75 year-old, from urban homes, and without fairly/very often OHIP-14 impact were associated with usage of complete upper and lower dentures all the time.

Bivariate analysis indicated that LTC residents who reported one or more
138 (41.2%) residents had some sort of oral mucosa conditions (or edentulous alveolar ridge resorption): 14.0%/12.2%/7.2%/6.0%/4.2%/3.3%/3.03 had extreme alveolar ridge atrophy, denture stomatitis, glossitis, ulcer, white patches, angular cheilitis, residual ridge fibrosis, respectively.

• DMFT = 23.6 ± 5.3, DT = 0.8 ± 1.8, MT = 19.7 ± 9.0, FT = 3.1 ± 4.9
In 198 dentate LTC residents

• DT = 1.4 ± 2.2, FT = 5.2 ± 5.4;
D root = 1.4 ± 2.6, F root = 1.1 ± 2.1;
51.0% had untreated coronal caries, 44.4% had untreated root caries

• Debris index = 1.4 ± 0.7,
calculus index = 1.1 ± 0.8; 65.6% surveyed had GI ≥2 at ≥1 site;
36.2% surveyed had PPD ≥4 mm at ≥1 site; 66.7% surveyed had PAL ≥ 4 mm at ≥1 site.

• 34.0%/21.0% residents perceived fair/poor general health or quality of life, respectively.
• OHIP-14 scores: community dwellers = 5.6 ± 7.6, LTC residents = 5.6 ± 9.6

USA impacts “fairly often” or ‘very often’ were associated with high school education or lower, had oral pain, perceive their general health, mouth health and quality of life to be fair or poor, or dissatisfied with their teeth or dentures.

Logistic regression indicated that LTC residents having ≤ high school education, with fair or poor perceived mouth health were more likely to report an OHIP-14 response of ‘fairly often’ or ‘very often’. 
Zimmerman et al. (2017) [41]

To characterize oral hygiene status of 14 nursing homes in North Carolina (11 profit making, with high pneumonia rehospitalization rate) residents and examine risk that might correlate with information in the minimum data set. Cross-sectional study, convenience sample.

- PI-LTC = 1.7 ± 0.8 (out of 3); GI-LTC = 1.5 ± 0.9 (out of 4), DPI = 2.2 ± 1.2 (out of 4).
- lower denture evidencing better hygiene, especially on the facial (exposed) surface

Cognitive problem was significantly related to all measures.

Did not collect/report DMFT/CPI data
No DMFT/CPI data
Did not attempt multivariate data analysis.

SOUTH AMERICA

Brazil

Piuvezam & de Lima (2012) [42]

To identify self-perceived oral health status, factors associated with missing teeth or TMJ alterations in institutionalized elderly in 2 cities each in 11 medium and large municipalities representing North, Northeast, South Cross-sectional study, convenience sample.

- CPI, LOA, DMFT; prosthetic need, TMJ examination; GOHAI score, binary approach adopted: dichotomized at ≤30; negative vs. positive perception of oral health
- CPI = 127/588 (21.8%) residents had dental visit in past 12 months
- 25, 49, 109, 4 or 22 (4.3%, 8.3%, 16.6%, 0.7% or 3.7% of total) had highest CPI of 4, 3, 2, 1 or 0, respectively; and 16, 31, 58, 57 or 47 (2.7%, 5.3%, 9.9%, 9.7% or 8.0% of total) had highest LOA of 4, 3, 2, 1 or 0, respectively. 378/64.4% sextants excluded
- DMFT = 28.8 ± 5.5 (> 28, i.e. third molars perhaps not excluded) making final DMFT >28.
- Adjusted multivariate analysis indicated males, residents last dental visited >1 year, lack of private health assistance, or at non-South Brazil regions were associated with higher rehabilitation needs; while residents self-perceived fair gum, teeth or prosthesis had more extraction needs; and, females, residents living independently, self-perceived poor health.

Piuvezam & de Lima, 2013 [61]; de Medeiro et al. 2019 [62]
Southeast, and Midwest Brazil. Total of 36 long-stay institutions for the elderly (LSIE) were surveyed.

the 1,192 cohort, DT = 1.2 ± 6.7, FT = 0.3 ± 1.2
- 454 (39.2%/245 (21.2%) wearing upper/lower denture
- 709 (61.2%/908 (78.4%) need some forms of upper/lower denture
- 179/15.5% had TMJ alternation
- median GOHAI score = 33

Gum, teeth or prosthesis or needing upper dentures were associated with more TMJ alterations.

Adjusted multivariate analysis indicated residents who visited dentist in last year, had gum problems or self-perceived poor gum, teeth or prosthesis were associated with poor GOHAI scores.

Ψ indicates the article(s) was/were referred because the articles(s) shared the same sample group with the main included study and reported relevant information that could not be retrieved in the main study.