



OPEN Oral health of nursing home residents in Flanders, Belgium, and its associated factors

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Oral health in care-dependent older adults is often compromised due to care dependency associated with deteriorating general health. This cross-sectional study assessed the oral health of 458 nursing home residents in Flanders, with a mean age of 82.7 years (70.3% female), using the optimised Oral Health Section of the interRAI Suite of Instruments and validated dental indices. Among residents with natural teeth (53.9%), poor oral hygiene (75.7%), poor tooth condition (56.6%), and poor gum condition (49.9%) were common. High dental plaque levels yielded a mean Oral Hygiene Index of 4.5, and 44.0% of participants had untreated caries with pulp involvement. A mean Modified Gingival Index of 1.8 indicated mild inflammation of the entire gingiva. Denture hygiene was inadequate in 68.5% of cases. Self-reported issues included dry mouth (32.8%) and chewing difficulties (23.4%). The higher correlation coefficients were observed between oral hygiene and gum condition ($r=0.324$, $p<0.0001$) and between chewing difficulty and pain ($r=0.247$, $p<0.0001$). Bivariate analyses showed cognitive and functional impairments were strongly linked to poor oral hygiene and gingival health. These findings highlighted the persistent need to improve oral health care in nursing home residents, particularly among those with cognitive decline or reduced self-care abilities.

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Keywords Aged, Geriatric assessment, interRAI, Long-term care, Oral hygiene, Oral health assessment

Abbreviations

ADL	Activities of Daily Living
ADL-H	InterRAI Activities of Daily Living Hierarchy scale
BelRAI LTCF	Belgian version of the interRAI for use in Long Term Care Facilities
CAP	Collaborative Action Points
CHES	InterRAI Changes in Health, End-stage disease, Signs, and Symptoms scale
CI	Calculus Index
CPS	InterRAI Cognitive Performance Scale
DI	Debris Index
DRS	InterRAI Depression Rating Scale
IMA	Intermutualistic Agency
LTCF	Long Term Care Facilities
MGI	Modified Gingival Index
NIHDI	National Institute for Health and Disability Insurance (Belgium)
OHAT	Oral Health Assessment Tool
OHI	Oral Hygiene Index
OHS-interRAI	Oral Health Section for use within the interRAI suite of instruments
PUFA	Pulp Ulceration Fistel Abscess
ROAG	Revised Oral Assessment Guide

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In Belgium, nearly 20% of the population is aged over 65, which is expected to rise to over 25% by 2050¹. In Flanders, the largest region of Belgium, 21% of the population was aged over 65 in 2023, with approximately 8% receiving nursing care at home, and 5% residing in long-term care facilities². Advancements in professional and daily oral care have enabled older adults to retain their natural dentition into later life^{3,4}, positively affecting their chewing ability and nutritional status³. However, declining self-care due to general health deterioration, cognitive impairment or physical limitations presents challenges for oral health in care-dependent older people^{5,6}.

The most common oral health problems among nursing home residents are dental caries including root caries, periodontal disease, edentulism, dry mouth/xerostomia, and oral cancer⁷. These issues are associated with both non-modifiable factors (e.g. care dependency, systemic diseases) and modifiable factors (e.g. lifestyle)^{8,9}. Care dependency, defined as a decrease in functional ability, can be measured through activities of daily living (ADLs). Personal hygiene, including oral hygiene, is often among the first activities to be affected. Research in short-term care has shown that older people requiring assistance with self-care, such as oral hygiene, have a significantly higher risk of experiencing oral health issues, particularly poor oral hygiene and broken teeth¹⁰. Poor oral hygiene is associated with plaque accumulation, which increases the risk of tooth decay and periodontal disease^{11,12}, while poor denture hygiene is linked to oral mucosal lesions^{9,13}. These conditions contribute to tooth loss, pain and chewing difficulties^{14,15}.

Oral health is closely related to overall health and well-being¹⁶. One of the most well-documented associations is between periodontal disease and systemic conditions, such as cardiovascular disease and diabetes¹⁷. Among older people, poor oral health has also been linked to aspiration pneumonia^{18,19}, malnutrition^{20,21}, cognitive decline²², frailty^{23–25}, and polypharmacy^{26,27}, particularly in nursing home residents. Additionally, oral health has been extensively linked to quality of life and well-being^{5,9,28–30}. Depression, the most common mental illness in older adults, is associated with an increased risk of caries and periodontal disease⁷.

The most recently published data on oral health among nursing home residents in Flanders were collected between 2010 and 2012^{13,31}. The national survey, conducted on behalf of the National Institute for Health and Disability Insurance (NIHDI) in 2010, revealed that 77% of individuals with natural teeth required treatment, primarily due to tooth decay and periodontal inflammation, as did approximately 50% of denture wearers¹³. Plaque levels were high for both natural teeth and dentures, with one in four participants showing mucosal lesions, mainly related to ill-fitting or inadequately maintained removable dentures¹³. About 36% of nursing home residents were edentulous, compared to 64% in another study. De Visschere et al. (2016) concluded that care-dependent older adults in Flanders had very poor oral health¹³.

This study aims to investigate the current prevalence of oral health problems among nursing home residents in Flanders, as assessed by oral health professionals. Furthermore, the study seeks to identify factors associated with these problems, particularly clinical characteristics of the participants, including care dependency, including cognitive impairment, and reduced functional ability.

Methods

Study design

This cross-sectional study was conducted between April and October 2022 in nursing homes in Flanders, Belgium. This study is part of a longitudinal cluster randomised controlled trial to evaluate the implementation of the OHS-interRAI in nursing homes. The OHS-interRAI is an oral health screening instrument for use by non-dental caregivers within the interRAI instruments^{32,33}. This study presents the oral health status of older people before any intervention took place in the trial.

Reporting of the study methods and results follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies^{34,35}. Details about the checklist are included in Supplementary Information.

This study was approved by the Ethics Committee Research UZ/KU Leuven, Belgium (B3222021000650).

Setting

All nursing homes in Flanders were invited and encouraged by e-mail to participate in this study. The managing board of the nursing homes received a comprehensive information note on the study and signed an informed consent. First criterion for eligibility of nursing homes was using the interRAI Long Term Care Facilities (LTCF) assessment instrument embedded in a specific software program. This tool allows caregivers to assess several domains related to residents' health and care, including their degree of dependency, their mental and physical capacities, and their care needs³⁶. This assessment will be named BelRAI LTCF from now on, as the validated Belgian version was used in this study.

In Flanders, two projects to improve oral health of nursing home residents are ongoing: the Oral Health Care Track³⁷ and the Gerodent project³⁸. To avoid bias, nursing homes participating in these projects were excluded from this study.

Participants

Two-stage sampling was performed, first at the level of nursing homes and secondly at the level of the individual participants.

In the included nursing homes, residents were recruited for voluntary participation from January 2022 until July 2022. They received comprehensive information about the study and, in case of incapability, the legally authorised representative was approached for consent. Eligibility criteria were being 65 or older and having a permanent residence in a nursing home. Furthermore, the answer to the question "Terminal stage of disease,

6 months or less to live' in BelRAI LTCF had to be negative as it was the intention to include people in the cluster randomised controlled trial for a period of 24 months.

In the course of this recruitment procedure, the medical director of the nursing home was consulted and apprised of the residents who wanted to participate. The medical director then informed the general practitioner of the resident about the study and their participation. Should either have any objections to the resident's participation, they were instructed to report this to the researchers.

Participants had the option to withdraw from participation or to revise their consent during the study; they also had the right to consult, correct or have their personal data deleted.

Sample size calculation

Sample size calculation was performed to allow for longitudinal research over two years in a cluster randomised controlled trial. The calculation was based on a Chi-squared test and considering a three parallel groups design, a power of 80%, significance level of 0.05 and an estimated effect size of 0.2 for activation of CAP Oral hygiene, indicating the need for improvement of oral or denture hygiene. This resulted in a total sample of 184 participants (residents) for a regular RCT study. Because of the clustering of participants in nursing homes, this sample size had to be multiplied with a design factor of 1.95 (based on cluster size of 20 participants per nursing home and an intraclass correlation coefficient of 0.05). This resulted in a total sample for cluster randomised controlled trial of 359 participants. Furthermore, a dropout of 35% to 50% over the period of 24 months was considered, leading to the objective of recruiting between 552 and 718 participants.

Outcomes

The oral health status of the nursing home residents was assessed using the following measures.

OHS-interRAI

The OHS-interRAI, is a validated oral health instrument developed for use within the interRAI instruments and to be filled out by non-dental caregivers^{32,33}. It includes three self-reported items focusing on symptoms in the last three days: chewing difficulty, pain and dry mouth. Additionally, six items require inspection of the mouth, assessing denture hygiene, oral hygiene, teeth, gums, tongue, and soft tissues (palate, inner surface of cheeks and lips). All items are scored dichotomously as acceptable/ healthy or not, with the possibility of scoring 'not applicable' or 'not possible to assess' when appropriate (e.g. when the resident is uncooperative or unable to participate in the assessment). The assessment utilises trigger algorithms that result in Collaborative Action Points (CAPs) indicating the need for referral to the dentist (CAP Referral to a dentist) or for improvement of oral hygiene (CAP Oral hygiene).

Dental indices

For people with natural teeth, additional dental information was collected, such as the number of teeth and root remnants, as well as the following dental indices:

The Modified Gingival Index (MGI)³⁹: index to assess gingival health. This is a non-invasive assessment, developed for research that allows for repeated measurements. The MGI has a range of 0–4 and is interpreted as follows: 0.1–1.0 = Mild inflammation of any portion of the gingiva; 1.1–2.0 = Mild inflammation of the entire gingiva; 2.1–3.0 = Moderate inflammation; and 3.1–4.0 = Severe inflammation⁴⁰.

The Oral Hygiene Index (OHI)⁴¹: index to assess oral hygiene that consists of two components: the Debris Index (DI) and the Calculus Index (CI), which represent the amount of plaque and calculus on the tooth surfaces, respectively. The DI and CI both range from 0–6 and the OHI is calculated by summing the DI and CI, with a total range of 0–12. It is interpreted as follows: 0–2 = acceptable oral hygiene; 2.1–5.9 = moderate oral hygiene; ≥ 6 = poor oral hygiene⁴².

The PUFA-index⁴³: index to assess the presence of oral conditions resulting from untreated caries. This index ranges from 0–32 and the higher the number, the worse the condition of the teeth.

The MGI and PUFA-index were especially designed to be assessed without using dental instruments. The OHI was scored visually using a mirror, without using a probe. Krausch-Hofmann et al. (2020) found that without mirror and probe about 6% less non-acceptable conditions were detected by dentists⁴⁴.

Additional information concerning the used indices and the formulas to calculate them are included in Supplementary Information.

Related variables

Sociodemographic and clinical characteristics from the participants were obtained by means of their most recent BelRAI LTCF assessment, filled out by their caregivers: age, gender, self-care capacities, cognitive performance, symptoms of depression, health stability, dental check-up in the last year, polypharmacy (≥ 9 medications) and smoking behaviour.

Self-care capacities were measured using the Activities of Daily Living Hierarchy Scale of the interRAI LTCF (ADL-H), ranging from 0 (independent) to 6 (total dependence)⁴⁵. This validated scale measures the extent to which persons are self-reliant for personal hygiene, toilet use, locomotion, and eating. Cognitive performance was assessed using the Cognitive Performance Scale (CPS), ranging from 0 (intact) to 6 (very severe impairment)⁴⁶. Symptoms of depression were measured with the Depression Rating Scale (DRS) which was developed for use in nursing homes⁴⁷. This validated scale ranges from 0 (no mood symptoms) to 14 (all mood symptoms present in the last 3 days). Health instability was measured with the Changes in Health, End-Stage Disease, Signs, and Symptoms scale (CHESS), ranging from 0 (no health instability) to 5 (very high health instability)⁴⁸.

Data collection

Data collection was carried out by seven dentists and one dental hygienist who were specifically trained to perform the assessments. To avoid potential bias, they cooperated as volunteers in the research project and had no other interest or involvement in the study.

The training consisted of a webinar (1.5 h), a written manual as well as a face-to-face training and calibration session prior to the start of the data collection. A key card with the core information regarding the indices to be scored was available during the assessments. The first author and an additional volunteer dentist assisted the dental professionals with recording the data.

Appointments for visits to the nursing homes were previously planned. All assessments were completed in the residents’ rooms to ensure privacy, and in accordance with the guidelines for infection prevention. During the assessment, a headlight (Bo-Camp Headlamp 150 lm) was used. The OHS-interRAI assessments were conducted without dental instruments, conform to the general guidelines. For the assessment of all dental indices, a disposable dental mirror (Flecta disposable mirrors Pulpdent) was used.

Analysis

All 9 items of the OHS-interRAI were dichotomised (0/1) and were analysed for the people for whom the items could be assessed. Responses to items that were scored ‘not applicable’ or ‘not possible to assess’ were omitted.

All scores of the interRAI scales were dichotomised using their validated cut-off values. For the interRAI ADL-H scale, a score of 3 or higher indicates a need for at least extensive assistance for activities of daily living (ADL)⁴⁵. A cut-off of 3 on the interRAI CPS scale indicates moderate cognitive impairment⁴⁶. A score of 3 on the interRAI scale represents minor depressive disorders⁴⁷ and the cut-off of 3 on the interRAI CHESS scale denotes that the resident has at least moderate health instability⁴⁸.

Statistical analysis

All analyses were performed with software SAS Enterprise Guide for Windows, version 8.1 update 1.

First, descriptive statistics were used to identify the population’s characteristics and the most prevalent oral health problems. The Chi-Square test was used to test for significant differences in the prevalence of oral health problems. Subsequently, bivariate analyses were performed to investigate associations between oral health items and the clinical characteristics of their most recent BelRAI LTCF assessment.

Results
Participants

A total of 489 residents from 11 Flemish nursing homes consented to participation. After examination of eligibility, eleven participants were excluded because they did not meet the inclusion criteria (according to age 65 or older and long-stay in the nursing home). A total of 478 participants were included in the study, with a total of 22 to 73 residents per nursing home. The oral health assessment could be performed in 462 participants. Reasons for the lack of assessment were death, refusal, absence in the nursing home, and medical conditions.

Data were analysed for a total of 458 participants.

The mean age of the participants was 82.7 (±7.8) years and the majority was female (70.3%). Their sociodemographic characteristics are presented in Table 1. About 68% of the participants needed extensive assistance for activities of daily living and 49% had moderate cognitive impairment.

Variables	N (%)	Mean (±SD)
Total	458 (100.0)	
Female	322 (70.3)	
Age		82.7 (±7.8)
CPS score (≥3)	188/381 (49.3)	
ADL score (≥3)	259/380 (68.2)	
DRS score (≥3)	144/382 (37.7)	
CHESS score (≥3)	43/369 (11.7)	
Dental visit last year	110/374 (29.4)	
Number of medications		8.4 (±3.7)
<4	29/378 (7.7)	
4–8	169/378 (44.7)	
≥9	180/378 (47.6)	
Smokers	35/381 (9.2)	

Table 1. Sociodemographic characteristics of the participants. Abbreviations: CPS, Cognitive Performance Scale; ADL, Activities Daily Living; DRS, Depression Rating Scale; CHESS, Changes in Health, End-stage disease and Sign and Symptoms scale.

OHS-interRAI	Assessed subjects*, n	Number of residents with problems or deficiencies, n	Prevalence, %
Self-reported oral problems OHS-interRAI			
Chewing difficulty	431	101	23.4
Pain in the mouth	434	39	9.0
Dry mouth	433	142	32.8
Observed oral problems OHS-interRAI			
Denture hygiene	260	178	68.5
Oral hygiene	255	193	75.7
Teeth	241	137	56.9
Gums	445	222	49.9
Tongue	427	32	7.5
Palate, lips and cheeks	437	87	19.9
CAP Oral Hygiene	454	315	69.4
CAP Referral to a dentist	452	339	75.0

Table 2. Prevalence of oral health problems or deficiencies, registered with the OHS-interRAI for all subjects (total sample N = 458). Abbreviations: OHS-interRAI, oral health section for use within the interRAI suite of instruments; CAP, Collaborative Action Point. *Number of participants for whom the item could be assessed, excluding answer options 'not applicable' and 'could not be assessed'.

	Assessed in subjects (N = 458), n (%)	Mean (\pm SD)
Dentates - Number of visible teeth or tooth remnants	247/458 (53.9)	12.8 (\pm 7.3)
Dentates with root remnants - Number of root remnants	97/241 (40.3)	3.3 (\pm 3.2)
Dental indices		
OHI	233	4.5 (\pm 2.6)
DI	233	2.9 (\pm 1.4)
CI	232	1.6 (\pm 1.5)
MGI	234	1.8 (\pm 1.2)
PUFA > 0 - Number of PUFA	106 (44.2)	2.9 (\pm 2.9)
Removable dentures, n (%)	102/247 (41.3)	
Edentulous persons	211/458 (46.0)	
Removable dentures		
Full dentures	170/207 (82.3)	
None	37/207 (17.8)	

Table 3. Participants' oral health status and dental indices scores (total sample N = 458). Abbreviations: OHI, Oral Hygiene Index; DI, Debris Index; CI, Calculus Index; MGI, Modified Gingival Index; PUFA, Pulp Ulceration Fistel Abscess index.

Outcome data

Oral health based on OHS-interRAI

The prevalence of oral health problems recorded with the OHS-interRAI is represented in Table 2. Insufficient oral (75.7%) and denture (68.5%) hygiene were the most prevalent problems. Most oral health problems were observed in people with natural teeth and were related to teeth (56.6%) and gums (49.9%). Soft tissue lesions of palate and inner surfaces of cheeks and lips were recorded in 19.9% of the participants.

Self-reported oral health problems were mainly related to dry mouth (32.8%) and chewing difficulty (23.4%). The oral health data retrieved from the screening indicated a need for referral to a dentist in 75% of the participants (CAP Referral to a dentist).

Oral health based on dental indices

For the participants with natural teeth (54% of the sample), additional dental indices were assessed. These results are presented in Table 3. The mean number of visible teeth or tooth remnants was 12.8 (\pm 7.3). When excluding tooth remnants, the mean number of teeth was 11.5 (\pm 7.3). Only 9.2% of the participants had at least 20 teeth. Over 44% of the people with natural teeth had untreated tooth decay with at least pulpal involvement. The mean OHI was 4.5 (\pm 2.6), indicating moderate oral hygiene⁴². A proportion of 17.6% of the participants had an OHI-score \leq 2, which is acceptable according to Mühlemann, and 26.2% had an OHI-score of 6 or higher, which indicates poor oral hygiene. Only 9.4% (22/233) of the participants with natural teeth had a DI-score \leq 1.0, representing an acceptable amount of plaque, whereas 48.7% (113/232) had a CI-score \leq 1.0, meaning that the calculus level was acceptable. The mean MGI of the residents was 1.8 (SD 1.2), indicating mild inflammation of

the entire gingiva⁴⁰. About 28.6% of the participants had an MGI-score ≤ 1.0 , indicating mild inflammation of any portion of the gingiva. A total of 41.0% had an MGI-score of 2.1 and higher, indicating moderate to severe inflammation of the gingiva. Overall, removable dentures were worn by 59.9% (272/454) of the participants.

OHS-interRAI associations

Correlations were explored between different aspects of oral health. These are shown in Table 4. The strongest correlation is found between the condition of the gums and oral hygiene ($r=0.324$, $p<0.0001$), followed by an association of chewing difficulty with pain ($r=0.247$, $p<0.0001$). Dry mouth is correlated with pain ($r=0.195$, $p<0.0001$) and with chewing difficulty ($r=0.183$, $p=0.0002$). Denture hygiene is correlated with mucosal problems of the palate, cheeks and lips ($r=0.169$, $p=0.0067$) and with gum condition ($r=0.158$, $p=0.01$).

Weaker positive correlations were found for the item oral hygiene and teeth ($r=0.127$, $p=0.05$) and also for the item palate, cheeks and lips with pain ($r=0.107$, $p=0.03$) and gum condition ($r=0.104$, $p=0.03$). Weak negative correlations were found for dry mouth with denture hygiene ($r=-0.135$, $p=0.03$) and gum condition ($r=-0.113$, $p=0.02$).

Denture hygiene shows weaker results and no statistical significance with oral hygiene ($r=0.153$, $p=0.11$) and teeth ($r=0.145$, $p=0.16$).

The condition of the tongue showed no statistically significant correlation with any of the other items.

Associations between oral health and sociodemographic and clinical characteristics

Associations were investigated between oral health and participants’ sociodemographic and clinical characteristics. These are presented in Table 5.

Moderate to severe cognitive impairment (CPS score ≥ 3) showed the strongest correlations with various aspects of oral health, mainly related to gingival health and oral hygiene. The strongest positive correlation was seen with an MGI score greater than 1.0 ($r=0.389$, $p<0.0001$), indicating at least mild inflammation of the entire gingiva. There was also a positive correlation with an MGI score greater than 2.0 ($r=0.321$, $p<0.0001$), indicating moderate to severe gingival inflammation. The correlation between cognitive impairment and gingival health also reflected in the OHS-interRAI item gums, although slightly weaker ($r=0.199$, $p=0.0001$). For oral hygiene, cognitive impairment showed a positive correlation with a DI score greater than or equal to 1.0 ($r=0.313$, $p<0.0001$), a CI score greater than or equal to 1.0 ($r=0.177$, $p=0.01$) and an OHI score greater than or equal to 2.0 ($r=0.299$, $p<0.0001$). This correlation was not reflected in the item oral hygiene of the OHS-InterRAI. However, there was a weak positive correlation with the item for denture hygiene ($r=0.138$, $p=0.04$). Cognitive impairment was also positively correlated to the CAP Referral to a Dentist ($r=0.139$, $p=0.01$).

Negative correlations were seen for cognitive impairment with the OHS-InterRAI items pain ($r=-0.133$, $p=0.01$) and dry mouth ($r=0.227$, $p<0.0001$), being edentulous ($r=-0.109$, $p=0.03$) and wearing dentures ($r=0.185$, $p=0.0003$).

Functional impairment (ADL score ≥ 3) and needing extensive assistance with personal hygiene showed positive correlations with items and indices related to oral hygiene and gingival health. For gingival health, the strongest correlation was seen with an MGI score greater than or equal to 2.0 ($r=0.209$, $p=0.003$ and $r=0.221$, $p=0.002$ respectively). For oral hygiene, the strongest correlation for both was found with the OHI score

	Pain	Dry mouth	Denture hygiene	Oral hygiene	Teeth	Gums	Tongue	Palate, cheeks and lips
Chewing difficulty	0.24669*** <.0001 426	0.18257*** 0.0002 424	-0.05307 0.40 251	0.07712 0.23 241	0.08558 0.20 227	-0.02862 0.56 424	-0.02576 0.60 414	-0.08890 0.07 419
Pain		0.19494*** <.0001 429	0.00985 0.88 254	0.03724 0.56 242	0.04781 0.47 229	0.01261 0.80 426	0.00000 1.00 416	0.10732* 0.03 422
Dry mouth			-0.13460* 0.03 253	-0.04112 0.52 243	-0.04169 0.53 229	-0.11334* 0.02 425	0.00343 0.94 417	-0.03771 0.44 423
Denture hygiene				0.15280 0.11 110	0.14513 0.16 96	0.15811** 0.01 255	0.04239 0.50 255	0.16873** 0.0067 257
Oral hygiene					0.12683* 0.05 236	0.32361*** <.0001 253	0.01571 0.81 236	0.02175 0.74 244
Teeth						0.08634 0.18 240	0.10135 0.13 223	0.02494 0.71 232
Gums							0.03661 0.45 422	0.10378* 0.03 433
Tongue								0.03890 0.42 425

Table 4. Correlation coefficients between the different oral health items of the OHS-interRAI, Prob >|r| under H0: Rho = 0, Number of Observations. $p \leq 0.001$ *** - $p \leq 0.01$ ** - $p \leq 0.05$ *

	CPS ≥ 3	ADL ≥ 3	Extensive support for personal hygiene	DRS ≥ 3	CHESS ≥ 3	Dental visit	Poly-pharmacy ≥ 9 drugs	Smoking
Chewing difficulty	0.00567 0.91 360	0.07170 0.18 359	0.08060 0.13 360	0.07612 0.18 361	-0.01619 0.76 348	0.00639 0.90 353	0.23029*** <.0001 356	-0.04262 0.42 359
Pain	-0.13295** 0.01 362	-0.03298 0.53 361	-0.01749 0.74 362	0.07087 0.18 363	0.03411 0.52 351	-0.06755 0.20 355	0.14847** 0.005 358	0.01929 0.71 361
Dry mouth	-0.22706*** <.0001 362	-0.00565 0.91 361	0.01408 0.79 362	0.11842* 0.02 363	0.06941 0.20 350	-0.09307 0.08 355	0.20842*** <.0001 358	-0.05778 0.27 361
Denture hygiene	0.13791* 0.04 214	0.12723 0.06 214	0.11494 0.09 215	-0.01006 0.88 214	0.00000 1.0000 207	-0.09230 0.18 208	0.03072 0.66 210	-0.12381 0.07 213
Oral hygiene	0.10795 0.12 214	0.15172* 0.03 212	0.16679** 0.01 213	0.04816 0.48 215	0.02005 0.78 204	-0.14467* 0.04 210	0.05426 0.43 211	-0.00019 0.10 214
Teeth	0.05790 0.41 204	-0.06098 0.39 202	-0.05569 0.43 203	0.11130 0.11 205	-0.08398 0.24 196	0.02259 0.75 200	0.07192 0.31 201	-0.02290 0.75 204
Gums	0.19872*** 0.0001 372	0.12490* 0.02 371	0.10731* 0.04 372	0.03392 0.51 373	0.02623 0.62 360	0.01374 0.79 365	-0.05473 0.30 368	-0.10954* 0.03 371
Tongue	0.01809 0.73 356	-0.03392 0.52 355	-0.02203 0.68 356	0.13776** 0.01 357	0.12828* 0.02 344	0.01703 0.75 349	0.06969 0.19 352	0.05029 0.34 355
Palate, cheeks and lips	-0.04644 0.38 365	-0.00577 0.91 364	-0.00807 0.88 365	-0.02901 0.58 366	0.01399 0.79 353	-0.01067 0.84 358	0.01945 0.71 361	0.02321 0.66 364
CAP Oral hygiene	0.06195 0.23 378	0.07514 0.15 377	0.08707 0.09 378	0.02072 0.69 379	-0.01607 0.76 366	-0.06065 0.24 371	-0.03397 0.51 375	-0.07383 0.15 378
CAP Referral to a Dentist	0.13939** 0.01 375	0.09008 0.08 374	0.10075* 0.05 375	0.06415 0.21 376	0.06812 0.20 363	0.07382 0.16 368	0.04741 0.36 372	-0.16052** 0.002 375
DI ≥ 1	0.31329*** <.0001 196	0.14294 0.06 194	0.11320 0.12 195	0.11204 0.12 197	0.07656 0.30 188	-0.10127 0.16 192	-0.02153 0.77 193	0.09862 0.17 196
CI ≥ 1	0.17687** 0.01 195	0.14642* 0.04 193	0.15,377* 0.03 194	-0.00869 0.90 196	0.10000 0.17 187	-0.21164** 0.003 191	0.00923 0.90 192	0.02408 0.74 195
OHI ≥ 2	0.29945*** <.0001 196	0.16929* 0.02 194	0.17217* 0.02 195	0.15342* 0.03 197	0.10082 0.47 188	-0.16017* 0.03 192	-0.01123 0.88 193	0.03899 0.59 196
MGI ≥ 1	0.38932*** <.0001 197	0.16810* 0.02 195	0.18160** 0.01 196	0.03447 0.63 198	0.07198 0.33 189	-0.19062** 0.008 193	-0.05045 0.48 194	-0.04469 0.53 197
MGI ≥ 2	0.32117*** <.0001 197	0.20913** 0.003 195	0.22094** 0.002 196	0.06612 0.35 198	0.08172 0.26 189	-0.19597** 0.006 193	-0.04371 0.54 194	-0.03595 0.62 197
PUFA ≥ 1	0.07569 0.28 202	-0.02886 0.69 200	-0.04109 0.56 201	0.01906 0.79 203	-0.04373 0.54 194	0.02152 0.76 198	0.06153 0.39 199	0.04715 0.51 202
Edentulous	-0.10929* 0.03 381	-0.02942 0.57 380	-0.00700 0.89 381	-0.01318 0.80 382	-0.01176 0.82 369	-0.08250 0.11 374	0.13417** 0.01 378	0.07497 0.14 381
Dentures	-0.18548*** 0.0003 378	-0.06610 0.20 377	-0.03654 0.48 378	-0.03894 0.45 379	-0.03115 0.55 366	-0.05558 0.29 371	0.01517 0.77 375	0.11171* 0.03 378

Table 5. Correlation coefficients between the oral health related information and participants' characteristics, Prob >|r| under H0: Rho = 0, Number of Observations. p ≤ 0.001*** - p ≤ 0.01** - p ≤ 0.05* Abbreviations: CPS, Cognitive Performance Scale; ADL, Activities Daily Living; DRS, Depression Rating Scale; CHESS, Changes in Health, End-Stage Disease and Sign and Symptoms Scale; DI, Debris Index; CI, Calculus Index; OHI, Oral Hygiene Index; MGI, Modified Gingival Index; PUFA, Pulp Ulceration Fistel Abscess index.

(r = 0.169, p = 0.02 and r = 0.172, p = 0.02 respectively), followed by that with the item oral hygiene of the OHS-interRAI (r = 0.152, p = 0.03 and r = 0.167, p = 0.01 respectively).

Having depressive symptoms (DRS score ≥ 3) showed a weak positive correlation with the OHI score (r = 0.153, p = 0.03) and the OHS-interRAI items tongue (r = 0.137, p = 0.01) and dry mouth (r = 0.118, p = 0.02).

Having had a dental visit in the 12 months prior to the oral health assessment showed only negative correlations. For oral hygiene-related outcomes, this was the case for the CI score (r = -0.212, p = 0.003), the

OHI score ($r = -0.160$, $p = 0.03$) and the item oral hygiene ($r = -0.145$, $p = 0.04$) of the OHS-InterRAI. For gingival health, this was the case for the MGI scores ($r = -0.196$, $p = 0.01$ and $r = 0.191$, $p = 0.01$).

For those taking 9 or more medications, positive correlations were seen for the self-reported items of the OHS-interRAI, namely chewing difficulty ($r = 0.230$, $p < 0.0001$), dry mouth ($r = 0.208$, $p < 0.0001$) and pain ($r = 0.148$, $p = 0.005$), as well as for being edentulous ($r = 0.134$, $p = 0.01$).

Smoking showed negative correlations with the item gums ($r = -0.110$, $p = 0.03$) of the OHS-interRAI and the CAP Referral to a Dentist ($r = -0.161$, $p = 0.002$). A positive correlation was seen with wearing dentures ($r = 0.112$, $p = 0.03$).

Discussion

Key results

This study aimed to map and update the prevalence of oral health problems among nursing home residents in Flanders, as assessed by oral health professionals. Furthermore, the aim was to explore associations between oral health and clinical characteristics using the BelRAI LTCF instrument.

The most recent national survey on the oral health of older adults in Belgium was conducted in 2010, involving data from approximately 440 nursing home residents¹³. The study reported high care dependency in 62% of the nursing home residents, as determined using the Katz index¹³. This aligns with the present study, where nearly half of the residents showed at least moderate cognitive impairment, and 68% required extensive assistance with activities of daily living.

The present study utilised the OHS-interRAI to map the oral health of older individuals. This oral health assessment instrument offers a comprehensive overview of all oral structures, including oral hygiene^{32,33}. Furthermore, dental indices were used to provide a more detailed assessment of common oral problems such as tooth decay, gum problems, and oral hygiene. This information provides a general understanding of the care needs of this study group.

Research has shown that a healthy lifestyle and prevention-oriented health care, with good oral hygiene and regular dental visits, are associated with tooth retention into later life⁴. Over half of the participants in the present sample still had a natural dentition with 13 visible teeth or tooth remnants. This aligns with findings by Janssens et al., who reported a mean of 12 teeth (SD 8.1), including 1.9 residual roots, in a study of 1226 Flemish nursing home residents (2010–2012)³¹. However, the prevalence of edentulism in the present study (46%) exceeds that reported by Janssens et al. (42%)³¹ and is 10% higher than the 35.7% reported in the national oral health survey of 2010¹³. This trend aligns with the findings of the WHO's Oral Health Status Report (2022), which indicates a 30% increase in edentulism in the European region between 1990 and 2019⁴⁹. A systematic review examining clinical and subjective oral health among European nursing home residents revealed that the prevalence of edentulism ranged from 40 to 60%, with those retaining natural teeth having a mean of 9.8 to 20.0 teeth per individual⁵⁰. The WHO sets a goal of retaining at least 20 teeth at the age of 80 to ensure sufficient functional tooth units and chewing ability^{51–53}. However, the study by De Visschere et al. reported that only 10% of nursing home residents had 21 teeth or more¹³. In the current study, only 9% of participants had 20 teeth or more.

In terms of self-reported oral problems, 23.4% of participants indicated difficulty chewing in the past three days. By contrast, Krausch-Hofmann et al. (2021) reported a higher prevalence (55.8%), likely due to a stricter assessment that considered food hardness, such as the ability to chew nuts, raw apples and steak³³. This approach was later optimised in the Delphi study by Schoebrechts et al. (2023)³². The prevalence of the current study aligns with the 23% identified by Abreu et al. (2022) in a meta-analysis of studies with large sample sizes⁵⁴ and falls within the 5% to 55% range of reported chewing difficulties found in the systematic review by Janssens et al.⁵⁰. Chewing difficulties are typically associated with tooth loss, musculoskeletal conditions, nutrition-related factors, and cognitive decline^{14,15}, but in the present study, they were primarily associated with pain.

Pain or discomfort in the mouth was reported by 9% of participants in this study, which is comparable to the 11.2% reported by Krausch-Hofmann et al.³³. In Europe, the prevalence of pain or discomfort in nursing home residents ranged from 6.0% to 40.5%⁵⁰. Orofacial pain is shown to be significantly more prevalent in residents with dementia⁵⁵. Nevertheless, a study by Delwel on the use of an Orofacial Pain scale for Non-verbal Individuals revealed that pain was reported in only 0–10% of cases⁵⁶. In another study by Delwel, combining self-reported pain with a more comprehensive oral examination, 25% of participants reported pain in at least one aspect of the examination, such as neurosensory testing, mouth opening, and additional testing for caries profunda⁵⁷. These differences suggest that orofacial pain may be underestimated when relying solely on self-reported data. Additionally, in the present study, cognitive impairment was negatively correlated with reported pain, xerostomia, and chewing difficulty, suggesting that individuals with cognitive decline may be less able to effectively communicate their pain and discomfort. Although self-reporting is considered the gold standard and should be encouraged, it may lead to inadequate diagnosis and inappropriate treatment in such cases⁵⁸.

The most commonly self-reported item in this study was xerostomia, with about one-third of participants experiencing dry mouth in the past three days. This is slightly lower than the 40.8% reported by Krausch-Hofmann et al.³³ and aligns with the systematic review of Janssens et al., which found xerostomia in 35% to 50% of nursing home residents⁵⁰. However, the sensation of dry mouth does not necessarily imply they suffer from hyposalivation^{59,60}. A cross-sectional study by Diep et al. (2021) showed xerostomia in older people was correlated with medication use, rheumatic disease, and radiotherapy in the head/neck region, while hyposalivation was associated with medication use and diabetes⁶⁰. A systematic review showed an overall prevalence rate of hyposalivation of 33.37% in older adults, with higher rates among women and those in institutional care⁶¹.

Xerostomia has been frequently associated with polypharmacy, a finding which was confirmed in the present study²⁷. Approximately half of the participants used at least nine medications, consistent with other research in Flanders²⁶. Furthermore, polypharmacy in the present study was also associated with chewing difficulty,

pain in the mouth, and edentulism. A systematic review on oral conditions associated with dry mouth in older adults with polypharmacy found tooth loss and dental caries as the most common issues, besides associations with chewing difficulty and pain²⁷. Beyond polypharmacy, the present study also found significant associations between dry mouth, chewing difficulty, and pain within the items of the OHS-interRAI.

The psychological condition most associated with dry mouth related to polypharmacy in older adults is depression²⁷. Anti-depressant use, in particular, has been significantly associated with dry mouth⁶², which may explain the weak association observed in the present study between dry mouth and symptoms of depression. In addition, symptoms of depression were weakly associated with changes in tongue appearance and poor oral hygiene in this study. However, literature shows associations between depression and dental caries, tooth loss, and edentulism^{7,63}, none of which were observed in the present study.

The most prevalent issues identified in this study were related to hygiene. However, no correlation was found between denture hygiene and oral hygiene, possibly due to the small number of participants with both dentures and natural teeth. Janssens et al. also reported inadequate oral hygiene and denture hygiene in nursing home residents, with high levels of plaque⁵⁰. In the present study, 68.5% of individuals with removable dentures had over a third of the inner surface covered with plaque or tartar, which is higher than the 55% reported by Krausch-Hofmann et al.³³. Among individuals with natural teeth, the proportion with inadequate oral hygiene was even higher, with 75.7% of participants scoring poorly, compared to 84% in Stefanie Krausch-Hofmann et al.³³.

A more detailed assessment of oral hygiene using the OHI indicated moderate overall oral hygiene. However, looking at the underlying Debris Index and Calculus Index, it is clear that plaque accumulation is the main problem. Only 9% of participants had an acceptable amount of plaque, while approximately half had acceptable tartar levels, based on Mühlemann's standards (1976)⁴². The latest national oral health survey also concluded that a significant proportion of participants had inadequate denture and oral hygiene, particularly among those living in residential care facilities¹³. However, differences in assessment and reporting methods make direct comparisons difficult. This study also confirmed the association between dental plaque and tooth decay, although the impact of each on the other is more difficult to distinguish due to the high prevalence of both conditions among the participants.

In this study, 57% of participants with natural teeth showed visible breakdown, decay or a defective restoration in at least one tooth. The PUFA index, which measures the severity of untreated caries, revealed that 44% of these participants had caries extending to the nerve, with an average of 3 occurrences per person. Janssens et al. reported in their systematic review significant variation in the prevalence of untreated caries across Europe (23% to 82%), with most studies reporting active caries in over half of residents⁵⁰. Although caries prevalence in the present study was high, it was lower than the 77% reported by Krausch-Hofmann et al. and 69.7% reported by Janssens et al.^{31,33}.

Similar to Krausch-Hofmann (2021), unacceptable gum conditions were found in about half of the participants in this study³³. Gum health was assessed using the OHS-interRAI, including for edentulous residents, where the alveolar ridge mucosa was evaluated for colour changes, swelling, or lesions. Therefore, conclusions regarding periodontal health cannot be drawn from this item. However, the modified gingival index (MGI) in dentate participants showed that 71.4% of them had mild to severe inflammation of the entire gingiva. Nevertheless, as the MGI is assessed visually only using a disposable mirror, it is not possible to draw robust conclusions regarding the extent of periodontal problems. A systematic review revealed varying periodontal health in nursing home residents across Europe, with gingivitis affecting 51% to 78% of residents with natural dentition⁵⁰. Overall, an American report showed that about 60% of older adults are affected with periodontitis⁶⁴. De Visschere et al. diagnosed periodontal disease in 87% of participants using a conventional periodontal probe for scoring the Dutch Periodontal Screening Index¹³. Krausch-Hofmann observed that dentists, who assessed oral health with the OHS-interRAI without using a mouth mirror and probe, identified approximately 6% fewer unacceptable conditions of oral hygiene, teeth and gums³³.

The strongest association observed within the items of the OHS-interRAI in this study was between gum condition and oral hygiene. A lack of adequate oral hygiene leads to increased accumulation of oral biofilm, which in turn causes gum problems, initially gingivitis and potentially periodontitis, a well-documented relationship¹¹. Furthermore, gum condition was also associated with cognitive decline, and to a lesser extent, with functional impairment and the need for extensive support. Research has shown a correlation between these personal characteristics and a higher prevalence of poor oral and denture hygiene and periodontal disease^{9,65}.

Consistent with Krausch-Hofmann³³, the tongue was the least problematic area, with only 7.5% of participants in the current study showing issues. This is slightly lower than the 10% reported by Krausch-Hofmann³³. The item tongue of the OHS-interRAI was also slightly modified following the international Delphi by Schoebracht et al.³² by eliminating the assessment of moisture of the tongue. Disorders of the tongue are rarely studied as a separate category. Instead, they are often grouped with other oral mucosal lesions⁶⁶.

Epidemiological studies on oral mucosal lesions are rather limited compared to those on caries and periodontitis⁶⁶. However, the tongue is included in other oral health assessment instruments, such as the Revised Oral Assessment Guide (ROAG) and the Oral Health Assessment Tool (OHAT). A German study using ROAG by dentists in an epidemiological study revealed a prevalence of 2.6% for the item tongue⁶⁷, while a Swedish study of over 2500 participants found that 15.0% of participants had tongue problems⁶⁸.

Oral mucosal lesions, including those on the palate and inner surfaces of the cheeks and lips, were inspected with the OHS-interRAI for colour changes, swelling, sores, or patches. The prevalence of these issues in the present study (20%) was similar to Krausch-Hofmann et al. (2021), which reported 23.4%³³. Literature showed that the most common oral lesions were denture-related⁶⁹. Janssens et al. reported prevalence rates between 10% and 15% for denture stomatitis, and pressure ulcers from dentures ranged from 1.5% to 18.0% among European nursing home residents⁵⁰. De Visschere et al. reported at least one lesion in nearly 25% of all participants, with the highest prevalence for denture pressure ulcers (10%)¹³. Within the OHS-interRAI, poor denture hygiene

was associated with poor condition of the gums and palate, cheeks, and lips. A systematic review by Wong et al. (2019) on the factors related to the oral health of nursing home residents reported a median of 21% of surveyed residents with some type of denture stomatitis⁹.

Overall, the oral health issues identified by dentists using the OHS-interRAI in the present study are consistent with previous findings in Belgium^{13,31} and Europe⁵⁰, showing the need for improved oral hygiene and professional dental care. With the assessment of the OHS-interRAI, CAPs are triggered when oral hygiene is deficient or when a resident needs referral to a dentist. Comparable to Krausch-Hofmann et al. the CAP Oral hygiene was activated in approximately 70% of the participants³³. In contrast, the CAP Referral to a Dentist was activated in 75% of participants in the present study, compared to 91% in the study of Krausch-Hofmann et al.³³.

The strength of oral health assessment with the OHS-interRAI is that it offers a comprehensive overview of all oral structures, including oral hygiene^{32,33} and that it is embedded in the holistic BelRAI LTCF assessment, which also evaluates residents' overall care needs and preferences. Furthermore, dental indices were used to assess common oral issues like tooth decay, gum problems, and oral hygiene, providing a general understanding of the oral care needs of the study group. However, as a limitation, it is essential to acknowledge that despite the utilisation of indices, this study represents an underestimation of oral health issues, as the dentists were not equipped with a comprehensive set of instruments and diagnostic options, as would be the case in a dental practice. Other limitations are related to inclusion criteria. Only nursing homes using a specific software package for BelRAI LTCF and OHS-interRAI data collection were included, and residents in the final phase of life were excluded to allow for a longitudinal follow-up of 2 years. Therefore, the findings of this study cannot be generalised to all nursing home residents in Flanders. Nevertheless, the results of this study confirm previous research in Belgium and Europe.

Despite advancements in dentistry and the Belgian health care system, which includes compulsory health insurance for all citizens, the oral health of nursing home residents has not improved compared to data collected on a larger scale in 2010–2012^{13,31}. Given the connection between oral health, overall health, and quality of life¹⁶, these findings indicate the need for continued efforts in the early detection and prevention of oral health issues in older people, especially for those with cognitive decline or functional impairment, as these conditions were associated with poor gingival health and oral hygiene. Good daily oral hygiene and regular dental visits are essential for maintaining oral health⁴. In this study, dental visits were associated with better oral hygiene and gingival health. However, only 30% of people had visited a dentist in the previous year, compared to 58.1% of those aged 65–74 and 41.3% of those aged 70 or older as reported by the Interinstitutional Agency (IMA atlas) in 2022. This disparity reflects the barriers nursing home residents face in accessing dental care⁷⁰. The introduction of dental hygienists in Belgium as of 2019 could represent an important improvement. Not only can dental hygienists enhance access to professional oral healthcare, but also to more effective daily oral care by empowering healthcare providers and residents.

Oral health is determined by many factors. Belgium, and specifically Flanders, has implemented several measures that aim to improve oral health among care-dependent older people. Since June 2023, the Belgian government has mandated the use of the BelRAI LTCF for care planning in nursing homes. As part of this initiative, the OHS-interRAI, an oral health assessment developed for healthcare providers without a dental background, is being integrated into the BelRAI LTCF. This standardised oral health screening enables regular monitoring of residents' oral health and integration of oral care into general care, but also provides a foundation for epidemiological research and evidence-based policy development.

Conclusions

The present study highlights the high prevalence of oral health problems among nursing home residents in Flanders, as assessed by oral health professionals using the OHS-interRAI and dental indices. The strongest associations were observed for poor oral hygiene and gingival health, and for pain in the mouth, chewing difficulties and dry mouth. The study also showed the need for greater attention to the oral health of people with cognitive or functional impairment, as these conditions were associated with poor gingival health and oral hygiene. Polypharmacy also showed significant associations for pain, chewing difficulty and dry mouth. Encouragingly, having a dental visit within the past year was associated with better oral hygiene and gingival health, underscoring the importance of regular dental care in improving oral health outcomes for this population.

Data availability

The data that support the findings of this study are available from Pyxicare, Belgium. However, restrictions apply to the availability of these data, which were used under a GDPR licence for the current study. Consequently, the data are not publicly available; however, they can be assessed upon reasonable request and with permission from the Belgian Privacy Commission. For any data or queries pertaining to the study, please contact the corresponding author, Patricia Ann Ivonne Vandenbulcke (patricia.vandenbulcke@kuleuven.be).

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PAIV: Conceptualisation, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing—Original Draft, Writing—Review and Editing, Visualisation, Project administration JdAM: Conceptualisation, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing—Original Draft, Writing—Review and Editing, Visualisation, Supervision, Project administration, Funding acquisition ES: Validation, Writing—Review and Editing, Visualisation JDL: Conceptualisation, Methodology, Validation, Writing—Review and Editing, Supervision AD: Conceptualisation, Methodology, Validation, Writing—Review and Editing, Supervision DD: Conceptualisation, Methodology, Validation, Resources, Writing—Review and Editing, Visualisation, Supervision, Funding acquisition JD: Conceptualisation, Methodology, Validation, Resources, Data Curation, Writing—Original Draft, Writing—Review and Editing, Visualisation, Supervision, Project administration, Funding acquisition All authors read and approved the final manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval and consent to participate

This study has been conducted in accordance with the ethical standards set forth in the Declaration of Helsinki and received ethical approval on 29 November 2021 from the Ethics Committee Research UZ/KU Leuven, Belgium, with reference B3222021000650. The nursing home management teams were provided with a comprehensive information note on the study, and signed an informed consent form. Each individual participant, or their legally authorised representative, was given comprehensive information about the study and provided their written informed consent for participation.

Consent for publication

All participants or their legally appointed representatives provided written consent for the publication of data in an aggregated and unidentifiable format.

Additional information

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