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10.2478/sjph-2024-00019 Zdr Varst. 2024;63(3):142-151

Žmavc JB, Verdenik M, Skomina Z, Ihan Hren N. Tooth loss and systemic diseases in the Slovenian elderly population: A cross-sectional study of the associaton between oral and systemic health. Zdr Varst. 2024;63(3):142-151. doi: 10.2478/sjph-2024-0019.

TOOTH LOSS AND SYSTEMIC DISEASES IN THE SLOVENIAN ELDERLY POPULATION: A CROSS-SECTIONAL STUDY OF THE ASSOCIATON BETWEEN ORAL AND SYSTEMIC HEALTH

OZOBLJENOST STAROSTNIKOV V SLOVENIJI TER NJIHOVE SOČASNE BOLEZNI IN STANJA: PRESEČNA RAZISKAVA SOČASNEGA VPLIVA USTNEGA IN SISTEMSKEGA ZDRAVJA NA IZGUBO ZOB

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Received: Jan 12, 2024
Accepted: May 21, 2024

Original scientific article

ABSTRACT

Introduction: This study aimed to assess the prevalence of edentulism and tooth loss in the Slovenian elderly population, along with the associated risk factors, and investigate the association between systemic and oral health.

Methods: The study included 445 individuals aged 65 or older (average age: 79.7±8.9 years). Data on preserved teeth, dental history, chronic diseases, and medications were collected through clinical examinations. Height and weight were recorded in order to calculate body mass index (BMI), and the education level was also collected. Chronic systemic diseases and medications were categorized. Statistical analysis was conducted using linear regression and nonparametric tests.

Results: Participants had an average of 4.7±7.7 teeth, with no significant gender differences. Higher age (β=-0.185, p<0.001) and lower education level (p<0.001) were associated with fewer teeth, while higher BMI showed no correlation (β=-0.085, p=0.325). Diabetes mellitus (p=0.031), cardiovascular diseases (p=0.025), and thyroid diseases (p=0.043) were inversely related to retained teeth. This inverse relationship also applied to individuals who recovered from malignancies, not including head and neck malignancies (p=0.019). No significant relationship was found between osteoporosis and the number of teeth (p=0.573). Notably, antidiabetic drug use was inversely related to the number of teeth (p=0.004), while analgesics showed a positive relationship (p=0.022).

Conclusions: This study highlights the association between specific sociodemographic factors, chronic diseases, and retained teeth among elderly individuals in Slovenia. High edentulism rates among the elderly emphasize the need for enhanced preventive measures and risk factor management, particularly for high-risk groups like the elderly.

Keywords:
Edentulism
Elderly population
Systemic diseases

IZVLEČEK

Izhodišče: *Namen študije je bil ugotoviti prevalenco popolne brezzobosti in izgube zob pri starostnikih v Sloveniji, s tem povezane dejavnike tveganja ter raziskati povezavo med sistemskim in oralnim zdravjem.*

Metode: *V raziskavo smo vključili 445 starostnikov, starih povprečno 79,7 ± 8,9 let. Vključitveni kriterij je bil starost 65 let ali več. S pomočjo kliničnega pregleda ustne votline in protokola raziskave smo pridobili podatke o številu ohranjenih zob, zobozdravniški anamnezi, kroničnih boleznih in zdravilih, ki jih jemljejo. Hkrati smo pridobili podatke o njihovi teži in višini za izračun indeksa telesne mase (ITM) ter podatke o stopnji izobrazbe. Kronične sistemske bolezni in zdravila smo razvrstili v smiselne skupine. Statistična analiza je bila opravljena z uporabo linearne regresije in neparametričnih testov (Kruskal-Wallisova enosmerna analiza variance, Mann-Whitneyjev U-test za neodvisne vzorce) za oceno povezav različnih dejavnikov s številom ohranjenih zob v ustni votlini.*

Rezultati: *Povprečno število ohranjenih zob je bilo 4,7 ± 7,7 in se ni bistveno razlikovalo med spoloma. Starost (β = -0,185, p < 0,001) in izobrazba (p < 0,001) sta statistično značilno povezana z manjšim številom zob, medtem ko povišan ITM nima vpliva na manjše število zob (β = -0,085, p = 0,325). Z manjšim številom zob je značilno povezana tudi sladkorna bolezen (p = 0,031). Tudi kardiovaskularne bolezni (p = 0,025) in bolezni ščitnice (p = 0,043) so bile značilno povezane z manjšim številom ohranjenih zob, prav tako stanje po preboleli neoplazmi brez področja glave in vratu (p = 0,019). Značilne povezave med osteoporozo in manjšim številom zob nismo uspeli dokazati (p = 0,573). Ugotovili smo tudi značilno povezavo med antidiabetiki in manjšim številom zob (p = 0,004) in zanimivo povezavo med analgetiki (p = 0,022) in večjim številom zob.*

Zaključki: *Oralno in splošno zdravje sta medsebojno povezana, saj so določeni sociodemografski dejavniki in nekatere kronične sistemske bolezni povezane z manjšim številom ohranjenih zob. Razvidno je, da je popolna brezzobost med starostniki v Sloveniji še vedno visoka. To nakazuje, da bi bilo potrebno izboljšanje programov preventivnega zobozdravstva za starostnike kot tudi vzajemnega sodelovanja zobozdravnikov in splošnih zdravnikov pri kontroli dejavnikov tveganja.*

Ključne besede:
brezzobost
starostniki
sistemske bolezni

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1 BACKGROUND

The World Health Organization (WHO) recognizes edentulous individuals as physically weakened or disabled because the absence of teeth restricts essential functions such as chewing, eating, and speaking. Edentulism significantly affects self-confidence, self-image, and overall quality of life, and serves as an indicator of oral health (1). This condition predominantly affects individuals aged 65 and older. Data from the Statistical Office reveal that as of January 1, 2021, there were 435,715 elderly individuals living in Slovenia, which constituted approximately one-fifth of the overall population. Women accounted for 57% of that elderly population (2).

The prevalence and incidence of severe tooth loss have consistently declined, particularly in developed countries like Sweden, due to enhanced preventive measures, heightened awareness of oral health, and more efficient dental care practices (3, 4). Despite this decline in prevalence, the number of edentulous individuals continues to rise. In 2002 Douglas projected that, despite a diminishing proportion of the edentulous population, the number of edentulous individuals in the United States would increase by 10% in 30 years (5), which relates to increased life expectancy among the elderly (6).

Various biological and nonbiological factors influence tooth loss. The most common biological causes are caries (tooth decay) and periodontal disease (7, 8). Apart from oral diseases, many sociodemographic and socioeconomic factors, including age, sex, socioeconomic status, education, social class, residency, smoking, lifestyle, dental health behaviour, and access to dental care, contribute significantly to increased tooth loss and subsequent edentulism (3, 9-11). Therefore, oral health promotion and education are vital in mitigating tooth loss (12).

Furthermore, the existing literature has highlighted evidence of a relationship between systemic chronic diseases and tooth loss. Studies have shown that systemic health conditions, such as diabetes mellitus (DM) (13, 14), rheumatoid arthritis (15), osteoporosis (16), neurodegenerative diseases (17, 18), liver diseases (19), hypertension (20), and stroke (21) can impact oral health, potentially leading to issues such as periodontal disease and tooth loss and vice versa. The number of retained teeth is also a predictor of mortality (22, 23). Additionally, medications used for chronic systemic diseases, along with their adverse effects, play an important role in the interplay of these conditions.

This study aimed to assess the prevalence of edentulism and tooth loss in the Slovenian elderly population, as well as the associated risk factors, and investigate the association between systemic and oral health.

2 METHODS

The non-randomized cross-sectional study consisted of 445 elderly people over 65. The sample mean age was 79.7±8.9, ranging from 65 to 102 years. The elderly were divided into three age subgroups: 65-69, 70-74, and over 75. Almost two-thirds (63%) of the study sample were 75 years of age or more, 20% were 70-74, and 17% were 65 to 69. Among the participants, 153 (34%) were male, while 292 (66%) were female. A total of 89 participants were selected from nursing homes (DSO). Specifically, 32 participants were from DSO Tabor, 20 from DSO Bežigrad, 16 from DSO Poljane, 14 from DSO Bokalce, six from DSO Strunjan, and one from DSO Moste. The remaining participants (356) were from the Clinical Department of Maxillofacial and Oral Surgery and Stomatology clinic at the University Clinical Centre of Ljubljana. The required inclusion criterion was age 65 years or older. We did not include immobile patients, patients with memory loss, and individuals incapable of making decisions or expressing their will. Subjects were inhabitants of different rural and urban areas of Slovenia. A letter explaining the purpose of the study and requesting informed consent to participate was handed to every participant. The study protocol was approved by the Medical Ethics Committee of the Republic of Slovenia (0120-173/2021/8). Data was collected from 2016 to 2022.

Data for this study were gathered through a brief oral examination and a questionnaire. Information on the number of retained teeth, basic demographics (name, age, sex), chronic diseases, medications, allergies, tooth loss causes, weight and height for BMI calculation, and education level were collected. Participants' general practitioners provided a list of medications and systemic diseases. Only 250 (56.2%) participants reported the cause of tooth loss. The primary reported reason was periodontal disease (31.7%), followed by caries and caries-related consequences (20.9%). A total of 43.8% of participants either did not mention or did not know the exact cause of tooth loss. Education levels were numerically categorized: 1 = completed primary school, 2 = completed secondary school, 3 = bachelor's degree, master's degree, or PhD. Among 301 participants who reported their level of education, the majority had completed high school (46.5%), whereas only 17.6% of participants had a bachelor's degree, master's degree, or PhD. Based on the clinical examination, the dental status and number of retained teeth were recorded separately for each jaw and the total, as well as the presence and type of dental prosthetic restorations and dental implants. Dental implants, residual roots (radices relicta), and dental prosthetic restorations such as removable prostheses, pontics, and implant-retained prostheses

were not considered as teeth and, therefore, were not included in the tooth count. Data about the type of dental prosthetic restorations and implants was collected solely to determine natural teeth. Teeth with fixed prosthodontic crowns were counted as normal teeth and included in the study. The dentate group included all subjects with at least one tooth in the upper or lower jaw. The criterion of fully preserved dentition was the presence of all 28 teeth in the upper and lower jaws, excluding wisdom teeth. All participants (edentulous and dentate) were included in calculating the average number of teeth.

Chronic systemic diseases were arranged into ten logical groups: DM, cardiovascular diseases (CVDs), respiratory diseases, rheumatic diseases, recovered after oncologic treatment (excluding the head and neck area), neurologic diseases, psychiatric conditions, thyroid diseases, prostate diseases, and osteoporosis. Medications were arranged into groups following the ATC classification (Anatomical Therapeutic Chemical classification).

IBM SPSS Statistics, version 18 (IBM Corporation, Armonk, USA) was used for statistical data analysis. First, we performed a descriptive analysis of the sample. The distribution of the observed variables, especially the number of teeth, was not normal, so we used nonparametric tests in the further analyses. Using the Mann-Whitney U test for independent samples, we checked the differences in the number of teeth between people who have a particular disease or take a specific medication, and people who do not have the condition or do not take this medication. Using the Kruskal-Wallis one-way analysis of variance, we checked the influence of the categorical variables of sex and education on the number of teeth. We used linear regression to check the influence of the independent numerical variables (BMI, age, number of medications) on the dependent variable (number of teeth). The statistical significance level was set at $p \leq 0.05$.

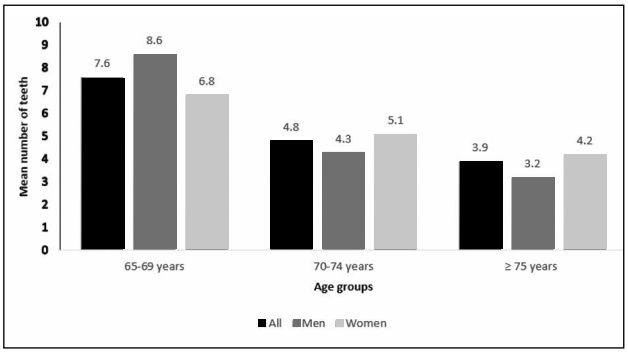

Figure 1. The mean number of teeth by age group and sex.

3 RESULTS

3.1 Number of teeth, sex, education level, and BMI

The mean number of retained teeth in our population was 4.7±7.7. Specifically, men had an average of 4.6±7.3 teeth, while women had an average of 4.7±7.9 teeth. The number of teeth decreased over the years, from 7.6 among those aged 65 to 69 to an average of only 3.9 teeth in persons 75 or older (Figure 1).

The regression analysis revealed that age significantly influenced the number of teeth (β=-0.185, $p<0.001$). The negative coefficient β indicates that older age is associated with a lower number of teeth.

As illustrated in Table 1, the upper jaw had, on average, 2.1 teeth, while the lower jaw had, on average, 2.6 teeth.

Among only dentate elderly people, the mean number of teeth was 5.5±4.6 in the upper jaw and 6.6±4.4 in the lower jaw.

Gender-based differences in tooth distribution were not statistically significant. Tooth loss increased over the years in both sexes (Figure 1), with men exhibiting a slightly higher average tooth loss (5.4 teeth) compared to women (2.6 teeth). However, this difference was statistically nonsignificant (p-value=0.783).

Among the participants, 273 (61%) were completely edentulous, with none meeting the criterion of fully preserved dentition (all 28 teeth in the upper and lower jaws, excluding wisdom teeth). In the age group of 65-69, 33 participants (46%) were completely edentulous. Among

Table 1. Mean number of teeth in both arches across age groups.

Scale	UPPER ARCH				LOWER ARCH			
	65-69 years	70-74 years	>75 years	All	65-69 years	70-74 years	>75 years	All
Men	3.2 (4.2)	2.0 (4.1)	1.4 (2.8)	1.9 (3.5)	5.4 (5.6)	2.3 (4.0)	1.9 (3.6)	2.7 (4.3)
Women	3.0 (4.7)	2.5 (4.0)	2.0 (4.0)	2.3 (4.1)	3.8 (4.7)	2.6 (4.3)	2.2 (4.0)	2.5 (4.2)
All	3.1 (4.5)	2.3 (4.0)	1.8 (3.7)	2.1 (3.9)	4.4 (5.1)	2.5 (4.2)	2.1 (3.9)	2.6 (4.2)

Legend: Numbers in parentheses represent the standard deviations for each corresponding value.

those aged 70-74, 56 participants (61%) were completely edentulous. For those aged 75 years or older, the number of completely edentulous participants was 184 (66%).

A total of 141 (31.7%) participants reported periodontal disease as the primary cause of tooth loss. Caries and caries-related consequences, reported by 93 (20.9%) participants, were the second most common cause, followed by head and neck cancer treatment, reported by 11 (2.5%) participants, and traumatic injuries, reported by five (1.1%) participants. One hundred and ninety-five (43.8%) participants either did not state the primary cause of tooth loss or were unaware of it.

Table 2 shows the distribution of elderly individuals and the mean number of teeth based on education level. A statistically significant association was observed, indicating that individuals with lower educational levels had fewer retained teeth (p-value<0.001). Specifically, those who completed elementary school had, on average, 2.9 times fewer retained teeth compared to those with a bachelor's degree, master's degree, or PhD.

Table 2. Number of subjects and mean number of teeth by education level (n=301).

Education level	1	2	3
n	108	140	53
Mean number of teeth	2.9	5.2	8.5

Legend: 1 = primary school education, 2 = secondary school education, 3 = bachelor's degree, master's degree, PhD; n represents sample size.

The mean BMI was 26.9, ranging from 16.6 to 40.0 (Table 3). However, as an independent variable, BMI did not significantly influence the number of retained teeth (β=-0.085, p=0.325). The influence was also independent of sex, with p-values of 0.717 (β=-0.055) for men and 0.307 (β=-0.109) for women.

Table 3. Mean age, BMI, and number of medications in the studied population with linear regression results.

	All (n=445)		All (n=445)		Men (n=153)	
	Mean (SD)	Beta coef. (sig.)*	Mean (SD)	Beta coef. (sig.)*	Mean (SD)	Beta coef. (sig.)*
Age [years]	79.7 (8.9)	-0.185 (p<0.001)	77.7 (8.1)	-0,312 (p<0.001)	80.7 (9.1)	-0.134 (p=0.11)
BMI [kg/m2]	26.9 (4.2)	-0.085 (p=0.325)	27.2 (3.9)	-0.055 (p=0.717)	26.8 (4.3)	-0.109 (p=0.307)
Number of medications	3.9 (3.8)	0.163 (p=0.116)	3.2 (2.9)	0.205 (p=0.332)	4.4 (4.0)	0.140 (p=0.250)

Legend: SD stands for standard deviation; n represents sample size; * results of the linear regression model (beta coefficient and significance) with teeth number as a dependent variable

3.2 The correlation between chronic diseases and the number of teeth

A total of 376 participants (84.5%) reported having at least one chronic disease and regularly taking medication. The prevalent chronic diseases were CVDs (73.3% of the elderly), followed by DM (18.4%). A significant relationship was found between a smaller number of retained teeth and DM (p=0.031), CVDs (p=0.025), thyroid diseases (p=0.043), and people after oncologic treatment, excluding head and neck malignancies (p=0.019). Tables 4 and 5 show data and p-values for specific disease groups.

Table 4. Distribution of the elderly with specific diseases and mean number of teeth, stratified by sex.

	Total (n=445)			Men (n=153)			Women (n=292)		
	n/%	Number of edentulous	Mean number of teeth	n/%	Number of edentulous	Mean number of teeth	n/%	Number of edentulous	Mean number of teeth
DM	82/18	60	3.6 (7.2)	29/19	22	2.6 (6.0)	53/18	38	4.1 (7.8)
CVD	327/73	210	4.2 (7.4)	114/75	69	4.1 (6.6)	213/73	141	4.3 (7.8)
Respiratory diseases	42/9	22	4.7 (7.2)	14/9	9	2.7 (5.0)	28/10	13	5.7 (8.0)
Rheumatic diseases	32/7	16	4.0 (6.0)	6/4	1	9.5 (7.4)	26/9	15	2.8 (4.9)
Post oncologic treatment	40/9	32	2.7 (6.3)	12/8	8	3.7 (6.8)	28/10	24	2.3 (6.2)
Neurologic diseases	42/9	24	4.4 (7.8)	9/6	6	2.4 (4.2)	33/11	18	4.9 (8.5)
Psychiatric diseases	57/13	35	5.0 (8.0)	8/5	4	5.5 (7.2)	49/17	31	4.9 (8.2)
Thyroid diseases	60/13	44	3.0(6.1)	5/3	3	5.2 (7.4)	55/19	41	2.9 (6.0)
Prostate diseases	42/9	27	3.6 (6.1)	42/27	27	3.6 (6.0)	/	/	/
Osteoporosis	67/15	43	4.2 (7.2)	1/<1	0	14	66/23	43	4.0 (7.2)

Numbers in parentheses represent the standard deviations for each corresponding value; n represents sample size.

We checked the statistical significance of osteoporosis and thyroid diseases separately for females, and for prostate diseases we assessed only males. Women with osteoporosis did not show a statistically significant inverse relationship with the number of teeth (p-value=0.494), and the same was true for men with prostate diseases (p-value=0.209). On the other hand, women with thyroid diseases had a significantly lower number of teeth (p-value=0.033).

3.3 The correlation between the number of medications and the number of teeth

There were 69 (16%) elderly patients without any medications. The overall mean medication count was 3.9, significantly increasing with age (p-value<0.001). However, the total number of medications did not significantly influence the number of teeth (β=0.163, p=0.116). Only two medication groups showed a significant association

Table 5. Number of subjects and mean number of teeth by education level (n=301).

Education level		N (%)	Mean age	Mean number of teeth	Number of edentulous	p-value
DM	0	363 (82)	79.9	4.9		**0.031**
	1	82 (18)	78.7	3.6	60	
CVD	0	118 (27)	77.6	6.0		**0.025**
	1	327 (73)	80.4	4.2	210	
Respiratory diseases	0	403 (28)	79.4	4.7		0.407
	1	42 (9)	81.9	4.7	22	
Rheumatic diseases	0	413 (93)	79.4	4.7		0.515
	1	32 (7)	83.3	4.0	16	
Post oncologic treatment	0	405 (91)	79.7	4.9		**0.019**
	1	40 (9)	79.1	2.7	32	
Neurologic diseases	0	403 (91)	79.2	4.7		0.800
	1	42 (9)	84.7	4.4	24	
Psychiatric diseases	0	388 (87)	79.2	4.6		0.886
	1	57 (13)	83.2	5.0	35	
Thyroid diseases	0	385 (87)	79.6	4.9		**0.043**
	1	60 (13)	80.0	3.1	44	
Prostate diseases	0	403 (91)	79.5	4.8		0.513
	1	42 (9)	81.0	3.6	27	
Osteoporosis	0	378 (85)	78.7	4.8		0.573
	1	67 (15)	85.0	4.2	43	

Legend: The presence of a medical condition is indicated by a value of 1, while the absence of a medical condition is indicated by a value of 0; bold text indicates statistically significant p-values; n represents sample size.

with the number of teeth (Table 6). The first group, antidiabetic medications (p-value=0.004), was associated with a lower number of retained teeth. Conversely, the second group, analgesic medications (p-value=0.022), showed a positive association, suggesting that individuals regularly taking analgesics had more teeth than those without such therapy.

4 DISCUSSION

The mean number of teeth among the elderly in our study was low at 4.7±7.7, with a high prevalence of edentulism at 61.2%. The primary reported cause of tooth loss was periodontal disease and caries and caries-related consequences, though self-reported data may lack accuracy. In 1990, Vrbič reported a 29.3% edentulism rate in Slovenia for individuals aged 65-74 years and 51.6% for those aged 75 years or more (24). It was estimated in 2016 that the prevalence of edentulism would decrease to 19.2% by 2020 in Slovenia (25), though Artnik reported an even lower prevalence in 2019, which stood at 12% for the age

Table 6. Comparison of mean age and mean number of teeth between two groups with p-values.

Education level		n/(%)	Mean age	Mean number of teeth	p-value
Insulins	0	427	79.7	4.5	0.056
	1	18	80.1	8.6	
Antidiabetics	0	389	79.8	5.0	**0.004**
	1	56	78.5	2.7	
Antihypertensives	0	206	78.1	5.0	0.322
	1	239	81.0	4.4	
Diuretics	0	377	78.9	4.6	0.600
	1	68	83.7	5.2	
Statins	0	309	79.6	4.2	0.067
	1	136	79.9	5.8	
Cardiac therapy drugs	0	299	78.4	4.9	0.294
	1	146	82.4	4.3	
Antiresorptives	0	407	79.4	4.7	0.861
	1	38	83.1	4.0	
Chemotherapeutics	0	435	79.8	4.8	0.174
	1	10	76.1	1.3	
Immunosuppressives	0	435	79.6	4.6	0.777
	1	10	82.3	5.9	
Adrenergics	0	418	79.6	4.7	0.920
	1	27	80.2	4.4	
Antithrombotics	0	383	79.1	4.7	0.955
	1	62	83.5	4.8	
Psychoanaleptics	0	401	79.3	4.6	0.717
	1	44	83.4	5.1	
Analgesics	0	375	78.6	4.4	**0.022**
	1	70	85.3	6.3	
Anticonvulsants	0	426	79.5	4.6	0.327
	1	19	82.6	5.4	
Psycholeptics	0	387	78.6	4.7	0.504
	1	58	86.6	4.3	
Other nervous system drugs	0	436	79.6	4.6	0.594
	1	9	83.2	6.6	
Drugs used in benign prostatic hypertrophy	0	412	79.5	4.8	0.303
	1	33	82.1	3.5	
Thyroid therapy drugs	0	402	79.6	4.8	0.123
	1	43	80.5	3.3	

Legend: 0 represents those not taking medication, and 1 represents those receiving medication; bold text indicates statistically significant p-values.

group 65-74 years (26). For better epidemiologic reliability and representativeness, we calculated the prevalence of edentulism without 100 subjects who came to the Centre for Removable Prosthodontics solely for rehabilitation with total dentures. Even after excluding these subjects, the prevalence of edentulism was high at 50%, aligning with Vrbič's earlier findings. The calculation was done to emphasize that the prevalence remains high and has not improved much over the last the 30 years. Notably, the exclusion of participants over 74 years old in the 2019 study, constituting almost two-thirds of our subjects, could contribute to a significant difference in edentulism prevalence. Nursing home residents, known to have poorer oral health, also represented a substantial proportion of the participants (20%). Therefore, in order to achieve a more representative prevalence, elderly participants should be selected blindly from across Slovenia.

In comparison, Sweden and Finland have much lower rates of complete edentulism among elderly individuals (aged 65 or more): 20.6% and 34.9%, respectively (4). In 2014, Germany reported a 12.4% prevalence of complete edentulism among individuals aged 65-74, 28.9% for those aged 75-84, and 44.8% for those over 85 (27). This highlights Slovenia's higher prevalence of edentulism compared to European countries like Sweden and Germany.

As expected, the number of teeth in the oral cavity significantly declines with age. This reflects the broader physiological changes occurring in the body over time, which are also reflected in the periodontal tissues and the number of preserved teeth. Schiffner et al. (28) found more inflammation of the periodontal tissues and more dental plaque in dentate elderly people than in adults; therefore, periodontal disease and caries, as the leading causes of tooth loss, are expressed to a greater extent in elderly individuals.

We did not find a relationship between sex and the number of teeth, which is supported by the results of previous studies (4, 29, 30). In contrast to our findings, the results of some studies indicated greater tooth loss and a higher prevalence of edentulism in women (1, 9, 10), mainly due to biological characteristics of sex (e.g., hormonal changes, pregnancy, greater susceptibility to caries) (31). Regardless, historical differences seem to be disappearing, possibly due to women's more equal socioeconomic status.

Consistent with other studies, a higher level of education was associated with a greater number of teeth in the oral cavity (32), likely influenced by better oral health knowledge and hygiene habits and more frequent dental practice visits (33).

Unexpectedly, increased BMI was not associated with a lower number of teeth. While obesity or high BMI may impact the number of teeth in younger people, in older people factors such as the ageing process, socioeconomic status, and lifestyle habits appear to play a more dominant role than actual BMI (34). Notably, a substantial portion of our study population had a BMI exceeding 24.9 kg/m^2, indicating elevated body weight, with almost half falling into the overweight category (BMI: 24.9-29.9 kg/m^2). This distribution may influence our findings, especially considering previous studies suggesting a reciprocal relationship between fewer teeth and obesity (21, 35).
It has also been reported that BMI can be a valuable tool for predicting poor oral hygiene habits in diabetic patients, and thereby possible oral health issues in this population (36).

DM was significantly associated with a lower number of teeth. DM acts through the progression of periodontal disease. The bidirectional relationship between diabetes mellitus and periodontal disease has already been studied in detail. Our findings are supported by those of Patel et al. (37), who claimed that patients with diabetes are more susceptible to complete edentulism. While we did not differentiate between diabetes types, further research is needed to clarify how each type affects the number of teeth.

Moreover, CVDs were significantly associated with a lower number of teeth, but the existing literature lacks evidence supporting the influence of CVDs on increased tooth loss. Our analysis did not differentiate between cause and effect, and therefore we can assume that, in this case, a smaller number of teeth influences the greater expression of CVDs. The literature mentions associations between tooth loss and increased risk of hypertension (20), coronary heart disease (38), peripheral arterial disease (39), and myocardial infarction (40). Although our results suggest that CVDs negatively influence the number of teeth, further studies are needed to answer this question.

Furthermore, our study observed significant associations between the prevalence of thyroid diseases, and post-oncologic treatment, excluding head and neck malignancies. Given that thyroid hormones have a proven influence on bone metabolism (41), disturbances in hormone secretion could influence the quantity and quality of alveolar bone and, consequently, tooth loss (42). The interpretation of the inverse association between past neoplasm treatment and the number of teeth is difficult due to the diverse nature of the assessed group, which included elderly individuals who had recovered from neoplasms of various origins and treatment methods, but excluded elderly people with head and neck tumours. Therefore, it is difficult to determine the mechanism behind this relationship from these criteria alone.
No statistically significant associations existed between the number of teeth and the remaining systemic disease groups.

Since elderly individuals are exposed to more medications, we assessed their potential impact on tooth number. Antidiabetic drug use was inversely associated with tooth number, likely reflecting the influence of diabetes mellitus. Conversely, regular analgesic therapy was positively linked to a higher number of teeth, suggesting a potential protective effect on tooth loss. The anti-inflammatory properties of certain analgesics, like paracetamol and NSAIDs (43), may contribute to this protective effect on teeth and periodontal tissues.

Oral health significantly impacts overall well-being and quality of life, and has a broader impact beyond clinical signs and symptoms (44). Poor oral health not only contributes to systemic conditions, but is also influenced by diseases and medications, potentially resulting in tooth loss. Unfortunately, oral health is often neglected in elderly care, leading to undiagnosed conditions. To address this, increased awareness, education, and integration of oral health into elderly care plans are essential, as well as promoting better communication between dentists and general practitioners for holistic healthcare.

The key strengths of our study include a large sample size, which provides strong evidence. A comprehensive assessment of medication use and systemic diseases provides valuable insights into potential associations with tooth loss, contributing to a deeper understanding of the association between oral and systemic health.

This study has certain limitations related to the representativeness of the sample, potentially affecting the generalizability of the findings to the broader elderly population in Slovenia. Factors like a higher proportion of female participants and fully edentulous individuals could impact the generalizability of the results. The nonrandomized recruitment process may have introduced a selection bias and thus also limited the generalizability of the findings. The involvement of the Statistical Office of Slovenia and a blinded selection process for recruiting representative individuals are recommended to enhance the reliability of any future research. Additionally, the cross-sectional design of the current study limited our ability to establish causal relationships between the variables of interest, and longitudinal studies would provide more robust evidence in this regard.

Self-reporting introduces a potential recall bias, impacting data accuracy on dental history and the cause of tooth loss, which could affect the validity of the observed associations. The study also lacks consideration of factors like oral hygiene, smoking, socioeconomic status, and dental care access, which could influence the relationships observed between the variables. Addressing these limitations in future research is thus essential for a stronger evidence base on the relationship between the number of teeth and systemic diseases.

5 CONCLUSIONS

The findings of this study highlight that certain socioeconomic factors and chronic systemic diseases are strongly associated with the number of retained teeth among the elderly in Slovenia, and that edentulism remains high among this population. This suggests more attention needs to be paid to at-risk groups, like the elderly, to improve preventive measures and minimize the impact of risk factors on oral health. Improved awareness among general practitioners regarding the interconnection between general and oral health is also vital to encourage better cooperation with dentists and the promotion of overall well-being.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

FUNDING

The study received no funding.

ETHICAL APPROVAL

Ethical approval to conduct the study was obtained from the National Medical Ethics Committee of the Republic of Slovenia (NMEC), No. 0120-173/2021/8.

CONSENT TO PARTICIPATE

Written informed consent to participate in the research was obtained from all respondents prior to data collection.

AVAILABILITY OF DATA AND MATERIALS

All data and materials used in this study were collected from publicly available sources and are available upon reasonable request.

AUTHORS' CONTRIBUTIONS

JBŽ: conceptualization, collected and analysed data, drafted the manuscript; NIH: conceptualization, supervised the study, assisted with data collection, reviewed, and edited the manuscript; MV: conceptualization, performed statistical analysis, reviewed, and edited the manuscript; ZS: conceptualization, supervised the study, assisted with data collection and analysis. All authors read and approved the final manuscript.

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