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Tooth loss in the elderly and its association with nutritional status, socio-economic and lifestyle factors

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Abstract

Objective. Tooth loss impacts on general health and is a risk factor for malnutrition, disability, loss of self-sufficiency, and deterioration in quality of life. The present study was carried out to evaluate the prevalence of edentulism and its association with social and lifestyle factors in a population of elderly Italians. ***Material and Methods***. Dental, social, and disease conditions were evaluated in a large community-based cohort (3054) of elderly subjects ($\geq$65 years) of both sexes in northern Italy. Logistic regression analyses with stepwise forward selection were performed to estimate the independent contribution of nutritional, socio-economic, and lifestyle variables to dental status. Adjusted ORs and 95% CI were estimated for variables significantly associated with edentulism. ***Results***. The prevalence of edentulism was about 44.0%. It was more pronounced in females and it was twice as prevalent in the 90+ years age group. Among edentulous subjects, 17.5% wore no prostheses. Difficulties in chewing and in swallowing were reported by 47.6% and 13.7% of the subjects, respectively. Multivariate analysis indicates that edentulism was associated with age in both sexes. For women, independently associated risk factors were: years since menopause >23 (OR = 1.81; 95% CI: 1.37–2.40), number of children >3 (OR = 1.95; 95% CI: 1.36–2.80), and living alone (OR = 1.47; 95% CI: 1.15–1.88). For men, these were serum albumin <40 g/l (OR = 1.79; 95% CI: 1.22–2.63), current smoking (OR = 4.01; 95% CI: 2.59–6.20), and former smoking (OR = 3.42; 95% CI: 2.42–4.82). ***Conclusions***. The prevalence of edentulism among the elderly Italian population studied was at the high end among Western countries, and higher in women than in men. In women, tooth loss correlated with aging, female events (pregnancies, menopausal status), and living alone. In men, aging and smoking are important determinants of edentulism, which is associated with the risk condition of hypoalbuminemia. Difficulty in chewing was associated with dentition type. In our study, the high prevalence of edentulous subjects without prostheses suggests a need for educational and social measures to improve patients' attitudes to dental care and to encourage the use of prostheses among the elderly.

Key Words: *Chewing, edentulism, elderly, risk indicators, swallowing*

Introduction

Assessment of oral status provides information pertinent to the overall evaluation of an individual's general health. In fact, tooth loss affects the patient's ability to chew and thus alters food choices and the digestive process, and may lead to malnutrition [1]. The impact of poor oral status can be even more severe, impairing taste, phonetics, and aesthetics, often resulting in limited social and personal interaction [2]. Tooth loss therefore represents a risk factor for malnutrition and disability, impedes self-sufficiency, and worsens the quality of life [3,4].

The etiology of tooth loss is complex. It includes factors such as predisposition, diet, hormonal status, coexisting diseases, as well as hygiene habits and use of dental clinics. At present, the dentist's main aim is that of conserving the patient's dental property [5].

The prevalence of edentulism in the elderly population worldwide is extremely high (ranging from less than 20% to 60%) [6–8], but a 10%

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decline has been reported in the last decade in Western countries [9,10]. In Italy, to our knowledge, no large study has been performed in this field, and there are few data available about the prevalence of edentulism. In Italy, epidemiological studies are generally carried out in and by public health facilities, since most health care is provided by public institutions. Dental care, on the other hand, is carried out, if at all, in private practices entirely at the expense of patients, and is therefore a personal matter depending on habit and other subjective considerations. As a result, data concerning dental status in Italy are for the most part unsuitable or unavailable to researchers.

The aim of the present work was to evaluate the prevalence of edentulism in an elderly Italian population, and to assess the association between tooth loss and social, nutritional, and lifestyle factors.

Subjects and methods

Sample population

The population considered is that of the Progetto Veneto Anziani (Pro.V.A.) Study, a large observational community-based cohort survey of elderly subjects resident in northeastern Italy. It was designed to provide clinical information on major chronic diseases, measure the consequent impairment, evaluate the participants' functional limitations, and assess their status of disability [11]. The study was approved by the local ethics committees and written informed consent was obtained from all the participants. The cross-sectional phase, carried out at two centers in the Venetian Region of northern Italy, began in 1995 and ended in 1998, while the longitudinal phase is ongoing.

The study centers were Camposampiero and Rovigo, two small cities surrounded by rural and industrial areas. These centers were selected because they reflect the larger Veneto Region in terms of socio-demographic and lifestyle factors, and because inhabitants showed low migration rates, resulting in a relatively stable population. In addition, the two cities have qualified physicians with expertise in geriatrics and institutions equipped for epidemiological studies.

The sampling frame for the Pro.V.A. Study included all the subjects aged 65 and older who were 100% Caucasian and residents of one of the two study centers at the beginning of the cross-sectional phase.

No exclusion criteria were used. The sampling strategy consisted of an age-stratified (65–74, 75–84, $\geq$85) and sex-stratified random sample designed to keep the male-to-female ratio at 2:3, and to oversample the oldest old. Oversampling was carried out to provide stable estimates of conditions with low prevalence. The original sampling frame was divided into mutually exclusive subsets balanced with respect to age and sex distribution. In accordance with this strategy, 14% of the target population were randomly drawn from health district registries, the databases of which included the entire resident population.

The overall response rate was 77% for men and 64% for women. The sampling design made it possible to reach the prefixed sex and age proportions, notwithstanding that the response rate depended on age ($p < 0.0001$) and gender ($p < 0.0001$). The final study population comprised an age- and sex-stratified random sample of 3099 persons (1245 M, 1854 F; M:F ratio 2:3; mean age 76.8 ± 8.7 years), corresponding approximately to 10% of the target population.

Statistical evaluation of information available for non-respondent subjects (income, loneliness, widowhood, number of children, years at school attended) indicated that their socio-economic conditions were not significantly different from those of the participants.

All participants agreed to undergo a detailed home interview concerning socio-demographic characteristics, cognitive status, diet, medical history and symptoms, and disability in instrumental and basic activities of daily living. They were subsequently invited to an outpatient clinic at the study center for a comprehensive work-up that included physical performance evaluations, instrumental determinations, and an oral examination. Home visits by nurses and physicians were arranged for homebound, institutionalized, and severely disabled persons. Interviewers, nurses, and physicians involved in the study were trained and calibrated on standardized data collection using questionnaires, performance measures, instrumental tests, and physical examinations, as described elsewhere [11].

A fasting blood sample was obtained from 99% of the participants. Samples were kept at 4°C for 1 h, then centrifuged at 3000 rpm/10 min to obtain the plasma or serum fraction. The routine biochemical determinations were carried out at local clinics using standardized procedures, while the more complex hormonal and metabolic assessments were performed at the University laboratory facilities.

Dentition

During the physical work-up at the study center, trained and calibrated clinicians performed an oral examination to assess each patient's general oral status and number of teeth. According to the World Health Organization oral examination procedures [12], all teeth, whether sound, decayed, or treated with any kind of restoration, were considered when the total number (remaining teeth) was being calculated. The presence of an upper and/or lower jaw prosthesis was also recorded.

Based on their dentition, subjects were classified using different criteria, depending on the aim of the analysis. For study of the association between natural dentition and different variables, the number of remaining teeth was applied as dichotomous (none versus at least 1) or categorical (0; 1–7; 8–19; ≥20). Four classes were identified when the effect of dentition type on chewing and on swallowing was being evaluated: edentulous persons not wearing any dental prosthesis (E), edentulous persons wearing both upper and lower dentures (ED), subjects with 0 to 19 teeth with or without dentures (TD), and subjects with most of their natural teeth (≥20) with or without dentures (NT).

Information on self-reported difficulty in chewing and in swallowing was obtained during the home interview by two specific questions: "Do you have problems chewing food?" and "Do you have problems swallowing food?"

Data about dental status were obtained from 3054 subjects (1226 M, 1828 F), all of whom answered the questions concerning chewing and swallowing.

Nutritional status

In the present study, nutritional status was described by means of body mass index (BMI), a general nutrition index, and serum albumin, a biomarker specific for protein energy malnutrition. BMI is a widely applied index of nutritional status in geriatric clinical practice, mainly identifying subjects at risk of under-nutrition [13]. Albumin is considered as an index of long-term malnutrition because its half-life is the longest among all circulating proteins [14]. Barefoot and lightly dressed subjects' heights and weights were assessed to calculate BMI (kg/m^2); body weight to the nearest 0.1 kg was measured using a plate balance, and height to the nearest centimeter was taken by a stadiometer at head level. To classify underweight and obese conditions, cut-off values of <20 kg/m^2 and ≥ 30 kg/m^2, respectively, were used as these are age-specific criteria in geriatrics [15].

Serum albumin levels were assessed in the fasting blood samples by means of a colorimetric method using bromocresol green (Roche). Albumin binds to the dye at pH 4.2, generating a complex whose absorbance is spectrophotometrically read at 570 nm (Roche Hitachi 747).

As low albumin levels are uncommon in the elderly Italian population, in the present study, in order to obtain more robust estimates, the condition of hypoalbuminemia was defined as values lower than 40 g/l.

BMI was calculated for 94% of the persons for whom information on dentition was available, while serum albumin values were obtained for 99%.

Socio-economic status and lifestyle factors

The information used to describe socio-economic status (SES) and lifestyle factors was self-reported during the baseline interview. The following surrogate variables were considered for socio-economic condition: monthly income (<500 €, ≥500 €), living alone (yes/no) and widowhood (yes/no). Lifestyle factors were described by means of educational level, smoking, number of children and, for women, only years since menopause (YSM). Educational level, described by the number of years of school attended, was categorized into three classes: 0–3; 4–8; >8 years. Smoking was assessed during the home interview by means of seven specific questions concerning current or past (for at least one year) smoking patterns, type of smoking (cigarettes, pipe, cigars, or cigarillos), mean number of cigarettes or other per day, age of the participant at beginning and at quitting (when appropriate). In the present study, smoking was categorized as "never", "former", or "current"; the latter two categories were further subdivided by number of cigarettes/day in light, mild, and heavy smokers (<10; 10–20; >20 cigarettes/day). Children were grouped as follows: 0, 1–3, and >3. Years since menopause in women was computed by subtracting the self-reported age at the onset of menopause from age at the interview. A condition of risk was defined for values of more than 23 years.

Information on SES and lifestyle factors was obtained from at least 99% of the participants.

Statistical analysis

Quantitative variables were summarized as mean ± standard deviation and qualitative variables as frequency distributions. Crude prevalence was calculated for edentulism, difficulty in chewing, and difficulty in swallowing. The sex- and age-standardized prevalence was estimated using the direct standardization method performed on the target population structure. Analysis of variance or *t*-test was used to compare mean values among groups for normally distributed variables, and the non-parametric Mann-Whitney test for non-normal variables. The chi-square test was applied to compare categorical distributions. Differences between respondent and non-respondent subjects were evaluated by *t*-test or chi-square test, as necessary. Logistic regression analyses with stepwise forward selection were performed to estimate the independent contribution of each variable considered (nutritional, socio-economic, and lifestyle factors) to edentulism. Age was entered as categorical (65–74, 75–84, ≥ 85). Adjusted ORs and the respective 95% CI were estimated for significantly associated variables. The same analysis was performed to evaluate the effect of four different categories of dentition on chewing and

on swallowing adjusting for sex and age. The class of dentition (E, ED, TD, NT) was entered in the regression as an ordinal variable (reference class: NT) along with age and sex. Chewing was added to a logistic model describing swallowing, and *vice versa*, to better clarify the relationship between chewing, swallowing, and dentition.

A p level lower than 0.05 was considered significant. All statistical analyses were performed using the SAS Statistical Software Package version 8.2 (SAS Institute, Cary, N.C., USA).

Results

Dentition

The population characteristics are outlined in Table I. The mean number of remaining teeth among dentates was 12.7 for women and 13.5 for men. The prevalence of edentulism was 43.8% (40.6% after adjusting for sex and age structure of the target population); this was more pronounced in women and increased with age. It was 31.8% in the 65–69 years age group and more than twice (63.9%) in the 90+ years group. Among edentulous subjects, 17.5% wore no prostheses. Subjects edentate or with a maximum of 7 teeth wearing no dentures comprised 15.3% of men and 14.3% of women.

Clinical, anthropometric, socio-economic, and lifestyle characteristics by remaining teeth group are given in Table II. All the considered variables were significantly associated with denture conservation, except in the case of participants living alone.

Serum albumin levels were significantly lower in edentulous persons not wearing prostheses (40.0 g/l) with respect to those wearing them (43.3 g/l; $p < 0.0001$).

Comparison between smoking habits and remaining teeth was performed only in men, i.e. not in women because of their low prevalence of smoking (see Table I). The relationship between dental status and smoking demonstrated that even though the mean age of the non-smokers was significantly higher than that of the current smokers (78.8 years versus 70.5 years, $p < 0.0001$), conservation of natural dentition was better among the non-smokers. The prevalence of edentulous subjects was much higher in heavy smokers than in non-smokers (55.6% versus 26.0%); consistently, the prevalence

Table I. Study population characteristics by gender*

	Total	Males	Females	p♣
Number	3054	1226	1828	
Age (years)	76.8±8.7	76.6±8.0	76.8±7.9	0.60
Remaining teeth (n) (median)	7.3±9.0 (3)	7.9±9.3 (4)	6.9±8.8 (2)	0.003 (0.004) §
Edentulism (%)	43.8	41.3	45.3	<0.03
Dentition class‡ (%)				
E	7.8	7.2	8.4	ns
ED	34.3	33.4	34.7	
TD	42.1	41.8	42.3	
NT	15.8	17.6	14.6	
Chewing difficulty (%)	47.6	41.6	52.0	0.0001
Swallowing difficulty (%)	13.7	11.0	15.5	0.0004
BMI (kg/m^2)	27.6± 4.6	26.8± 3.8	28.1± 5.0	<0.0001
Albumin (g/l)	43.1±4.0	43.3±3.8	42.9±4.1	0.005
Smoking (%)				
Never	62.2	24.3	87.6	0.001
Former	29.3	59.8	8.8	
Current	8.5	15.9	3.6	
Years of education (n)	4.8±2.9	5.3±3.2	4.3±2.7	<0.0001
Monthly income <500 € (%)	61.0	48.8	69.5	0.001
Widowhood (%)	41.3	20.7	55.2	0.0001
Living alone (%)	17.4	8.6	23.1	0.001
No. of children (n)	2.54±2.19	2.56±1.85	2.52±2.39	ns
YSM (years)#			26.3±9.1	

*For quantitative variables, the results are presented as mean ± SD; for qualitative variables, the results are given as prevalence or frequency distribution (%).

♣p-values refer to comparison between sexes. Student's t-test was used to compare mean values, while the chi-square test was applied to compare categorical distributions.

§Significance obtained by Mann-Whitney test.

‡E = edentulous persons not wearing any dental prosthesis; ED = edentulous persons wearing both upper and lower dentures; TD = subjects with 0 to 19 teeth with or without dentures; NT = subjects with most of their natural teeth ($\geq$20) with or without dentures.

#YSM = Years since menopause, only for women.

Table II. Study population characteristics* by remaining teeth class

	No. of teeth				
	Edentulous	1–7	8–19	≥20	p ♣
Women:men ratio	1.63	1.52	1.39	1.23	
Number (%)	1334 (43.6)	586 (19.2)	651 (21.3)	483 (15.8)	
Age (years)	78.2±8.0	76.0±7.8	74.0±7.2	71.0±6.1	0.0001
Prosthesis (%)					
Upper	3.3	8.1	19.2	4.5	0.0001
Lower	0.4	2.3	8.7	5.3	
Both	78.7	52.5	19.5	2.1	
None	17.5	37.1	52.6	88.1	
Difficulty in chewing (%)	49.4	62.5	49.9	21.9	0.0001
Difficulty in swallowing (%)	15.9	15.6	12.2	7.5	0.0001
Albumin (g/l)	42.7±4.1	43.0±3.6	43.4±3.8	43.9±4.3	0.0001
BMI kg/m^2	27.3±4.6	27.2±4.6	28.1±4.6	27.8±4.5	0.0005
Smoking (%)					
Never	60.2	63.4	63.1	62.9	0.02
Former	30.5	25.3	29.7	30.9	
Current	9.4	11.3	7.2	6.2	
Education (%)					
0–3 years	52.4	54.2	48.6	36.9	0.0001
4-8	44.3	42.5	45.7	53.7	
> 8	3.3	3.3	6.0	9.4	
Income <500 € (%)	61.2	66.3	59.5	56.0	0.006
Living alone (%)	19.0	14.6	17.6	15.2	0.08
Widowhood (%)	46.7	42.2	39.6	27.4	0.0001
No. of children (%)					
0	13.2	14.9	12.4	17.0	0.0001
1–3	58.2	60.8	70.1	68.4	
≥4	28.6	24.4	17.5	14.6	
YSM (years) #	28.0±9.3	26.5±8.8	25.0±8.9	23.1±8.2	0.0001

*For quantitative variables, the results are presented as mean ± SD; for qualitative variables, the results are given as prevalence or frequency distribution (%).
♣Analysis of variance was used to compare mean values, while the chi-square test was applied to compare categorical distributions.
YSM: Years since menopause, only for women.

of subjects presenting with the best dentition (20+ teeth) increased from the heavy current smokers to the non-smokers (11.1% versus 25.0%).

A marked difference was found when educational levels were compared by group of remaining teeth.

The socio-demographic and lifestyle variables listed in Table II were entered in the logistic regression model by gender to explain the edentulous state. Results of the stepwise forward analysis for significantly associated variables are presented in Table III.

A different relationship pattern was found for men and women, as age was the only factor that gave ORs >1 in both sexes, notwithstanding a stronger effect in men. The importance of smoking on denture preservation is underlined by the lack of association in women, in contrast to ORs reaching a value in current male smokers (OR = 4.01; 95% CI: 2.59–6.20) comparable to that found in the oldest age group. However, a significant independent role was played by female variables, such as years since menopause (OR = 1.81; 95% CI: 1.37–2.40) and having more than 3 children (OR = 1.95; 95% CI: 1.36–2.80). Living alone, moreover, appeared to be a risk factor for edentulism in women, while a low albumin level was specific for men.

Difficulty in chewing and swallowing

The prevalence of difficulty in chewing and in swallowing (Table I) was 47.6% (sex- and age-adjusted prevalence 44.8%) and 13.7% (sex- and age-adjusted prevalence 12.3%), respectively, and rose to 77.3% and 26.2%, respectively, in the edentate without prostheses. Worst off were the subjects with 1 to 7 teeth and without prostheses, in whom the prevalence of difficulty in chewing reached about 82%. The prevalence of both chewing and swallowing difficulties was significantly higher in women ($p < 0.0004$).

Table III. Results of the logistic regression analyses with stepwise forward selection of variables significantly associated with edentulism

Independent factors			β	St Err (β)	*p*	OR	95% CI
Men	Age	65–74§	0.00			1.00	
		75–84	0.63	0.15	0.0001	1.88	1.41–2.50
		≥ 85	1.39	0.18	0.0001	4.01	2.83–5.68
	Smoke	No§	0			1.00	
		Former	1.23	0.18	0.0001	3.42	2.42–4.82
		Current	1.39	0.22	0.0001	4.01	2.59–6.20
	Albumin	< 40.0 g/l	0.58	0.20	0.003	1.79	1.22–2.63
Women	Age	65–74§	0.00			1.00	
		75–84	0.03	0.14	ns	1.03	0.78–1.36
		≥ 85	0.60	0.20	0.003	1.82	1.22–2.69
	Living alone	Yes	0.38	0.13	0.002	1.47	1.15–1.88
	YSM (years) #	> 23	0.59	0.14	0.0001	1.81	1.37–2.40
	No. of children	0§	0.00			1.00	
		1–3	0.04	0.16	ns	1.04	0.76–1.44
		> 3	0.67	0.18	0.0003	1.95	1.36–2.80

The following variables were entered in the full model: age class, smoking, education level, BMI, serum albumin level, monthly income, living alone, widowhood, number of children, years since menopause (only for women).
§Reference category with conventional risk equal 1.
#YSM: Years since menopause.

Separate logistic regression models were performed with difficulty in chewing and difficulty in swallowing as the dependent variables in order to evaluate the relationships between type of dentition (E, ED, TD, NT) and masticatory function. Table IV reports the estimated age- and sex-adjusted ORs and 95% CI provided by the different models. Only significantly associated variables are shown. Age and sex were independent predictors of both problems. Type of dentition was an independent predictor of difficulty in chewing, even after entering difficulty in swallowing in the regression. In particular, the risk was highest in edentulous persons without dentures (OR ~7 versus NT class), while it was much lower

Table IV. Results of the logistic regression analyses with stepwise forward selection of variables significantly associated with difficulty in chewing and in swallowing

Dependent variable	Model	Independent factors		β	St Err (β)	*p*	OR	95%CI
Chewing	Model I	Age (years)	Years	0.05	0.005	0.0001	1.05	1.04–1.06
		Sex	1 = Man	−0.46	0.08	0.0001	0.63	0.54–0.74
		Type of dentition‡	E	2.00	0.20	0.0001	7.40	4.99–10.97
			ED	0.71	0.13	0.0001	2.03	1.58–2.62
			TD	1.38	0.13	0.0001	3.99	3.11–5.11
			NT§	0.00			1.00	
	Model II	Age (years)	Years	0.04	0.005	0.0001	1.05	1.04–1.06
		Sex	1 = Man	−0.42	0.08	0.0001	0.66	0.56–0.77
		Type of dentition‡	E	1.94	0.21	0.0001	6.95	4.65–10.38
			ED	0.68	0.13	0.0001	3.91	1.53–2.56
			TD	1.36	0.13	0.0001	1.98	3.04–5.02
			NT§	0.00			1.00	
		Difficulty in swallowing	1 = Yes	1.26	0.13	0.0001	3.54	2.75–4.55
Swallowing	Model I	Age (years)	Years	0.05	0.007	0.0001	1.05	1.03–1.06
		Sex	1 = Man	−0.42	0.11	0.0003	0.66	0.53–0.83
		Type of dentition‡	E	0.95	0.24	0.0001	2.58	1.60–4.16
			ED	0.39	0.20	0.009	1.66	1.14–2.44
			TD	0.51	0.19	0.05	1.48	1.00–2.19
			NT§	0.00			1.00	
	Model II	Age (years)	Years	0.04	0.007	0.0001	1.04	1.03–1.05
		Sex	1 = Man	−0.32	0.12	0.007	0.73	0.58–0.92
		Difficulty in chewing	1 = Yes	1.30	0.13	0.0001	3.65	2.86–4.67

‡E = Edentulous persons not wearing any dental prosthesis; ED = edentulous persons wearing both upper and lower dentures; TD = subjects with 0 to 19 teeth with or without dentures; NT = subjects with most of their natural teeth (≥20) with or without dentures.
§Reference category with conventional risk equal 1.

(OR ~2) in rehabilitated edentate (ED). After adjusting for difficulty in chewing, it was found that dentition type was not associated with difficulty in swallowing.

Discussion

The present research is a large population-based study on dentition in an elderly cohort of north-eastern Italians. It gives up-to-date and reliable estimates of the prevalence of edentulism, since dental condition was not self-reported.

Because of its large sample size, analyses of the relationships between edentulism and associated factors could have been adjusted for a number of covariates. According to our data, the sex- and age-adjusted prevalence of edentulism was about 41%, a figure that is consistent with those reported in several epidemiological studies [16–21], but higher than estimates in other Mediterranean countries [22]. Subjects with 0 to 7 teeth and without dentures comprised about 15% of the whole population. The presence of 7 teeth or fewer is a condition of severe dental impairment, as oligodontia does not provide the necessary anchorage for tooth-supported partial dentures. However, it has been established that a shortened dental arch should consist of at least 20 teeth to guarantee functionality and durable occlusal stability [23–26]. This type of dentition was detected in only 16% of our sample.

Some studies [27,28] have reported an association between edentulism and female gender, low social status, modest income, and living in rural areas. According to our data, most nutritional, social, and lifestyle factors (BMI, monthly income, education level, widowhood), even if associated with tooth loss in the bivariate analysis, do not give a significant contribution to edentulism in the multiple logistic regression model and different patterns of relationships were observed in the two sexes.

It was found that income is not a predictor of edentulism. It is possible that certain historical and social factors have influenced the dental status of the elderly subjects studied more than has their present economic situation. All the participants were born before 1930, and all directly or indirectly experienced the Second World War and the economically depressed post-war period. Dental care and prevention were uncommon at that time throughout Italy and tooth extraction was the treatment of choice. The lack of association between edentulism and monthly income could also be explained by the inadequacy of this variable in representing real economic status, since the income of a retired individual, in the Italian pension system, does not strictly reflect economic level during the active working years.

While a higher prevalence of edentulism among females has been reported in many studies [29,30], the authors found the gender difference difficult to explain. In the present study we found that the number of children was significantly associated with edentulism only in women, and years since menopause remained independently related even after adjusting for age. These findings might be explained by the detrimental effect of pregnancy, lactation, and estrogen withdrawal on bone and teeth [31–34].

Smoking, in contrast, is a highly relevant determinant for males. The prevalence of smoking among men in our study was high. Cigarette smoking is a well-known risk factor for periodontal disease; it has been demonstrated that smokers have a higher prevalence, as well as a more severe degree, of periodontitis [35]. Previous investigations have reported that smokers tend to visit a dentist less often than non-smokers, thus increasing their risk of dental problems and of oral soft-tissue diseases [36].

We observed a noteworthy relationship between smoking habits and the prevalence of edentulism without regard to age. Statistical analyses of our cross-sectional study demonstrated that the odds ratio of former smokers for edentulism was comparable to that of current smokers. Krall [37] reported similar results for smokers (4.5-fold increase risk of edentulism) in a study on veterans of both sexes. Nevertheless, Krall underlined the benefits of quitting smoking, after prospective observations found that tooth loss rates were significantly reduced when subjects quit. It is possible that the odds of losing one's teeth are related to the total number of cigarettes smoked throughout one's lifetime rather than to the acute effect of current smoking. It has long been debated whether the nutrition of edentulous subjects is adequate, but this question is still open as the relationships between nutrition, nutritional status, and oral health are fairly complex [38,39]. In a large epidemiological study comparing white and black United States populations, Lee [40] reported that impaired ability to chew is not associated with insufficient caloric intake, notwithstanding the alteration in the types of food eaten. Our findings of no alteration in BMI, nor in waist and hip circumferences (data not shown), are in agreement with those reported by Lee and others [41] and confirm that the link between dietary change and impaired nutrition is not straightforward. Nonetheless, the condition of edentulism without prosthesis identifies a subgroup of more severely impaired subjects in whom serum albumin levels are significantly lower. This association is particularly relevant, since hypoalbuminemia has been reported to be a predictor of cardiovascular disease and disability [42].

The modification in nutritional intake reported in the elderly could be explained by the strong relationship between the type of dentition and the difficulty in chewing observed in our population. A higher OR for difficulty in chewing was found in edentates

without prosthesis and in subjects with a limited number of teeth with or without dentures. Our results concur with those of the Seneca study [21] and stress that completely restored though artificial dentition represents a favorable condition. Interestingly, the results of our study show that the type of dentition affects only chewing function, while swallowing is strictly conditioned by chewing. It seems that having no or incomplete dentition makes swallowing harder only as a consequence of the difficulty in chewing.

In conclusion, the prevalence of edentulism in the elderly population studied was at the upper level among Western countries, and higher in women than in men. Edentulism is associated with patterns of gender-specific covariates. In women, aging, female events (pregnancies, menopausal status), and living alone are related to tooth loss. In men, aging and smoking are important determinants of edentulism, which is associated with the risk condition of hypoalbuminemia. Difficulty in chewing is more prevalent in women and the type of dentition is an important predictive factor in both genders. The high prevalence of edentulous subjects without prostheses found in our study suggests a need for educational and social measures to improve patients' attitudes to dental care and to encourage the use of prostheses among the elderly.

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