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Number of teeth – a predictor of mortality in the elderly? A population study in three Nordic localities

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Abstract

Objective. Although associations between number of teeth and mortality have been found in some studies, the results have not been conclusive. The aim of this study was to determine whether dental status at age 75 is an independent predictor of survival in three Nordic populations. ***Material and Methods.*** The baseline study was conducted as part of a comparative Nordic investigation of systematic samples of 75-year-old men and women born in the period 1914–16 ($n = 1004$) and living independently in three Nordic localities: Glostrup in Denmark, Jyväskylä in Finland, and Göteborg in Sweden. Performed in 1989–91, the study included a home interview, a health questionnaire, and a laboratory examination. For the present study, the mortality data of all participants up to age 82 were collected from official registers in 1999. ***Results.*** Lower mortality during 7 years was associated with higher number of remaining teeth at age 75. In Jyväskylä and Göteborg, but not in Glostrup, the association between number of teeth and mortality was statistically significant. For all three samples pooled and adjusted for sex and location, this association was significant (odds ratio 0.86; $p < 0.001$). ***Conclusions.*** Number of teeth is a significant predictor of 7-year mortality in 75-year-old women independently of a number of factors related to lifestyle, disease, and reduced functional capacity.

Key Words: *Dental status, edentulism, functional aging, general health, survival*

Introduction

The relationship between oral and general health has long been controversial, with a possible association between periodontitis and both coronary heart disease (CHD) and cerebrovascular disease (CVD) being explored in many studies during the past decade [1–4]. The results have been far from conclusive, and recent reviews suggest that the positive associations found in some studies should be interpreted with caution, since the evidence is weak and an influence of confounding risk factors cannot be excluded [5–8].

The association between number of teeth and mortality documented in several studies [9–14] differs between the genders, e.g. sometimes significant in men but not in women. In a study of possible associations between loss of teeth and total mortality and death from CHD [15], a significantly increased risk of total mortality was found for all oral factors analyzed (number of remaining teeth, edentulousness, and number of years of edentulism). However, the significance was lost when smoking was added to the Cox regression analysis. It was therefore concluded that the oral factors were not independent risk factors for mortality but surrogate markers for the risk from smoking. Similar results were obtained in a study focusing on oral health status and mortality. Unadjusted, edentulism was significantly associated with higher mortality risk, but when adjusted for confounders this association lost statistical significance [16]. In a study based on interview data, and not including a clinical examination, it was reported that poor dental status was not a significant risk factor for mortality [17]. In a later study, the same group concluded that self-assessed masticatory disability could be associated with a greater risk of mortality in community-residing elderly people [18].

The not fully conclusive findings so far suggest that further studies could be of interest. It was therefore the aim of this study to evaluate whether dental status at age 75 is a predictor of mortality during a 7-year follow-up. In a previous study of

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3 Nordic 75-year-old populations [19,20], dental status varied a great deal and was associated with functional capacity. By adding survival data over 7 years to the original registrations, the hypothesis that a low number of teeth at age 75 would be associated with high mortality was tested.

Material and methods

The baseline study was conducted in 1989–91 as part of a comparative Nordic project (Nordic Research on Ageing – NORA 75) on systematic samples of 75-year-old men and women born in 1914–16 and living in 3 Nordic localities: Glostrup in Denmark, Jyväskylä in Finland, and Göteborg in Sweden [19–22]. The study included a home interview focusing on socio-economic factors, living conditions, social network, and drug consumption; a health questionnaire concerning smoking, physical activity, symptoms and diseases, activity of daily life (ADL) functions, subjective health and dental status; and a laboratory examination comprising anthropometric measurements, isometric muscle strength, walking speed, pulmonary functions, audiological examination, speech audiometry, reaction time, and medical examination. The participation rate differed between the parts of the study, but was highest for the home interview and lowest for the laboratory examinations in all localities (Table I). After excluding 32 individuals living in institutions, the final number of participants was 1004 (573 F and 431 M).

The covariates used in the analyses in the present study were coded as follows: Education (elementary school, higher education), self-perceived economy (good, satisfactory, poor), smoking habit (non-smoker, previous smoker, current smoker), alcohol consumption (daily, 2–3 times per week, once per week, 1–2 times per month, rarely or never), self-assessed health (good, satisfactory, poor), physical activity (light, 3 h moderate activity per week, 4 h moderate or intense activity per week, 3 h active sports per week, competitive sports), social activity (based on frequency of travel, membership of societies, etc.; higher scores of these indices denote higher activity), circulation/cardiovascular disease (no, yes), respiratory disease (no, yes), number of other chronic diseases, instrumental ADL function (I-ADL, not impaired, impaired), hospitalized last year (no, yes), body mass index (BMI; kg/m^2). Pulmonary functions were measured using computed spirometers based on an electric flow meter (FEV 1.0). Walking speed was recorded as the time taken to walk a distance of 10 m at the participant's maximum speed. The question on tooth loss in the health questionnaire was: "Almost all adults have had to have some teeth extracted. How many of your teeth remain?" The number of teeth was obtained from the participants' self-report in accordance with seven predetermined alternatives: no teeth, 1–4, 5–9, 10–14, 15–19, $\geq$20, and all teeth. In regression models, the levels were coded 1, 2, .., 7; therefore, the reported hazard ratios for number of teeth do not estimate the effect on survival of one extra tooth, but of belonging to one higher level in this grouping of dental status.

At a 5-year follow-up of 80-year-old participants in Göteborg, a clinical examination focusing on number of teeth was performed in 128 subjects to compare between self-reported dental status and the dentist's clinical recording of the number of teeth.

Details of the study protocol, interview, questionnaire, and laboratory examinations have been presented previously [19–22].

Statistics

Logistic regression models were used to test the association between categorized number of teeth and 7-year mortality adjusted for locality and gender. Univariate and multiple Cox regression models were used to test the association between categorized number of teeth and length of survival – expressed as number of days during the 7-year follow-up period – with covariates such as socio-economic, lifestyle and health factors and functional capacities. Not all available covariates were used in the final regression models. Using stepwise selection of variables, a smaller set of predictors was found explaining the variation in survival almost as well as the full set of predictors; this set was used as adjustment factors when estimating the association between number of teeth and mortality. The reason was that by eliminating "unnecessary" independent

Table I. Participation rate in different parts of the study of 75-year-old subjects in 3 Nordic locations.

	Jyväskylä		Glostrup		Göteborg	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
Sample	388	100	571	100	450	100
Home interview	355	91	480	84	368	82
Laboratory	295	76	411	72	301	67
Questionnaire	316	81	411	72	309	69
Participation in present study	306	79	394	69	304	68

Table II. Agreement between number of teeth from self-report and a dentist's clinical recording of 128 subjects at age 80 in Göteborg (5-year follow-up).

No. of teeth	0	1–4	5–9	10–14	15–19	20–32	Total
None	24	0	1	0	0	0	25
1–4	0	4	3	0	0	0	7
5–9	0	1	7	6	3	1	18
10–14	1	0	2	8	7	0	18
15–19	0	0	1	1	11	5	18
20–32	0	0	0	0	10	32	42
Total	25	5	14	15	31	38	128

Rows: Number of self-reported teeth. Columns: Clinically recorded number of teeth.
Full agreement: 67%. Weighted kappa: 0.81 (95% CI: 0.75–0.87).

variables in a regression model the robustness of the remaining effects is improved.

Results

Agreement between self-reported number of teeth and the dentist's clinical recording was 0.81, as assessed with the weighted kappa statistics (performed with SAS version 8.2 for Windows). Full agreement between the two measures was obtained in 67% of the observations (Table II).

The distribution of number of teeth differed markedly between the Göteborg sample and the other two samples ($p < 0.001$). The reported prevalence of edentulism in the 75-year-old subjects was 23% in Göteborg, 45% in Glostrup, and 58% in Jyväskylä, whereas the prevalence of people with $\geq$ 20 teeth was 27%, 15%, and 9%, respectively. In the Finnish sample, significantly more females than males were edentulous, whereas dental status was distributed similarly between the genders in the other two samples.

The mortality rates 3 years after age 75 were similar in the 3 samples and in both genders, but lower for women than for men after 5 and after 7 years. The 7-year mortality was significantly lower in females than in males in Glostrup and Göteborg (Table III). Mortality was lowest in females in Göteborg (21%) and highest among males in Glostrup (39%).

The 7-year mortality was lower for those with more remaining teeth at age 75, especially women (Table IV). The association between 7-year mortality and number of teeth was significant among females in Jyväskylä and Göteborg, but in males only in Jyväskylä (Table V). When genders were pooled, the association between number of teeth and 7-year mortality, as well as the length of time before death (survival) expressed as number of days, was statistically significant in Jyväskylä and Göteborg but not in Glostrup. The odds ratio (OR) for mortality was 0.86 for all 3 samples pooled, suggesting that there was about a 14% lower mortality risk up to age 82 for those in a group with a greater number of teeth. When stratified by gender, the association was significant for women but not for men (Table V).

In both genders, most of the tested baseline characteristics at age 75 were significantly associated with the 7-year mortality independently of locality (Table VI). Besides number of teeth, factors such as increased social and physical activity, FEV, and walking speed were associated with decreased risk in both genders, whereas smoking and several factors indicating impaired health increased the risk of 7-year mortality.

The multiple Cox regression models in women demonstrated that smoking, impaired self-assessed health and I-ADL, and cardiovascular/circulation disease were significant predictors of increased 7-year mortality risk, whereas high number of teeth decreased the mortality risk (Table VII). In men, impaired self-assessed health at age 75 and residence in Glostrup were significant risk factors for higher mortality, whereas higher physical activity and higher BMI were predictors of a lower 7-year mortality risk. When FEV and walking speed in women were included in the regression model, the prediction did not change. In men, however, higher FEV and walking speed were associated with lower mortality risk, whereas physical activity and self-assessed health disappeared as significant predictors.

Table III. Mortality (%) during a 7-year follow-up of 75-year-old subjects (1004) in 3 Nordic localities.

	3-year		5-year		7-year	
Locality	Women	Men	Women	Men	Women	Men
Jyväskylä	12	12	19	21	29	31
Glostrup	9	10	19	27	26	39
Göteborg	7	13	17	23	21	31

Table IV. Seven-year mortality (%) in relation to number of teeth in 75-year-old women (F) and men (M) in 3 Nordic localities.

No. of teeth	0		1–9		10–19		≥20	
Locality	F	M	F	M	F	M	F	M
Jyväskylä	34	43	29	31	14	11	0	18
Glostrup	30	40	32	41	22	33	14	43
Göteborg	26	32	37	35	16	36	10	23

Discussion

This study corroborates earlier findings of an association between number of teeth and survival in elderly people [9–12,14,23]. However, there were differences in strength of the associations between the genders and between the samples from three different countries. Major differences were found in dental status between the three Nordic localities, a fact that corroborates findings in other studies based on national data in the three countries [19,24,25]. It has been demonstrated in national surveys in Scandinavia that edentulism is more prevalent in rural areas and small municipalities than in big cities [24,26]. In terms of number of teeth, the three localities are not representative of their countries. Glostrup, incorporated in Copenhagen, and Göteborg are big cities (from a Nordic point of view), whereas Jyväskylä is a small city [21]. This may partly explain the differences observed between the localities.

The complexity of associations between mortality and dental status is indicated also by differences reported in other studies. With respect to gender, for example, the association was significant in women but not in men in the present study, whereas in a study of the 10-year mortality in 80-year-old subjects the number of lost teeth increased mortality more in men than in women [11]. The difference between the genders in the two studies may be due to background factors in the samples, because in the present study, too, there were differences between the samples from the three countries, for example regarding smoking, alcohol habits, physical activity, and healthy diet [27–29]. In a recent study, an inverse association between number of teeth and systolic blood pressure and hypertension was documented in men but not in women [30], the authors concluding that this finding partly explained the relation between tooth loss and mortality.

Many lifestyle factors certainly play important roles in mortality. Therefore, in the present study, multiple survival regression analyses were used to control for factors such as lifestyle (e.g. smoking habits), socio-economic status, social network, activity, and need for help. The results showed that, besides smoking, subjective health factors, and gender, number of teeth was the most important independent predictor for survival during the 7-year follow-up. In contrast to the present results, the significant association between mortality and edentulousness in a study of individuals aged 25 to 79 years was lost when smoking was added to the analyses. It was therefore concluded that the oral factors analyzed were not independent risk factors for mortality but surrogate markers for the risk from smoking [15]. The different outcomes of the two studies may to some extent be explained by the different age distributions of the two samples. The risk from smoking may be more evident and the variation in dental status smaller in a sample with younger participants. In a large study on rural Chinese adults, tooth loss significantly increased the risk of total death. This association was also apparent in non-tobacco smokers [12].

The causality of the independent association between number of teeth and mortality has not been fully explained, but there may be several mechanisms accounting for the relationship. The relationship between poor oral health and increased mortality has been suggested to be through inflammatory mediators [4,7]. Lost teeth may also be considered a surrogate marker for previous dental infection. Reduced number of teeth and edentulism are associated with impaired oral function, leading to altered dietary intake and an increased risk of systemic diseases [5,31]. Genetic factors may also be of importance, because one study has shown the same genetic factors for periodontal and cardiovascular disease [32].

Several previous investigations and our cohort studies indicate that number of teeth is a robust predictor of general health and functional capacity [9,14]. In the NORA study of 75-year-old subjects,

Table V. Association between number of teeth (7 categories) and 7-year mortality in 75-year-old subjects in 3 Nordic localities. Hazard ratio (95% CI) according to Cox regression model and significance level.

Locality	Women	Men	Total[a]
Jyväskylä	0.72 (0.57–0.91)**	0.78 (0.63–0.96)*	0.75 (0.64–0.88)***
Glostrup	0.86 (0.74–1.01)^{NS}	0.97 (0.85–1.10)^{NS}	0.92 (0.83–1.02)^{NS}
Göteborg	0.79 (0.67–0.94)**	0.96 (0.82–1.12)^{NS}	0.88 (0.79–0.99)*
Total[b]	0.80 (0.72–0.89)***	0.92 (0.84–1.00)^{NS}	0.86 (0.81–0.92)***

***$p \leq 0.001$; **$0.001 > p \leq 0.01$; *$0.01 > p \leq 0.05$; NS = non-significant, $p > 0.05$.

[a]Adjusted for gender.

[b]Adjusted for locality (and gender in total model).

Table VI. Association between baseline characteristics at age 75 and mortality in 3 Nordic localities. Hazard ratio (HR) (95% CI) for mortality during 7 years adjusted for locality in univariate Cox regression model.

	Women		Men	
Predictors	(*n*)	HR (95% CI)	(*n*)	HR (95% CI)
Education	571	1.00 (0.70–1.42)^{NS}	430	1.04 (0.73–1.49)^{NS}
Economic situation	573	1.63 (0.90–2.95)^{NS}	431	0.97 (0.52–1.81)^{NS}
Social activity	568	0.79 (0.73–0.86)***	430	0.90 (0.83–0.92)***
Physical activity	568	0.53 (0.43–0.66)***	428	0.68 (0.57–0.81)***
Smoking habits	567	1.53 (1.23–1.91)***	431	1.25 (0.99–1.57)^{NS}
Alcohol consumption	566	1.22 (1.06–1.40)**	424	1.01 (0.91–1.14)^{NS}
FEV (1 SD)†	483	0.64 (0.49–0.84)**	373	0.66 (0.56–0.78)***
Walking speed (1 SD)†	523	0.57 (0.48–0.69)***	389	0.72 (0.61–0.86)***
BM1	547	0.99 (0.95–1.03)^{NS}	415	0.95 (0.90–1.00)^{NS}
Self-assessed health	568	2.15 (1.68–2.76)***	427	1.58 (1.25–2.01)***
Circulation disease	573	2.13 (1.50–3.04)***	431	1.79 (1.26–2.54)**
Respiratory disease	573	1.18 (0.70–1.98) ^{NS}	431	1.74 (1.15–2.63)**
No. of other diseases	573	1.30 (1.07–1.58)**	431	1.13 (0.90–1.40)^{NS}
I-ADL	561	3.27 (2.20–4.85)***	427	1.96 (1.39–2.76)***
Hospitalized last year	571	1.79 (1.24–2.58)**	430	1.65 (1.14–2.39)**
Dental status/ no. of teeth	573	0.80 (0.72–0.89)***	431	0.92 (0.84–1.01)^{NS}

***$p \leq 0.001$; **$0.001 > p \leq 0.01$; *$0.01 > p \leq 0.05$; NS = non-significant, $p > 0.05$.
†HR was calculated per 1 SD increase.

impairment of functional capacities, such as respiratory capacity, muscle strength, walking speed, maximal power, and of sensory functions, such as reaction time and auditory capacity, was associated with low number of teeth, even after adjustment for anthropometric measurements and other background factors [20]. Similar results were obtained in a study of cohorts of 70-year-old subjects in Göteborg. Functional capacities such as cognitive and cardiovascular function, lung volume, bone mineral content, and muscle strength were significantly reduced in subjects with small numbers of teeth. Hearing and visual ability were also associated with dental status. These significant associations were independent of smoking, socio-economic factors and common diseases [9]. In a recent study of 4 cohorts of 70-year-old subjects, number of teeth was a significant predictor in both genders for 7-year survival after age 70, independently of health factors, socio-economic status and lifestyle [14]. It was concluded from these studies that the association between impairment in dental function and other functional capacities and survival indicates a common functional ageing [9,14,20].

The results point to a two-way relationship between dental health and general health. Poor oral health has medical and psychosocial implications, as well as vice versa. The importance of a common approach to odontological and other medical fields is obvious – in research as well as in dental and medical education.

Even though associations between various risk factors and mortality are complex and not fully understood, the present results and our previous

Table VII. Significant ($p < 0.05$) predictors of 7-year mortality in 75-year-old subjects in 3 Nordic localities. Hazard ratios (HR) and confidence limits (in parentheses) are given for two multiple Cox regression models: HR-a including all independent factors and HR-b excluding FEV and walking speed (because of a large number of missing data).

	Female		Male	
Predictors	HR-a ($n = 460$)	HR-b ($n = 525$)	HR-a ($n = 345$)	HR-b ($n = 399$)
Physical activity				0.73 (0.60–0.82)**
Smoking habits	1.51 (1.19–1.92)***	1.43 (1.15–1.78)**		
BMI			0.94 (0.89–0.99)*	0.94 (0.89–0.99)*
FEV 1.0 (1 SD)†		#	0.68 (0.57–0.81)***	#
Walking speed (1 SD)†		#	0.78 (0.65–0.94)**	#
Self-assessed health	1.42 (1.05–1.93)*	1.56 (1.18–2.05)**		1.36 (1.05–1.75)*
Circulation disease	2.04 (1.33–3.13)**	1.93 (1.32–2.83)***		
I-ADL	2.24 (1.41–3.57)***	2.10 (1.37–3.21)***		
Dental status/no. of teeth	0.83 (0.74–0.95)**	0.87 (0.78–0.97)**		
Glostrup			1.50 (1.02–2.21)*	1.75 (1.23–2.51)**

***$p \leq 0.001$; **$0.001 > p \leq 0.01$; *$0.01 > p \leq 0.05$; NS = non-significant, $p > 0.05$.
†HR was calculated per 1 SD increase.
#Not included in regression model.

studies suggest that number of teeth is a predictor of mortality and a marker of functional ageing in the elderly. The results are thus in line with the hypothesis.

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