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Edentulism and all-cause mortality among Brazilian older adults: 11-years follow-up

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Abstract: We assessed the association between edentulism and all-cause mortality among community-dwelling older adults from São Paulo, Brazil, from 2006 to 2017. This prospective cohort study used data from the Health, Well-being and Aging Study (SABE, Portuguese acronym). Edentulism was evaluated by means of clinical oral examination and all-cause mortality data were obtained from state official records. Covariates included socioeconomic factors (age, sex, and schooling); health behavior (smoking, alcohol intake, and physical activity); dental care (prostheses use); general health (multimorbidity); and nutritional status (underweight). Kaplan-Meier survival curves were stratified by edentulism and compared using the log-rank test. Cox proportional hazards model was applied to calculate hazard ratios (HRs) for the association between edentulism and mortality after adjusting for covariates. The study sample included 1,687 participants (age, 60–102 years; edentulous: 47.2%). In the 11 years of follow-up, we analyzed 10,494 person-years and 566 deaths. In bivariate analysis, edentulous older adults were found to be at a higher risk of dying from all causes than the dentate participants (HR: 1.81; 95%CI: 1.53–2.15). After sequential adjustment for socioeconomic factors, health behavior, dental care, general health, and nutritional status, this association was attenuated, but remained significant (HR: 1.34; 95%CI: 1.10–1.63). In conclusion, edentulism is a significant predictor of all-cause mortality among older adults.

Keywords: Tooth Loss; Mortality; Aged.

Introduction

Edentulism is an important oral health marker in older individuals,^{1,2} as it captures life-course cumulative effects of oral diseases.³ Prevalence of edentulism depends on the region⁴ and sociodemographic characteristics of the individual,^{5,6} approximating to 10% in those aged ≥ 50 years worldwide⁷ and 54% in Brazilian adults aged 65–74 years.⁵ Edentulism is considered a disability,² affecting the quality of life,¹ nutritional aspects,^{8,9,10} and morbidity of the individual.⁶ Furthermore, several cohort studies^{11,12,13,14,15} and recent systematic reviews^{4,16,17} have reported reduced survival rates among older edentulous individuals.

In addition to the hypothesis of the significant association between edentulism and mortality because of insufficient adjustment for proper confounders,^{13,16,18} other explanations have been proposed. One explanation



states that edentulism and related chewing problems predispose individuals to poor nutritional intake,⁸ and malnutrition.¹⁰ Furthermore, tooth loss could carry effects from a previous low-grade chronic inflammation due to periodontal disease,^{3,19} which, together with “inflammaging”,²⁰ increases the risk for arteriosclerotic diseases.^{11,21,22}

Both malnutrition and chronic inflammation predict lower survival rates²³ and have been used to adjust the relationship between oral impairments and mortality in some studies,^{12,13,21,24} although evidence of this association remains unclear. Lee and colleagues¹² observed that the association between chewing ability and 6-year all-cause mortality disappeared after adjusting for appetite in Taiwanese older adults. Watt and colleagues¹³ found no evidence of the role of body mass index (BMI) or high-sensitive C-reactive protein (CRP) on the association between dental status and both all-cause and cardiovascular disease mortality during the 8-year follow-up period in a Scottish Health Survey. However, Hiratsuka et al.²⁴ reported a significant role of serum albumin level, not of CRP, on the association between tooth loss and all-cause mortality during the 13-year follow-up period in Japanese older adults.

Considering the accelerating aging population,²⁵ high prevalence of edentulism among older adults in Brazil,⁵ and the small number of studies evaluating the association between edentulism and mortality outside high-income countries,^{14,16,17} despite its noticeable relevance,^{16,17} we performed this study. We aimed to assess the relationship between edentulism and all-cause mortality among community-dwelling older adults from São Paulo, Brazil, from 2006 to 2017.

Methodology

Study design and participants

All data were obtained from the Brazilian Health, Well-being and Aging Study (SABE), a multicenter survey conducted in major urban centers in Latin America in 2000. However, in 2006, SABE was transformed into a cohort study performed in 5-year intervals in São Paulo, Brazil, with the representative probabilistic sample of urban older persons aged ≥ 60 years. A sample of participants aged 60–64 years were included in each new wave to keep the representativeness of that age

group. In the survey, trained examiners collected data on the individual's living conditions, socioeconomic status, anthropometric measures, general well-being, and oral health at his or her residence. Clinical oral examinations have been performed since 2006. In our study, we used data from all participants who presented complete information for the variables of interest, from 2006 to 2017. As participants were followed up for different time periods, we computed the time of contribution to the study for each participant. Of the 1,831 participants screened (1,413 interviewed in 2006 and 418 interviewed in 2010), 144 were excluded (102 from 2006 and 44 from 2010) due to loss of data. Therefore, the final sample consisted of 1,687 participants. We linked SABE data to official mortality records up to May 2017. More details on the study design, setting, and sampling are described elsewhere.^{8,25}

Ethics statement

SABE study was approved by the Ethics in Research Committee of the School of Public Health of the University of São Paulo. Written informed consent from the volunteer participants was obtained at the time of each interview.

Variables

The time to death from all causes was calculated as the years from the date of the baseline interview to: a) the date of death (for those who died during the follow-up period) or b) the date of the last location (for those who did not die during the follow-up period). For participants whose contact was lost for any reason, the time of contribution to study was defined as the participation time between two waves plus/or half the period between the last location and the next wave that he/she did not participate.

The presence of edentulism, defined as the absence of all natural teeth, was obtained through clinical oral examinations performed by trained dentists using standardized criteria.²⁶

To adjust for the association between edentulism and all-cause mortality, we selected relevant covariates, in accordance with recent systematic reviews,^{16,17} measured at baseline. The covariates were a) socioeconomic factors (age, 60–69; 70–79; >80 years; sex; years of schooling, 0–3; 4–7; ≥ 8); b) health behavior (current smoking status; current alcohol use [any amount of alcoholic beverages

consumed weekly in the past 3 months]; physical activity [at least 150 min of moderate or vigorous activities per week²⁷]; c) dental care (prostheses use); d) general health (multimorbidity: self-reported ≥ 2 long-term conditions,²⁸ including diabetes mellitus, hypertension, heart disease, chronic obstructive pulmonary disease, osteoporosis, stroke, and arthritis); and e) nutritional status (if the individual was underweight; *i.e.*, BMI < 22 kg/m²).²⁹ In SABE, weight and height were measured using a portable scale (seca, Germany) and an anthropometer (Harpenden, England), respectively.

Statistical analysis

Descriptive data are expressed as proportions. Difference in the characteristics for all variables according to edentulism were evaluated using the chi-square test (Table 1).

The median survival time, as the time point in which half of the participants are alive, based on the Kaplan–Meier survival curve and its 95% confidence interval (95% CI), calculated using the Greenwood exponential formula, was estimated. Survival curves stratified by edentulism status were also performed

Table 1. Baseline characteristics according to edentulism status among Brazilian older adults.

Characteristics	Dental status			p-value
	Overall	Dentate	Edentulous	
	(n = 1,687)	(n = 891)	(n = 796)	
	%	%	%	
Total		52.8	47.2	
Socioeconomic factors				
Age (years)				< 0.001
60–69	50.4	63.5	35.8	
70–79	25.6	22.7	28.8	
≥ 80	24.0	13.8	35.4	
Sex				< 0.001
Women	62.0	54.6	70.5	
Men	38.0	45.6	29.5	
Schooling (years)				< 0.001
≤ 3	43.4	32.9	55.3	
4–7	36.9	38.7	34.6	
≥ 8 years	19.7	28.4	10.1	
Health behavior				
Smoking				0.018
No	88.0	89.8	86.1	
Yes	12.0	10.2	13.9	
Current alcohol use				< 0.001
No	72.3	66.9	78.3	
Yes	27.7	33.1	21.7	
Physical activity (min/week)				0.071
≤ 150	43.9	41.9	46.2	
> 150	56.1	58.1	53.8	
Dental care				
Use of prostheses				< 0.001
No	19.8	30.9	7.4	
Yes	80.2	69.1	92.6	
General health				
Multimorbidity				< 0.001
0–1 diseases	44.5	50.1	38.3	
2 or +	55.5	49.9	61.7	
Nutritional status				
Underweight (kg/m ²)				< 0.001
≥ 22	84.6	89.2	79.4	
< 22	15.4	10.8	20.6	

using the Kaplan–Meier method and compared using the log-rank test (Figure).

Cox proportional hazard models were used to estimate the risk of mortality according to the edentulism status, with the results expressed as hazard ratios (HRs) and 95% CIs (Table 2). Model 1 corresponded to the unadjusted model. Further models were sequentially adjusted by socioeconomic factors (model 2), health behaviors (model 3), dental care (model 4), general health conditions (model 5), and nutritional status (model 6). The assumption

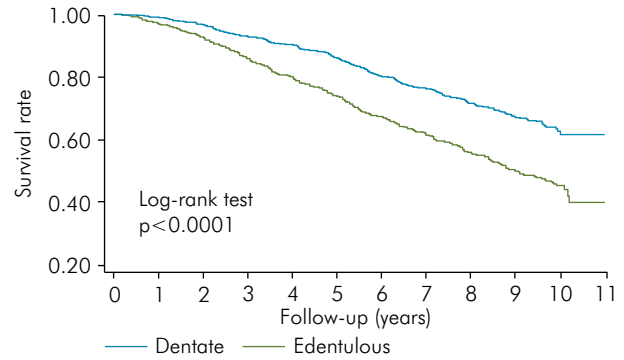


Figure. Kaplan–Meier survival curves according to edentulism among Brazilian older adults.

Table 2. Association between edentulism and all-cause mortality among Brazilian older adults.

Variable	HR (95%CI)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Edentulism						
No	1	1	1	1	1	1
Yes	1.81 (1.53–2.15)	1.39 (1.16–1.67)	1.30 (1.08–1.56)	1.39 (1.15–1.69)	1.39 (1.14–1.68)	1.34 (1.10–1.63)
Socioeconomic factors						
Age (years)						
60–69		1	1	1	1	1
70–79		2.24 (1.76–2.87)	2.29 (1.79–2.93)	2.31 (1.80–2.95)	2.26 (1.77–2.90)	2.20 (1.72–2.82)
≥ 80		5.55 (4.41–6.97)	5.59 (4.41–7.08)	5.69 (4.49–7.21)	5.64 (4.45–7.15)	5.45 (4.30–6.92)
Sex						
Women		1	1	1	1	1
Men		1.68 (1.42–1.99)	1.63 (1.37–1.95)	1.58 (1.33–1.89)	1.66 (1.38–1.98)	1.64 (1.37–1.97)
Schooling (years)						
0–3 years		1	1	1	1	1
4–7 years		1.10 (0.91–1.31)	1.12 (0.93–1.34)	1.14 (0.95–1.37)	1.13 (0.94–1.36)	1.12 (0.93–1.34)
≥ 8 years		0.91 (0.69–1.21)	0.94 (0.71–1.24)	0.98 (0.73–1.30)	0.97 (0.73–1.30)	0.96 (0.72–1.28)
Health behavior						
Smoking						
No			1	1	1	1
Yes			1.93 (1.50–2.50)	1.92 (1.49–2.49)	2.01 (1.55–2.60)	1.92 (1.48–2.49)
Current alcohol use						
No			1	1	1	1
Yes			0.74 (0.60–0.92)	0.74 (0.60–0.92)	0.76 (0.61–0.93)	0.77 (0.62–0.95)
Physical activity (minutes/week)						
≤ 150			1	1	1	1
> 150			0.70 (0.59–0.83)	0.70 (0.59–0.84)	0.72 (0.61–0.86)	0.72 (0.60–0.85)
Dental care						
Use of prostheses						
No				1	1	1
Yes				0.72 (0.57–0.89)	0.71 (0.57–0.88)	0.71 (0.57–0.89)
General health						
Multimorbidity						
0–1 diseases					1	1
2 or +					1.28 (1.07–1.53)	1.35 (1.12–1.61)
Nutritional status						
Underweight						
No						1
Yes						1.54 (1.26–1.89)

HR: hazard ratio; 95%CI: 95% confidence interval.

of proportional hazards was assessed using the Schoenfeld residuals and log-log plots.

For all statistical procedures, a significance level of 5% was considered. All statistical analyses were performed using Stata14.0 (Stata Corp LLP, College Station, USA).

Results

In this study, we evaluated 1,687 adults aged 60–102 years, representing 10,494 person-years (maximum: 10.98-year follow-up period) with a median survival time of 10.2 years and 566 (33.6%) deaths during the follow-up period. Less than half (47.2%) the participants were edentulous, with edentulism being associated with all covariates, but not with physical activity (Table 1).

The cumulative survival rate plot demonstrated a higher mortality rate for edentulous participants than dentate participants (Figure), and this was confirmed by the log-rank test ($p < 0.0001$).

Edentulism was associated with shorter survival in crude and all adjusted analyses (Table 2). The unadjusted model demonstrated higher mortality risks from all causes for edentulous participants (HR: 1.81; 95%CI: 1.53–2.15) than for dentate participants (Table 2, model 1). These estimates became lower after sequential adjustment for socioeconomic factors (Table 2, model 2) and health behavior (Table 2, model 3). However, they increased after additional adjustment for dental care (Table 2, model 4) and remained stable after insertion of general health variable (Table 2, model 5). Even after further adjustment for nutritional status, the risk for death for edentulous participants was 1.34 times (95%CI: 1.10–1.63) the risk for dentate participants (Table 2, model 6). However, these estimates have been attenuated over again.

Discussion

In this prospective cohort study with a 11-year follow-up period, we demonstrated higher all-cause mortality risks among edentulous participants than dentate participants from São Paulo, Brazil. Although attenuated, this association remained significant even after adjusting for a comprehensive number of

covariates,^{16,17} such as socioeconomic, health behavior, dental care, health conditions, and nutritional status.

Our findings are in line with other studies conducted in high- and upper-middle-income countries, which revealed small but significant association between tooth loss, especially edentulism, and all-cause mortality, independent of socioeconomic and health conditions.^{11,13,14,16,17} The higher risk of dying from all causes for edentulous participants found in this study is similar to summary estimates from a recent meta-analysis.¹⁷ In a systematic review, Koka et al.¹⁶ suggested that the association between tooth loss and mortality may not be causal but associative. Our findings indicate that most part of the increased risk of dying among edentulous could be explained by socioeconomic factors and health behavior, which are consistent with previous study results.^{12,16,17} This could be because tooth loss and mortality share common risk factors such as health behavior, socioeconomic, and health conditions.^{5,11,23,30}

Furthermore, tooth loss and edentulism predict adverse health outcomes closely related to mortality.^{15,18,31} Two main pathways have been proposed to explain this observed association.^{16,17} The first argues that tooth loss may carry the effects from a previous low-grade chronic infection due to periodontal disease, which, together with the chronic inflammation in aging, predisposes the individual to atherothrombogenesis occurring in coronary and cardiovascular diseases.^{13,21} However, few studies have reported attenuation of the association between tooth loss and mortality to a certain degree after adjusting for CRP and fibrinogen,²¹ whereas other studies have found no significant change in the association.^{13,24} Among present-day Brazilian older adults, this could be partially true because their teeth were lost in early adulthood.⁵ However, poor nutritional status, that is also related to edentulism,^{8–10} predicts chronic inflammation and circulatory diseases³² and, hence, higher mortality.^{11,22,33}

The second pathway places edentulism and mortality at their final points and lists nutritional factors as their mediator. This is because tooth loss, edentulism, and related chewing problems affect nutritional behaviors (decrease in protein and fiber intake and increase in fat, carbohydrate,

and processed food intake) and predispose individuals to malnutrition, underweight, or even overweight/obesity.⁸⁻¹⁰ Both poor nutritional status and obesity predict all- and specific-cause mortality.^{22,33} In our study, the association between edentulism and all-cause mortality was attenuated by 12.8% after adjusting for nutritional status, but remained significant. Importantly, underweight does not entirely reflect malnutrition and, therefore, does not seize completely the nutritional pathway of the association between tooth loss and mortality.^{16,22} Studies assessing the association between tooth loss and malnutrition using nutritional assessment measures other than those based on BMI have demonstrated stronger associations.^{9,10} Similarly, the association between oral health and mortality after adjusting for nutritional factors, including serum albumin level²⁴ or nutrient intake,¹² resulted in greater attenuation than in studies using BMI.^{13,34} This could be because underweight captures only the information on body mass, but cannot qualify the loss.⁹

The strengths of this study must be highlighted. To the best of our knowledge, this was the first study to assess the relationship between dental status and mortality in an unequal western upper-middle income country. This population-based study was conducted on a large representative probabilistic sample of community-dwelling older adults living in São Paulo, the largest Brazilian city that represents significant sociodemographic variety of that country.²⁵ However, there are some limitations. First, the use of a summary measure of poor nutritional status was based on BMI, which has been shown to be a useful and reliable tool in large surveys.³⁶ Second, the Lipschitz nutritional status classification limits comparison of our results

with those from other studies, although this cut-off has been validated and indicated for older adults.²⁹ Finally, edentulism and nutritional status were measured at baseline. However, reverse causality hypothesis can be ruled out because edentulism occurred several years before the occurrence of weight loss among Brazilian older adults.⁵

The results of this study highlight the importance of preventing tooth loss throughout life to avoid edentulism and the related adverse health outcomes.^{1,6,8-12} Furthermore, it is necessary to evaluate how prosthetic dental rehabilitation affects the relationship between edentulism and mortality considering its already known beneficial effects on quality of life³⁵, general health,⁶ and survival.⁴

Conclusions

Edentulism is a significant predictor of all-cause mortality, independently of socioeconomic factors, health behavior, and health status among Brazilian older adults. This association remains significant, although attenuated, even after additional adjustment for underweight. Further studies should investigate the effect of other nutritional assessment measures and the role of inflammatory markers and health conditions on this association, considering the most recent causal mediation approaches available.

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