

# Severe tooth loss and mortality risk: a population-based, longitudinal prospective study in a rural setting

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**Background:** Information on the relationship between tooth loss and mortality among individuals living in rural settings is limited.

**Methods:** In this prospective cohort study, Atahualpa residents  $\geq 40$  y of age ( $n=933$ ) were followed for a mean of  $7.3 \pm 3.2$  y to estimate mortality risk according to whether they had severe tooth loss ( $<10$  remaining teeth).

**Results:** Overall, 151 individuals (16%) died, resulting in a crude mortality rate of 2.35 per 100 person-years of follow-up. Individuals with severe tooth loss were more likely to die (73/276) compared with those with mild–moderate tooth loss (78/657), after adjusting for relevant covariates (hazard ratio 1.45 [95% confidence interval 1.02 to 2.04]).

**Conclusions:** Severe tooth loss is associated with increased mortality in remote communities.

**Keywords:** mortality, population study, rural communities, tooth loss.

## Introduction

Recurrent non-traumatic tooth loss has been associated with cardiovascular morbidity and all-cause mortality.<sup>1</sup> A history of deficient healthcare and dental access, poor masticatory ability, poor socio-economic status, smoking and other cardiovascular risk factors and diseases may play a role in tooth loss-related mortality, but exact causes have not yet been elucidated.<sup>1</sup> In addition, most studies assessing tooth loss-related mortality have been conducted in urban centers,<sup>1–3</sup> where lifestyles, risk factors and access to medical and dental care are different than in rural communities. In addition, a lack of consensus on the number of remaining teeth that increases mortality risk and heterogeneity in designs make it difficult to compare results across studies.<sup>1</sup> More information is needed in order to develop cost-effective preventive interventions aimed at improving oral health in individuals living in underserved populations, which, in turn, may reduce the risk of premature mortality. This study aimed to assess differences in mortality risk according to tooth loss severity in community dwellers living in a rural setting.

## Methods

The Atahualpa Project is a population-based prospective cohort study designed to assess the impact of risk factors associated with the increasing burden of non-communicable diseases in rural Ecuador. Community dwellers  $\geq 40$  y of age were identified during annual door-to-door surveys (June 2012–June 2019) and invited to participate. Those who declined consent were excluded. All subjects received interviews and procedures to assess demographics, level of education, cardiovascular risk factors (smoking status, body mass index (BMI), physical activity, diet, blood pressure (BP), fasting glucose and total cholesterol levels) and underwent a dental exam to assess the number of remaining teeth. Based on studies conducted in the same population, individuals were stratified into two groups according to whether they have severe tooth loss, defined as the presence of  $<10$  remaining teeth, or not.<sup>4</sup>

Study participants were visited every 3 months to determine their vital status and permanence in the cohort. The last administrative censoring date was 1 June 2022. Individuals who declined

consent and those who emigrated were censored at the last annual survey when they were interviewed and those who died were censored at the time of death (according to death certificates). All these individuals contributed to the total time of follow-up.

An unadjusted Poisson regression model was fitted in order to calculate crude mortality rate and a multivariate Cox proportional hazards model (adjusted for all the above-mentioned covariates) estimated mortality risk according to tooth loss severity. Stata version 17 (StataCorp, College Station, TX, USA) was used for data analysis.

## Results

A total of 933 individuals participated in this study. Follow-up time between enrolment and censoring date was 6799 person-years (95% confidence interval [CI] 6609 to 6987). The mean person-years of follow-up was 7.3 y (standard deviation [SD] 3.2).

At baseline, the mean age was 55.2 y (SD 12.8), 54% were women, 58% had a primary school education only, 4% were current smokers, 28% had a BMI  $\geq 30$  kg/m<sup>2</sup>, 10% had poor physical activity, 6% had an unhealthy diet, 32% had BP  $\geq 140/90$  mmHg, 26% had fasting glucose  $\geq 126$  mg/dl and 11% had a total cholesterol level  $\geq 240$  mg/dl. Severe tooth loss was noticed in 276 (28%) individuals.

A total of 151 individuals (16%) died during the follow-up, resulting in an overall unadjusted crude mortality rate of 2.35 (95% CI 2.05 to 2.85) per 100 person-years. Mortality occurred in 73/657 (11%) individuals with mild-moderate tooth loss and in 78/276 (28%) of those with severe tooth loss ( $p < 0.001$ ). In unadjusted analyses, individuals with severe tooth loss were older, less educated, less often obese, had worse physical activity, more often had high BP and fasting glucose and had higher mortality than those with mild-moderate tooth loss (Table 1). A Cox proportional hazards model (adjusted for all the above-mentioned covariates) showed that individuals with severe tooth loss were 1.45 times (95% CI 1.02 to 2.04) more likely to die compared with

**Table 2.** Fully adjusted Cox proportional hazards model showing increased mortality among individuals with severe tooth loss compared with those with mild-moderate tooth loss

Mortality	Hazard ratio	95% CI	p-Value
Severe tooth loss	1.45	1.02 to 2.04	0.036*
Age at baseline	1.05	1.04 to 1.07	0.001*
Being female	0.79	0.57 to 1.09	0.158
Primary school education	1.06	0.68 to 1.66	0.788
Current smoker	0.49	0.12 to 2.03	0.328
BMI $\geq 30$ kg/m <sup>2</sup>	0.95	0.63 to 1.42	0.794
Poor physical activity	2.47	1.62 to 3.77	0.001*
Unhealthy diet	1.41	0.73 to 2.72	0.309
BP $\geq 140/90$ mmHg	1.03	0.73 to 1.45	0.858
Fasting glucose $\geq 126$ mg/dl	1.81	1.31 to 2.52	0.001*
Total cholesterol $\geq 240$ mg/dl	0.56	0.30 to 1.05	0.070

\*Statistically significant result.

those with mild-moderate tooth loss. In this model, increased age, poor physical activity and high fasting glucose remained independently significant (Table 2). Kaplan-Meier survival estimates showed a significant increased mortality (no overlapping CIs) among individuals with severe tooth loss (Figure 1).

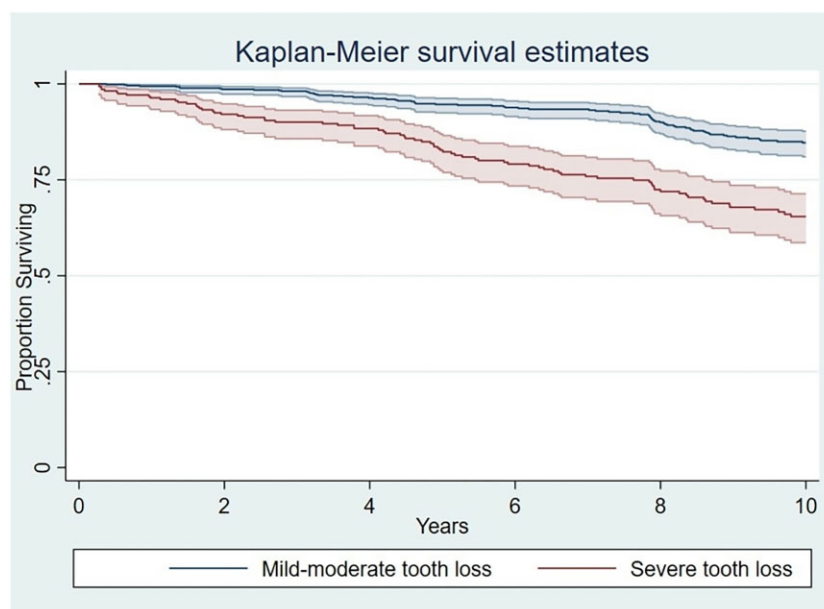
## Discussion

This study shows that severe tooth loss is associated with increased mortality risk. The pathogenesis of this relationship is not totally understood.<sup>1</sup> However, it is possible that chronic periodontitis (associated with severe tooth loss) stimulates the production of inflammatory cytokines that, in turn, damage the heart, brain and other organs, leading to death. It has also been suggested that poor dentition may be associated with nutritional

**Table 1.** Characteristics of 933 community-dwellers  $\geq 40$  y of age enrolled in this study according to categories of tooth loss severity (unadjusted analyses).

Characteristics	Mild-moderate tooth loss (n=657)	Severe tooth loss (n=276)	p-Value
Age at baseline (years), mean (SD)	51.6 (11.6)	63.7 (11.4)	<0.001*
Women, n (%)	363 (55)	142 (51)	0.287
Primary school education, n (%)	306 (47)	223 (81)	<0.001*
Current smoker, n (%)	29 (4)	11 (4)	0.768
BMI $\geq 30$ kg/m <sup>2</sup> , n (%)	199 (30)	60 (22)	0.008*
Poor physical activity, n (%)	45 (7)	45 (16)	<0.001*
Poor diet, n (%)	35 (5)	19 (7)	0.353
BP $\geq 140/90$ mmHg, n (%)	178 (27)	119 (43)	<0.001*
Fasting glucose $\geq 126$ mg/dl, n (%)	152 (23)	92 (33)	0.001*
Total cholesterol $\geq 240$ mg/dl, n (%)	74 (11)	32 (12)	0.884
Mortality, n (%)	73 (11)	78 (28)	<0.001*

\*Statistically significant result.



**Figure 1.** Kaplan–Meier survival curves and hazard ratios with 95% CIs for all-cause mortality according to the severity of tooth loss. There is a significant difference in mortality across groups.

deficiencies that may account for the occurrence of chronic diseases and death. However, this is unlikely to have occurred in the study population since B vitamins–enriched white rice and oily fish are important components of the diet irrespective of the number of teeth.<sup>5</sup>

Our study has limitations. We cannot conclude on a causative mechanism of tooth loss in mortality because several non-explored variables may have a role in the outcome. Biomarkers of inflammation were not determined during the study years, precluding assessment of the role of inflammatory mechanisms in this association. In addition, generalization of our findings to other populations should be undertaken with caution in view of the homogeneity of the study participants. These limitations are compensated for by the population-based prospective design and the systematic assessment of covariates by means of uniform and standardized protocols.

In conclusion, this study shows a significant association between severe tooth loss and all-cause mortality. These results open avenues of research for the implementation of preventive strategies aimed at improving the dental care of individuals living in remote settings.

**Authors' contributions:** OHD was responsible for the study design and drafting the manuscript. RMM was responsible for the statistical analysis. BYR and DAR were responsible for data collection and analysis. All authors have access to the data and read and approved the final version of the manuscript.

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**Competing interests:** None declared.

**Ethical approval:** The study was approved by the Ethics Committee of Hospital Clinica Kennedy, Guayaquil, Ecuador (FWA 00030727). All participants signed a comprehensive informed consent at enrolment. The procedures followed in this study were in accordance with the ethical standards of the Helsinki Declaration of the World Medical Association.

**Data availability:** Data are available upon reasonable request to the corresponding author.

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