

***The role of behavioural and age-related factors in the long-term impact of tooth loss on oral health-related quality of life: a 25 yr follow up of Swedish older adults***

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## Abstract

**Introduction:** The primary aim of this study was to assess any long-term association between tooth loss at age 50 and subsequent impaired oral health related quality of life, OHRQoL, at age 65, 70 and 75, adjusted for time invariant socio-demographic-and time variant behavioural and age-related factors in terms of disadvantages with functional, social, health and psychological concerns. As a second aim, this study examined whether behavioural and age-related factors played a role in explaining any long-term association between early tooth loss and subsequent OHRQoL. **Methods:** In 1992, 6346 residents, aged 50, consented to participate in a prospective cohort study and 3060 completed postal questionnaire follow-ups every fifth year (6 in total) until 2017. Information on tooth loss was assessed at baseline at age 50. Behavioural and age-related covariates were assessed repeatedly at ages 65,70 and 75. OHRQoL was the repeated outcome measure assessed by the Oral Impact on Daily Performance, OIDP at age 65,70 and 75. Generalized Estimating Equations, GEE, with binomial logit function was used to test the association between tooth loss and prevalence of oral impacts (OIDP) adjusting for counfounders and potential mediators. The role of behavioural and age-related factors in explaining the association between early tooth loss and OHRQoL was tested using the change in estimate approach. **Results:** Tooth loss and time variant behavioural and age-related covariates associated independently with higher odds of impaired OHRQoL across time. The long-term impact of tooth loss seemed to be partly explained by time variant covariates related to functional and psychological concerns. Participants who had excessive tooth loss at age 50 were 2.5 times more likely to experience oral impacts before adjustment of covariates. After adjustment of functional- and psychological covariates, participants were respectively, 1.6 times and 1.4 times more likely to experience oral impacts. **Conclusion:** This study revealed that early tooth loss at age 50 was independently associated with subsequent impaired OHRQoL at ages 65,70 and 75. Aspects of behavioural and age-related factors in terms of disadvantages in functional and psychological concerns seemed to play a role in explaining the long-term impact of tooth loss on impaired OHRQoL. A mid life approach to the prevention of tooth loss for the protection of subsequent adverse health outcomes should guide health promotion interventions and also be recognized by oral health care providers both for patient interaction and clinical decision making.

**Key words:** Tooth loss, Quality of life, Follow-up studies, Oral Health

## INTRODUCTION

Oral diseases are prevalent among older people and thus a public health concern.<sup>1,2,3</sup> Edentulism among 65-74 years old, reflecting the cumulative exposure to untreated oral diseases and treatment options over the life course, affects about 35% and 10% in upper-middle-income and low income countries, respectively.<sup>2</sup> Research evidence suggests a negative impact of edentulousness and excessive tooth loss (loss of considerable numbers of teeth) on health- and oral health related quality of life, OHRQoL.<sup>3-5</sup> In a systematic review by Gerritsen et al<sup>4</sup>, all studies included showed that tooth loss and the position of teeth were associated with poorer OHRQoL, independent of study area and OHRQoL instrument utilized. OHRQoL has been associated with clinical measures of oral diseases and also independently with socio-behavioral and psychological factors across age groups within and between populations.<sup>6-10</sup> However, most of the available evidence emanates from cross-sectional studies, therefore prospective studies with long-term follow-up periods are needed to substantiate the association between tooth loss and OHRQoL.

The association between tooth loss and OHRQoL is not devoid from overall health and function, particularly among older people where comorbidities are a common feature. In that context, increases in life expectancy and in the number of older people globally have made behavioural and age-related factors in terms of disadvantages with functional-, social-, health- and psychological concerns by increasing age a critical component of health expenditures<sup>11-17</sup>. Such factors might encompass accumulation of deficits across multiple aspects, often overlapping with disabling conditions and comorbidity and thus leading to adverse health outcomes, decline in functional, social, psychological and cognitive capacity and homeboundness.<sup>17,18,19,20</sup>

Oral conditions, as recognized risk factors for poor functional ability, have also been linked to social and cognitive capacity limitations in older adults.<sup>21-25</sup> A systematic review identified positive associations between number of teeth, periodontal disease and occluding pairs of teeth and components of weight loss, handgrip strength, and fatigue.<sup>13</sup> Hakeem et al<sup>15</sup> reviewed longitudinal studies and identified a temporal relationship between poor oral health and incidence of age-related deficits among older people. On the other hand, age-related deficits and social and cognitive capacity limitations have also been associated with tooth loss, use of dental services, masticatory ability, occluding pairs of teeth and self-reported oral health<sup>14-16, 18, 24--28</sup>, and thus the direction or bidirectionality of the associations

is not clear. Studies examining associations between indicators of poor oral health and age-related social and cognitive capacity limitations have most commonly focused on institutionalized older people and used a cross-sectional design. No studies have looked into the role of behavioral and age-related deficits in the long-term prospective association between tooth loss and OHRQoL, targeting community dwelling older adults. In this study we consider behavioural and age-related factors as disadvantages with functional, social, health and psychological concerns by increasing age.

The primary aim of this study was to assess any long-term association between tooth loss at age 50 and subsequent impaired OHRQoL at age 65, 70 and 75, adjusted for time invariant socio-demographic- and time variant behavioural and age-related factors in terms of disadvantages with functional-, social-, health- and psychological concerns. As a second aim, this study examined whether behavioural and age-related factors played a role in explaining any long-term association between early tooth loss and subsequent oral health related quality of life.

## **METHODS**

### **Study population**

The present study used 25-yr-follow-up data from an ongoing cohort of Swedish middle aged- and older adults born in 1942. In 1992, all individuals (a census) aged 50 years and residing in Örebro and Östergötland counties of Sweden were invited to participate in the cohort study. Of the total population of 8888 eligible adults, 6346 (71.4%) participated in the baseline survey. In 1997, 2002, 2007, 2012 and 2017, the cross-sectional participation rates were respectively, 74.3% (6513/8764), 75.0% (6372/8500), 73.1% (6078/8313), 72.2% (5697/7889) and 70.6% (5091/7204). Of the 6346 adults who participated in 1992, 3060 (48.2% of baseline) participated in all six postal follow ups. The study protocol and its updated versions were approved by a Research Ethic Committee in Sweden in 1992, 2012 and 2017. Research was undertaken with the understanding and written consent of each participant and in accordance with the Declaration of Helsinki.

### **Data collection**

Data has been collected every fifth year since the baseline survey in 1992 (at age 50) by postal self-administered questionnaires and with most questions repeated in each survey wave.

### *Time variant outcome*

The primary outcome for this study, was OHRQoL measured by the eight-item Oral Impacts on Daily Performances, OIDP in 2007, 2012 and 2017.<sup>29</sup> This measure has demonstrated appropriate psychometric properties in population based cross-sectional and longitudinal studies of adult people in Norway and Sweden.<sup>30,31</sup> We used the OIDP frequency scale and participants were asked how often they had the following impacts on daily activities due to problems with their teeth and mouth; difficulty eating, difficulty speaking clearly, difficulty cleaning teeth, avoiding smiling and showing teeth without embarrassment, maintaining emotional stability, difficulty enjoying social contact, difficulty performing daily work. Each item was assessed on a Likert scale with initial categories ranging from (1) affected daily or almost every day to (5) never affected. Each item was dichotomized into (0) not affected (1) affected at least monthly (including the original categories 1-4). A summary oral impacts extent score (0-8) was further dichotomized into (0) no impacts (1) at least one impact, in order to determine the prevalence of oral impacts.

### *Time invariant exposure*

Tooth loss was assessed by the question '*How many of your own teeth are left?*' initially scored in terms of (1) all teeth (28-32), (2) missing a few teeth, (3) missing many teeth, (4) Almost no teeth left, (5) edentulous. For analyses a dichotomy variable was constructed; 0= Not missing /missed a few (original categories 1,2) and 1= missed many teeth/all teeth (excessive tooth loss).

### *Time variant covariates and mediators*

Eight separate behavioural and age-related covariates were measured repeatedly in 2007, 2012 and 2017. **Functional concern** was assessed by two variables; '*Are you capable to eat/chew all sorts of food*' ranging from 1= very good to 4=bad, and dichotomized into 0=good (including the original category 1) and 1=bad (including the categories 2,3,4) and '*How often do you visit for dental care*'; 1=at least annually, 0= less than annually. **Social concern:** was assessed; '*How many persons do you know and talk to during one week*' ranging from 1= no people to 6= more than 15 people and dichotomized into 0=at most 3-5 people (poor social network) and 1=more than 3-5 people (good social network); and '*What is your marital status?*' (1=married/cohabiting, 0= single/unmarried). **Health concern:** was

assessed through three questions. *'Do you consider yourself to be healthy?'* ranging from 1= "yes, absolutely" to 4= "No, absolutely not" and dichotomized into 0= good health (original categories 1,2) and 1= poor health (original categories 3,4). *'Have you been taken prescribed medicines the last 14 days?'*, 1= yes , 0= no; *'Do you feel dry in your mouth during daytime?'* ranging from 1= yes often to 4= No never and dichotomized into 1= yes often/most of the time, 0=seldom/never . **Psychological concern:** was assessed in terms of one question; *'Do you believe that you will keep your teeth for life?'*, ranging from 1= yes absolutely to 4= no probably not, and dichotomized into 1=yes, absolutely /maybe and 0=no probably not.

#### *Time invariant covariates*

At baseline (1992) time invariant covariates (early life course factors) were measured in terms of sex (male, female), educational level (low, medium, high) and smoking status (smoking, no smoking). BMI status (low, medium, high) was assessed in 2007 and calculated from weight and height measures of each participant.

#### **Statistical methods**

Data were analysed using SPSS version 23.0 (IBM Corp. Released 2013, IBM SPSS Statistics for Windows, Armonk NY: IBM Corp) with individuals participating in all survey years (n=3060). Using cross-tabulation and Chi-squared test, characteristics measured at baseline in 1992 were compared between the cohort followed-up from 1992-2017 and the total number of participants at baseline. Time invariant- and time variant characteristics were compared between participants reporting several teeth lost/all teeth lost and no teeth lost at baseline. ODP prevalence in 2007, 2012 and 2017 was compared between groups defined according to tooth loss in 1992 and all covariates. Generalized Estimating Equations, GEE, with binomial logit function and unstructural correlation matrix was used to model prevalence of oral impacts (OIDP) across time according to baseline tooth loss and invariant- and time variant covariates and mediators. Six models were built by adding variables sequentially to each equation. Tooth loss was entered in Model I, followed by time invariant socio-demographic covariates entered in Model II and time variant behavioral and age-related covariates successively entered in Model III (functional), Model IV (social), Model V (health ) and Model VI (psychological). According to the change-in-estimate approach, the role of behavioural and age related factors in explaining the association between early tooth loss and

OHRQoL was tested by comparing the estimate for tooth loss from Model I with the estimates of tooth loss from Model III (including functional activity deficit), Model IV (including functional and social activity deficits), Model V (including functional, social and health related activity deficits) and Model VI (including functional, social, health related and psychological activity deficits).

## RESULTS

Table 1 presents baseline socio-demographic and behavioral characteristics between participants followed-up and all participants in 1992. Having no/a few teeth lost, higher education, being a non-smoker, married and attending dental care annually were more frequently observed among participants followed-up/included in the panel (1992-2017), than among all participants of the baseline survey in 1992.

A total of 3060 adults (53.4% females) were included in the panel 1992-2017 and analyzed in this study. At age 50 (in 1992), 22.0% reported to have lost many or all teeth, 74.8% were non-smokers/quitted smoking and 31.6% reported higher level of education. Higher proportions of males, higher educated and non-smokers were observed among participants without tooth loss compared to those with tooth loss. Across the survey years 2007-2017, behavioural and age-related factors varied between 14% and 37 % and were more prevalent among participants with than without tooth loss (Table 2).

The percentages of participants who reported oral impacts (OIDP>0) were 25.9%, 19.4% and 24.2% in 2007, 2012 and 2017, respectively (not tabulated). Table 3 shows the crude associations of tooth loss, socio-demographics and behavioural and age-related factors in 2007-2017 with the prevalence of OIDP in 2007, 2012, and 2017. For the time variant behavioural and age-related covariates, cross-sectional associations with OIDP in each survey wave were presented. Participants who had excessive tooth loss in 1992 were more likely to report oral impacts in 2007 (45.7% versus 22.1%) , 2012 (35.3% versus 16.4%) and 2017 (35.6% versus 22.1% ) compared to those without excessive tooth loss. Among participants attending dental care less than annually the prevalence of oral impacts was 33.7%, 25.1% and 28.9% in 2007, 2012 and 2017. Corresponding prevalences of oral impacts among participants attending dental care annually were 24.8%, 18.5% and 23.7%.

Table 4 presents the association between tooth loss in 1992 and OHRQoL across 2007-2017, through GEE models that were sequentially adjusted for time invariant covariates in 1992 and 2007 and behavioural and age-related factors in terms of disadvantages with functional-, social-, health-- and psychological concerns in 2007, 2012 and 2017. Model I revealed that participants who had excessive tooth loss in 1992 were 2.5 (95% CI: 2.1, 2.9) times more likely to report oral impacts in 2007-2017 than participants without excessive tooth loss. This association remained unchanged after adjustment for time invariant covariates (Model II). After subsequent adjustment for functional disadvantages (chewing- and dental attendance problems) in Model III, participants with excessive tooth loss were 1.6 (95% CI: 1.3-1.9) times more likely to report oral impacts across time. This estimate remained unchanged after further adjustment for social- and health related disadvantages in models IV and V. In the final model VI after adjustment for psychological disadvantage, the OR estimate for the association between tooth loss in 1992 and oral impacts across time was reduced to 1.4 (95% CI: 1.2,1.7) indicating that participants with excessive tooth loss were 1.4 times at higher odds of reporting oral impacts compared to their counterparts without excessive tooth loss.

## **DISCUSSION**

This study provides new information about the extent to which tooth loss influences OHRQoL over long time into older ages. Although previous evidence suggests that excessive tooth loss is associated with impaired OHRQoL, no study has investigated prospectively the association of OHRQoL with both tooth loss and behavioral and age-related factors, focusing on community dwelling older people. This large population based study demonstrated a temporal association between early tooth loss at age 50 and impaired OHRQoL at ages 65, 70 and 75 that was partly explained by variables reflecting age-related disadvantages with functional and psychological concerns . The findings were robust to adjustment for potential confounders measured across time and covering early middle- and later older life-course stages. The magnitude of the observed 25-yr long-term influence of early tooth loss was such that participants who had lost several or all teeth at age 50 were 2.5 times more likely to experience oral impacts in later life before adjustment of covariates and 1.4 times more likely to experience impacts in the fully adjusted model. Thus, tooth loss at age 50 had an enduring influence on subsequent oral impacts across time among older Swedish adults. The present findings are in line with previous studies including shorter follow-up periods showing strong independent association of tooth loss with OHRQoL and thus suggesting that adverse earlier



life circumstances have enduring influence on subsequent oral health independent of later life course experiences.<sup>4,32,33</sup> Other studies have shown that clinical indicators of oral diseases are not associated or associated only weakly with OHRQoL, indicating that they are not sufficient to describe perceived oral health status.<sup>4</sup>

The findings indicated a seemingly large role for behavioural and age-related factors in explaining the long-term association between tooth loss and oral impacts. According to the change-in-estimate model suggested by Baron and Kenny<sup>34</sup>, mediation was indicated by an observed substantial reduction in the estimated regression coefficients after accounting for functional- and psychological deficits in the multivariable model. This appears to imply that disadvantages with functional and psychological concerns have a role to play in the temporal association between early tooth loss and impaired OHRQoL among community dwelling older adults. This indication of an indirect effect of early tooth loss on OHRQoL does support the critical period and the the chain of effect life course models.<sup>32</sup> Some previous studies have used more novel approaches to mediation analysis than the change-in-estimate model implemented in this study and demonstrated direct and indirect effects between early life course experiences and later oral health status.<sup>35,36</sup>

A strength of this study is the use of a prospective design that permitted examination of long-term influence of excessive tooth loss on subsequent OHRQoL, allowing for temporal covariation of tooth loss and behavioral and age-related factors as well as temporal covariation of behavioral and age-related factors and oral impacts. Thus, the longitudinal nature and long-term follow-up of the data made it possible to establish a temporal sequence in the hypothesized tooth loss – behavioural and age-related factors - OHRQoL relationship. Evidently, high quality data from longitudinal studies covering very long time periods are extremely scarce. Moreover, the richness of the data allowed adjustment for a number of potential confounding factors at various time points. Another strength is that data were generated by a study based on the general non-institutionalized older population with a relatively high participation rate. The present findings would probably have been more generalizable if the follow-up participants included larger proportions of unhealthy people and less frequent dental attenders. Thus, differential follow-up in this cohort study might have underestimated the associations in the population. A limitation is that a comprehensive assessment of behavioural and age-related factors through a validated frailty index such as suggested by the Fried's phenotype model or Searle's 40 item index<sup>19,20</sup> was not available. Although self-reported measures of number of teeth are considered to be valid and reliable

and thus useful for research, the study could have benefited if tooth loss was assessed clinically. However, previous studies have shown strong correlations between self reported and clinically assessed dentition status (number of teeth or edentulous).<sup>37</sup>

The present findings also expand on previous evidence by demonstrating long-term temporal associations between early excessive tooth loss and subsequent behavioral and age-related factors as well as between those factors and OIDP.<sup>14-16,18</sup> Previous studies have commonly been of cross-sectional design or used shorter follow-up periods (2-5 yrs). Participants who had lost many teeth at age 50 presented with higher subsequent prevalence of functional- and psychological disadvantages compared with their counterparts without tooth loss. Moreover, participants with functional- and psychological disadvantages presented with higher subsequent prevalence of impaired OHRQoL than their counterparts without. These patterns might indicate the suggested bidirectionality in the association between indicators of poor oral health and behavioural and age-related factors that has also been reported in other studies.<sup>24,26</sup> Although about 80% of the Swedish older adult population is enrolled in a recall system, some lose their contact with the dental care services.<sup>38</sup> Behavioral and age-related deficits have been more frequently reported in people who did not use dental services the previous year and people with any kind of disability have difficulties in accessing dental services.<sup>39</sup> Previous studies have suggested that tooth loss reduces masticatory function and chewing ability and in turn leads to a preference for easy to chew foods high in fat and sugar.<sup>40</sup> A positive association between tooth loss and belief in keeping teeth for life might reflect a psychological pathway and increased vulnerability to stressors and lower self esteem.<sup>41</sup>

Independent of early tooth loss, this study revealed significant associations between behavioural and age-related factors and OIDP across time. In the fully adjusted model (Table 4), having disadvantages with functional-, health related- and psychological concerns were all strongly associated with impaired OHRQoL. This accords with findings from previous studies suggesting that disadvantaged older people are at increased risk for poor oral health.<sup>24,26</sup>

## CONCLUSIONS

This study revealed that early tooth loss at age 50 was independently associated with subsequent impaired OHRQoL at ages 65,70 and 75. Behavioural and age-related factors related to disadvantages in functional- and psychological concerns seemed to play a role in explaining the long-term impact of tooth loss on impaired OHRQoL. A mid-life approach to

the prevention of tooth loss for the protection of subsequent adverse health outcomes should guide health promotion interventions and also be recognized by oral health care providers both for patient interaction and clinical decision making.

## **ACKNOWLEDGEMENTS**

This study received financial support from the Department of Dentistry, Orebro county, Sweden, and from the Dental Commissioning Unit, Ostergotland County, Sweden. The authors acknowledge the numerous participants for their efforts in completing the questionnaires.

## **CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest.

## **AUTHOR CONTRIBUTIONS**

ANÅ: had the idea of this study, wrote the manuscript and conducted statistical analyses. Berit Mastrovito and Josephine Sannevik have monitored the cohort surveys and handled data files. They have reviewed the manuscript. Georgios Tsakos has contributed substantially both intellectually to the development of the manuscript as well as to the writing process.

## **DATA AVAILABILITY STATEMENT**

Data upon which this study is based is available from the authors upon request

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Table 1. Baseline characteristics in 1992 by follow-up status

	Baseline total n=6346	Follow ups n=3060
<i>Time invariant 92</i>	% (n)	% (n)
Many/all teeth lost	22.0 (1360)	16.3 (488)
No teeth lost	78.0 (4828)	83.7 (2514)
Female	50.2 (3184)	53.4 (1635)
Male	49.8 (3162)	46.6 (1425)
Low education	40.1 (2518)	36.4 (1108)
Medium education	30.3 (1903)	32.0 (976)
High education	29.7 (1864)	31.6 (962)
Dental care annually	90.1 (5671)	93.8 (2858)
Dental care seldom	9.9 (635)	6.2 (189)
Civil status- married	81.3 (5139)	85.8 (2622)
Civil status- not married	18.7 (1185)	14.2 (435)
Smoking : yes	32.8 (2071)	25.2 (766)
Smoking -quitted	28.6 (1805)	29.9 (911)
Smoking never	38.6 (2434)	44.9 (1368)
Considered healthy	88.9 (5582)	93.3 (2839)
Considered unhealthy	11.1 (694)	6.7 (203)

**Table 2. Socio-demographics characteristics (1992) and behavioural and age-related factors (2007-2017) among participants reporting tooth loss and no tooth loss at baseline (1992) (n=3060).**

	Total % (n)	Lost teeth % (n)	No teeth lost % (n)
<b><i>Time invariant (1992)</i></b>			
Female	53.4 (1635)	16.8 (270)	83.2 (1334)
Male	46.6 (1425)	15.6 (218)	84.4 (1180)
Education - Low	36.4 (1108)	23.6 (253)	76.4 (821)
Education - Medium	32.0 (976)	14.5 (140)	85.5 (828)
Education High	31.6 (962)	10.0 (95)	90.0 (855)**
Smoking yes	25.2 (766)	38.1 (186)	22.5 (562)
Smoking : no	74.8 (2279)	61.9 (302)	77.5 (1941)**
<b><i>Time invariant 2007</i></b>			
Low BMI	40.1 (1148)	32.0 (148)	41.6 (1000)
Medium BMI	44.7 (1281)	49.6 (229)	43.8 (1052)
High BMI	15.2 (435)	18.4 (85)	14.6 (350)**
<b><i>Time variant activity deficits 2007-2017</i></b>			
Chewing all types food – no (2007)	31.4 (954)	61.3 (296)	25.7 (641)**
Chewing all -no (2012)	32.0 (968)	59.4 (281)	26.7 (667)**
Chewing all-no (2017)	37.4 (1125)	59.8 (281)	33.2 (823)**
Dental attendance < annually (2007)	19.2 (583)	19.9 (96)	9.9 (247)**
Dental attendance <annually (2012)	22.2 (653)	17.1 (81)	9.5 (236)**
Dental attendance <annually (2017)	28.6 (862)	19.8 (94)	10.6 (262)**
Social contact-low (2007)	19.1 (573)	24.9 (120)	17.9 (443)**
Social contact .low (2012)	27.4 (803)	35.3 (164)	25.9 (625)**
Social contact low (2017)	32.5 (972)	35.7 (169)	31.6 (779)
Marital status – single (2007)	19.2 (583)	22.9 (111)	18.4 (459)*
Marital status - single (2012)	22.2 (653)	27.9 (129)	21.1 (511)*
Marital status - single (2017)	28.6 (862)	36.7 (176)	27.0 (669)**
Considered unhealthy (2007)	15.4 (466)	23.0 (111)	14.0 (347)**
Considered unhealthy (2012)	14.2 (425)	20.0 (95)	13.2 (324)**
Considered unhealthy (2017)	19.2 (575)	27.4 (131)	17.7 (437)**
Use of medicine: yes (2007)	63.3 (1925)	67.5 (328)	62.6 (1565)*
Use of medicine: yes (2012)	72.3 (2192)	76.7 (365)	71.6 (1788)*
Use of medicine: yes (2017)	81.9 (2473)	86.1 (414)	81.1 (2011)*
Dry mouth: yes (2007)	25.6 (769)	37.5 (179)	23.3 (575)**
Dry mouth: yes (2012)	27.9 (832)	36.1 (168)	26.4 (649)**
Dry mouth: yes (2017)	33.9 (974)	40.4 (184)	32.6 (772)**
Belief in keeping teeth: no (2007)	14.5 (440)	43.1 (206)	8.9 (222)**
Belief in keeping teeth: no (2012)	26.3 (793)	55.5 (258)	20.8 (519)**
Belief in keeping teeth: no (2017)	24.8 (742)	51.6 (242)	19.6 (484)**

\*\*p<0.001, \*p<0.05. All comparisons are between those with and those without tooth loss.



Table 3. Prevalence of oral impacts (OIDP>0) in 2007, 2012 and 2017 by time invariant (92) socio-demographics and time variant (07-12) behavioural and age-related factors at every wave (Cross-sectional associations at every wave are reported with time variant frailty aspects).

	OIDP>0 (07)	OIDP>0 (12)	OIDP >0 (17)
<b>Time invariant (92)</b>			
Many/all teeth lost	45.7 (215)	35.3 (164)	35.6 (149)
No/ a few teeth lost	22.1 (538)**	16.4 (396)**	22.1 (510)**
Female	26.9 (424)	18.7 (290)	22.9 (333)
Male	24.7 (340)	20.1 (278)	25.7 (340)
<b>Education</b>			
Low	24.6 (265)	18.9 (198)	24.8 (239)
Medium	26.3 (249)	19.5 (184)	23.8 (216)
High	26.9 (247)	19.8 (184)	24.2 (216)
Smoking: yes	32.2 (298)	23.5 (171)	27.0 (183)
Smoking: no	23.8 (561)**	18.0 (395)**	23.4 (487)**
<b>Time invariant 07</b>			
BMI: low	25.7 (289)	17.8 (200)	22.4 (238)
BMI: moderate	25.8 (329)	19.7 (248)	24.7 (294)
BMI: high	24.4 (104)	22.7 (95)	25.5 (104)
<b>Time variant</b>			
<b>Activity deficits 2007-2017</b>			
Chewing all types:yes	13.3 (269)	9.2 (184)	13.9 (244)
Chewing all types:no	53.8 (491)**	40.8 (377)**	42.2 (422)**
Dental attendance - annually	24.8 (641)	18.5 (484)	23.7 (577)
Dental attendance – less than annually	33.7 (113)**	25.1 (78)**	28.9 (91)*
Social contact: high	24.4 (574)	18.1 (372)	22.7 (422)
Social contact - low	31.5 (175)**	21.4 (165)*	27.8 (244)*
Marital status - married	24.5 (581)	18.3 (405)	23.0 (456)
Marital status- single	31.7 (176)*	21.8 (136)	27.5 (212)*
Considered healthy	23.5 (581)	16.9 (420)	20.4 (457)
Considered unhealthy	40.1 (178)**	32.2 (129)**	41.7 (210)**
Use of medicine : no	22.9 (246)	16.2 (131)	18.4 (92)
Use of medicine - yes	27.6 (516)*	20.5 (432)*	25.6 (578)*
Dry mouth : no	21.8 (472)	16.5 (345)	19.4 (345)
Dry mouth - yes	37.3 (276)**	26.8 (209)**	34.6 (299)**
Beliefs in keeping teeth- yes	19.8 (499)**	13.1 (282)	18.3 (385)
Beliefs in keeping teeth - no	62.1 (259)	36.8 (275)**	43.4 (276)**

\*\*p<0.001, \*p<0.05.

**Table 4. Oral impacts (OIDP>0) across time 2007-2017 regressed on tooth loss, time invariant covariates and time variant behavioural and age-related factors (2007-2017). Generalized Estimating Equations.**

	Adjusted Model I	Adjusted Model II	Adjusted Model III	Adjusted Model IV	Adjusted Model V	Adjusted model VI
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Time</b>						
2007	1	1	1	1	1	1
2012	0.9 (0.8-1.1)	0.9 (0.8-1.1)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.7 (0.6-0.8)
2017	1.3 (1.2-1.4)	1.3 (1.2-1.5)	1.2 (1.1-1.4)	1.2 (1.1-1.5)	1.2 (1.1-1.4)	1.2 (1.1-1.5)
No teeth lost	1	1	1	1	1	1
Many/all teeth lost	2.5 (2.1-2.9)	2.5 (2.1-3.0)	1.6 (1.3-1.9)	1.6 (1.3-1.9)	1.6 (1.4-2.0)	1.4 (1.2-1.7)
<b>Time invariant covariates</b>						
Male		1	1	1	1	1
Female		1.0 (0.0-1.2)	0.9 (0.8-1.1)	0.9 (0.8-1.1)	1.0 (0.9-1.2)	1.0 (0.9-1.2)
High education (1992)		1)	1	1	1	1
Medium education		1.2 (0.9-1.4)	1.2 (1.0-1.5)	1.2 (1.1-1.5)	1.2 (1.0-1.5)	1.3 (1.1-1.5)
Low education		1.3(1.1-1.6)	1.6(1.3-1.8)	1.6(1.3-1.9)	1.7(1.4-2.0)	1.7(1.4-2.1)
Smoking (1992)		1	1	1	1	1
No smoking		0.7 (0.6-0.9)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.8 (0.7-1.0)	0.9 (0.7-1.1)
High BMI (2007)		1	1	1	1	1
Medium BMI		1.0 (0.8-1.3)	0.9 (0.7-1.2)	0.9 (0.7-1.1)	0.8 (0.7-1.1)	0.8 (0.7-1.1)
Low BMI		1.1 (0.9-1.3)	1.0 (0.8-1.2)	1.0 (0.8-1.3)	0.9(0.7-1.1)	0.8 (0.6-1.1)
<b>Time variant activity deficits</b>						
<i>Functional</i>						
Chewing all food yes			1	1	1	1
Chewing all food -no			5.6 (4.9-6.4)	5.5 (4.8-6.3)	5.1 (4.5-5.9)	4.2 (3.7-4.9)
Dental attendance annually			1	1	1	1
Dental attendance less annually			1.1 (0.9-1.3)	1.1 (0.9-1.3)	1.1 (0.8-1.3)	1.0 (0.8-1.2)
<i>Social</i>						
Social contact - high				1	1	1
Social contact - low				1.5 (1.0-1.3)	1.1 (0.9-1.2)	1.1 (0.9-1.3)
Civil - married				1	1	1
Civil not married				1.2(1.0-1.4)	1.2 (1.0-1.4)	1.2 (0.9-1.4)
<i>Health related</i>						
Considered healthy					1	1
Considered unhealthy					1.7 (1.4-2.0)	1.6 (1.3-1.9)

Table 4. continued. Oral impacts (OIDP>0) across time 2007-1017 regressed on tooth loss, time invariant covariates, and socio-demographics and time variant behavioural and age-related factors (2007-2017). Generalized Estimating Eqations.

	Adjusted Model I OR (95% CI)	Adjusted Model II OR (95% CI)	Adjusted Model III OR (95% CI)	Adjusted Model IV OR (95% CI)	Adjusted Model V OR (95% CI)	Adjusted Model VI OR (95% CI)
<i>Health related</i>						
<i>continued</i>						
Use of medicine - no					1	1
Use of medicine - yes					1.1 (0.8-1.2)	1.0 (0.8-1.2)
Dry mouth-no					1	1
Dry mouth yes					1.6 (1.4-1.8)	1.6 (1.3-1.8)
<i>Psychological</i>						
Belief in teeth :no						1
Belief in teeth :yes						0.4 (0.4-0.5)

Footnote: odds ratio and 95% confidence interval abbreviated OR, 95% CI.

Model I: Tooth loss adjusted for survey years (time); Model II: tooth loss adjusted for Model I and time invariant covariates (sex, education, smoking, BMI); Model III: adjusted for Model II and time variant disadvantages in functional concerns; Model IV adjusted for Model III and time variant disadvantages in social concerns; Model V: adjusted for Model IV and disadvantages in health concerns; Model VI: adjusted for Model V and disadvantages in psychological concerns.





