

## Influences of behaviour and attitude on education related inequality in tooth loss: findings from Norway and Sweden over 5 years of follow-up

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### ABSTRACT

**Objectives:** Following community dwelling cohorts in Norway and Sweden from 65 to 70 years, this study aimed to answer the following questions; Is there cross country variation in educational inequality in tooth loss between the Norwegian and Swedish cohorts? Does oral health behaviours and attitudinal beliefs play a role in explaining educational inequality in tooth loss across time and cohorts?

**Material and Methods:** In 2007 and 2012 Statistics Norway administered mailed questionnaires to all individuals born in 1942 in three counties. The response rate was 58% ( $n = 4211$ ) in 2007 and 54.5% ( $n = 3733$ ) in 2012. In Sweden the same questionnaires were sent to the 1942 cohort in two counties. The final response rate in 2007 and 2012 were respectively, 73.1% ( $n = 6078$ ) and 72.2% ( $n = 5697$ ).

**Results:** In Norway, tooth loss prevalence was 21.8% in 2007 and 23.2% in 2012. Corresponding figures in Sweden were 25.9% and 27.3%. The prevalence of tooth loss was higher among lower than higher educated participants and the gradient was significantly weaker in Sweden than in Norway. Multiple variable analyses adjusting for oral behavioural and attitudinal variables attenuated education related gradients in both cohorts.

**Conclusion:** Education related inequality in tooth loss was stronger in the Norwegian than in the Swedish cohort across the survey years. Oral behaviours and attitudinal beliefs played a role in explaining the gradients across time. This illustrates a necessity to promote oral health enhancing behaviours and attitudinal beliefs, particularly so in lower educational groups.

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### Introduction

Dentition status in terms of partial and complete tooth loss is a reliable marker of population oral health [1]. A significant reduction in the global burden of severe tooth loss occurred between 1990 and 2010, whereby the global age standardised prevalence of edentate people declined from 4.4% to 2.4% [1]. Accordingly, epidemiological figures from Sweden have shown that the prevalence of complete tooth loss among 40–70 yr olds decreased from 16% in 1973 to 0.3% in 2013 [2]. In Norway, Ekornrud et al. [3] and Holst and Skau [4] reported a prevalence of complete tooth loss of respectively, 3 and 7% among 60–74-year-olds in 2008. In spite of these declining trends, it is evident that the mean number of lost teeth increases with increasing age and that a substantial proportion of older people experience tooth loss [5–8].

Epidemiological studies have provided evidence on prevailing socioeconomic inequalities in the prevalence and incidence of tooth loss regardless of the social indicator utilised [for review see 9, 10]. Recently, repeated cross sectional studies suggest little change across time regarding the absolute differences in complete tooth loss between poor and non-poor groups [9–11]. The social gradients in tooth loss seem to persist despite marked improvement in tooth retention

[9–11]. In accordance with the relatively generous redistributive oral health policies implemented in Scandinavian countries, absolute differences in total tooth loss between the highest and lowest income groups in Norway decreased by 5.4% from 1975 to 2002 in people 60 years and above. However, the relative inequality increased from a prevalence ratio of 2.0% to 7.5% during the same period [12]. Between 1969 and 2000, absolute differences in tooth loss decreased while relative differences remained unchanged in the adult Swedish population [13]. A number of prospective longitudinal studies have revealed contradictory results when examining whether social inequalities in oral health indicators remain stable, increase or decrease with ageing in the middle aged- and older parts of the populations [14–17].

Tooth loss is the final outcome of a multifactorial process and has been recognised to be the consequence of socio-behavioural issues as much as being disease related [18]. Multiple behavioural, psychological and cognitive factors such as tobacco and alcohol consumption, poor oral hygiene, irregular dental attendance and cognitive decline have been associated with higher prevalence of tooth loss, recognising the social distribution of those risk factors and their influences across time [19–21]. From a life course perspective, early

exposure to social and behavioural factors influences oral health at later life stages and thus adds to the interpretation of oral health inequality [22]. Moreover, evidence suggest that behavioural, psychological and cognitive factors associate with both socioeconomic conditions and tooth loss making them potential candidates as mediators of any association between social conditions and oral diseases [23, 24]. Some studies, mostly of cross sectional design, suggest that oral health behaviours and psycho-social factors partially explain social inequalities in oral health and that the mediating role of behaviours vary according to the nations' social policy approach [24–30].

There is limited information regarding social inequality in tooth loss among ageing people in countries with generous welfare regimens [31–32]. Less is known as to why educational inequality in tooth loss exists among ageing people. Following community dwelling (i.e. non-institutional general population) cohorts in Norway and Sweden from 65 to 70 years, this study aimed to answer the following questions. Is there cross-country variation in educational inequality of tooth loss between the Norwegian and Swedish cohorts? Does oral health behaviours and attitudinal beliefs play a role in explaining educational inequality in tooth loss across time and cohorts?

## Methods

This study is based on cohorts of individuals born in 1942 in Norway and Sweden. Details of the 1942 cohorts have been described in a previous study [8]. In 2007, Statistics Norway mailed a self-administered questionnaire to all individuals born in 1942 and currently residing in three counties of Norway, selected to represent both urban and rural areas and variation in oral conditions. The final response rate was 58.0% ( $n=4211$  of a net population of  $n=7248$ ). In 2012, the same questionnaire was sent to all individuals of the 1942 cohort in the three counties. The final response rate was 54.5% ( $n=3733$  of a net population of  $n=6841$ ). Of the cohort members who completed the 2007 survey, 70% (2947/4211) participated also in 2012. The surveys were approved by the Ethics Committee of the Norwegian Social Science Service and the Regional Committees for Medical Health Research (REK). In Sweden, similar questionnaires were sent to all persons born in 1942 and currently residing in two Swedish counties. The final response rates in 2007 and 2012 were respectively, 73.1% ( $n=6078$  of a net population of 8313) and 72.2% ( $n=5697$  of a net population of  $n=7889$ ). Individuals participating both in 2007 and 2012 constituted the Swedish panel of 65–70-year olds. Of the cohort members who completed the 2007 survey, 80% (4862/6078) participated also in 2012. The Ethics Committee of Uppsala, Sweden approved the Swedish surveys.

## Measures

Questionnaires with similar content and ways of administration at each data collection, ensured comparability of the Norwegian and the Swedish data. The outcome variable, *tooth loss* was assessed as a time variant measure in 2007

and 2012 by questioning; How many of your own teeth do you still have, categorised as (1) all (28–32 teeth), (2) missing a few teeth, (3) missing many teeth, (4) have almost no teeth left, (5) edentulous. Both variables were dichotomised into (0) all or almost all teeth (including the original categories 1,2) and (1) lost many teeth (including original categories 3,4,5). The main exposure variable, *education*, used as a time invariant measure and an indicator of early life course social indicator was measured in 2007 using the categories; (1) primary school, (2) secondary school, (3) high school, (4) university/college and (5) other. The variable was recoded into (0) higher education (including the original categories 3 and 4) and (1) lower education (including the original categories 1 and 2). The other category (5) was recoded into *sysmiss*. *Social network* was assessed as a potential confounder and time variant measure in 2007 and 2012 by asking “How many people that you know do you meet and talk with during an ordinary week” and categorised as (1) none, (2) 1–2, (3) 3–5, (4) 6–10, (5) 11–15 and (6) more than 15. This variable was dichotomised into (1) weak social ties (including the original categories 1–3) and (0) strong social ties (including the original categories 4–6). A number of covariates were assessed as potential mediators of the association between education and tooth loss. *Smoking* was assessed as a time variant measure in 2007 and 2012 by asking, “What are your smoking habits?” with categories (1) smoking daily, (2) smoking occasionally (3) have been a smoker but have quit, (4) never smoked. Smoking was dichotomised into (0) no smoking (including the original categories 3–4) and (1) smoking (including the original categories 1–2). *Frequency of dental attendance* was assessed as a time variant measure in 2007 and 2012 by asking “How often do you attend a dentist?” using the response categories (1) Twice or more a year, (2) once a year, (3) every other year and (4) less than every other year. This variable was dichotomised into (0) Attendance at least once a year (including the original category (1) and (1) less than once a year (including the categories 2–4). *Use of fluoridated toothpaste* in 2007 and 2012 was assessed; “How often do you use fluoridated toothpaste” and categorised on a 5 point scale from (1) more than twice daily to (5) seldom never. This variable was dichotomised into (0) at least twice daily and (1) daily or less than daily. *Use of alcohol* was assessed in 2007 and 2012 by asking “How often do you drink alcohol using the categories (1) several times a week, (2) a few times a week, (3) about once a week, (4) about several times a month, (5) never. This variable was dichotomised into (1) several times a week (including the original categories 1, 2) and (0) more seldom (including the original categories 3–5). *Attitudinal beliefs* were assessed in 2007 and 2012 by the question; Do you believe that you can keep your teeth for life using 5 categories (1) Quite sure, (2) may be (3) I do not know (4) nor probably, (5) absolutely not. This variable was dichotomised into (0) yes (including the original category (1) and (1) no including the original categories 2–5).

## Statistical analyses

Data were analysed using the statistical package of SPSS (IBM, New York, NY, USA) version 20.0 and STATA version

13.1 (STATA, College Station, TX, USA) with the intact cohorts, i.e. subjects participating at both survey occasions in Sweden ( $n=4862$ ) and in Norway ( $n=2947$ ). To account for loss to follow-up, data were weighted by using inverse probability weighting (IPW) Using STATA (33). Analyses were conducted with pooled samples for interaction analyses between country and education and stratified by country. Differences in the proportions of cohort members who reported tooth loss in 2007 and 2012 were analysed using Cochran's Q test for several related samples. Bivariate associations between tooth loss and socio-behavioural covariates in 2007 and 2012 were analysed using cross-tabulations and Chi-Square tests. The association between socio-behavioural and attitudinal characteristics and tooth loss across time was analysed using Generalised Estimating Equation (GEE) with robust variance estimates to account for repeated measures of the same individuals in different survey years. Absolute differences were estimated using binomial distribution with identity link. Education was used as a time invariant variable whereas all other socio-behavioural variables were entered as time variant variables. Only covariates that were statistically significantly associated with education and tooth loss in unadjusted analyses were included in the multiple variable logistic regression analyses. Covariates were entered in four steps or models estimating the goodness of fit for each model in terms of QIC (Quasi Likelihood under Independence). The model that obtains the smaller QIC is better fit. Mediation of the association between the main exposure, education, and tooth loss by socio-behavioural covariates was evaluated by change-in-estimate regression models.

## Results

Data from 2947 Norwegian and 4862 Swedish cohort participants followed from 65 to 70 years were analysed. In Norway, the prevalence of tooth loss was 21.8% in 2007 (at age 65) and 23.2% in 2012 (at age 70). Corresponding figures in Sweden were 25.9% and 27.3%. Analyses of non-response in the Norwegian and Swedish cohorts revealed some deviations from a random distribution. Thus, in both countries there were statistically significant differences between the groups who were and were not successfully followed-up with respect to tooth loss, smoking status, belief in keeping teeth for life and education ( $p < .05$ ) as assessed in 2007 (not shown in Table).

Table 1 depicts the distribution of socio-behavioural and attitudinal factors in 2007 and 2012 as a function of educational level in 2007 (time invariant), separately for each cohort. In both cohorts, lower education (2007) was significantly ( $p < .05$ ) associated with social network, tooth brushing, of fluoride toothpaste, smoking, more seldom use of alcohol, belief in keeping teeth for life and dental attendance assessed in 2007 and 2012. Large cohort differences in smoking is shown in both educational groups across the survey year. In Sweden the prevalence of smoking was 52.9% and 45.7% among lower and higher educated in 2007. The corresponding figures in Norway amounted to 18.0% and 13.5%.

Table 2 depicts the bivariate associations in both survey years of behavioural and attitudinal variables with tooth loss stratified by country. In Norway, lower education, limited social network, less than daily tooth brushing, less than daily use of fluoridated tooth paste, smoking, more seldom use of alcohol, no belief in keeping teeth for life and dental attendance less than once a year associated with higher prevalence of tooth loss in both survey years. Similar trends of associations occurred in the Swedish cohort.

Table 3 presents tooth loss in 2007/2012 regressed on education, social network, oral health related behaviours and attitudinal beliefs in the Swedish cohort. The sex- and survey year (time) adjusted GEE model I revealed that tooth loss across time (2007–2012) was more likely among lower than higher educated participants with ORs of 1.8 (95% CI 1.5–2.1). The goodness of fit for Model I in terms of QIC (Quasi Likelihood under Independence) was 10680.263. Adding social network and oral health behaviours in Model II, attenuated the association between education and tooth loss to OR = 1.6 (95% CI 1.3–1.8). The QIC value in Model II was reduced to 8849.196. Limited social network, no smoking and more seldom use of alcohol remained statistically significantly associated with tooth loss across time. The corresponding ORs were 1.2 (95% CI 1.1–1.3), 0.5 (95% CI 0.5–0.7) and 1.3 (95% CI 1.1–1.4). Adding belief in keeping teeth for life in Model III and dental attendance in Model IV further attenuated the association between education and tooth loss. The QIC for Model III and IV were respectively, 7426.414 and 7369.542. In the final model, education, social network, smoking, more seldom use of alcohol and belief in keeping teeth remained statistically significantly associated with tooth loss across time. OR for the association between educational level and tooth loss attenuated from OR = 1.8 (95% CI 1.5–2.1) in Model I to OR = 1.4 (95% CI 1.2–1.7) in Model IV.

Table 4 presents tooth loss in 2007/2012 regressed on education, social network, oral health related behaviours and attitudinal beliefs in the Norwegian cohort. The sex and survey year adjusted GEE Model I revealed that tooth loss across time (2007–2012) was more likely among lower than higher educated cohort participants with ORs of 2.7 (95% CI 2.1–3.3). The goodness of fit for Model I in terms of QIC was 5539.558. Adding covariates in terms of social network, tooth brushing, fluoridated toothpaste, smoking, alcohol use, belief in keeping teeth for life and dental attendance in Model II, attenuated the association between education and tooth loss to OR = 2.2 (95% CI 1.8–2.8). The QIC value was reduced to 4538.839. Smoking and more seldom use of alcohol associated significantly with tooth loss across time. The corresponding ORs were 0.5 (95% CI 0.4–0.6), and 1.3 (95% CI 1.3–1.6). Adding belief in keeping teeth for life in Model III further attenuated the association between education and tooth loss to OR = 2.0 (95% CI 1.6–2.5). The QIC for Model III was 3392.158. Adding dental attendance to the final Model IV finally attenuated the association between tooth loss and education to OR = 1.9 (95% CI 1.6–2.4). In the final model education, smoking seldom, more seldom use of alcohol, no belief in keeping teeth for life and dental attendance less

**Table 1.** Social and behavioural characteristics of older adults in Sweden and Norway (2007 and 2012) by lower and higher education (2007).

	Sweden		Norway	
	Lower education % (n)	Higher education % (n)	Lower education % (n)	Higher education % (n)
Sex				
Male	49.7 (1854)	46.3 (475)	48.5 (968)	58.4 (447)
Female	50.3 (1873)	53.7 (552)*	51.5 (1029)	41.6 (318)
Social ties 07				
Low	23.9 (875)	11.5 (116)	21.9 (433)	11.2 (85)
High	76.1 (2782)	88.5 (8919)*	78.1 (1544)	88.8 (673)**
Social ties 12				
Low	32.4 (1153)	21.9 (8217)	30.7 (608)	22.2 (168)
High	67.6 (2401)	78.1 (774)**	69.3 (1375)	77.8 (589)**
Brushing 07				
≤once daily	16.6 (593)	8.9 (87)**	30.4 (579)	18.2 (133)
At least twice daily	83.4 (2971)	91.1 (894)	69.6 (1326)	81.8 (599)**
Brushing 12				
≤once daily	16.7 (561)	10.1 (96)	29.6 (552)	20.6 (151)
At least twice daily	83.3 (2806)	89.9 (857)**	70.4 (1316)	79.4 (582)**
F-toothpaste 07				
≤once daily	18.6 (655)	11.0 (108)	35.5 (652)	26.5 (190)
At least twice daily	81.4 (2868)	89.0 (873)**	64.5 (1183)	73.5 (528)**
F-toothpaste 12				
≤once daily	19.5 (643)	11.6 (109)	35.3 (632)	28.1 (202)
At least twice daily	80.5 (2659)	88.4 (834)**	64.7 (1157)	71.9 (518)**
Smoking 07				
Smoking	52.9 (1960)	45.7 (467)	18.0 (357)	13.5 (102)
No smoking	47.1 (1746)	54.3 (554)**	82.0 (1621)	86.5 (656)**
Smoking 12				
Smoking	52.4 (1748)	46.7 (477)	12.3 (244)	9.0 (69)
No smoking	47.6 (1748)	53.3 (544)**	87.7 (1741)	91.0 (695)**
Alcohol 07				
Several times a week	24.1 (883)	40.6 (414)	20.0 (392)	35.3 (266)
More seldom	75.9 (2787)	59.4 (605)**	80.0 (1568)	64.7 (487)**
Alcohol 12				
Several times a week	25.8 (936)	43.4 (439)	23.2 (455)	40.5 (307)
More seldom	74.2 (2692)	56.6 (573)**	76.8 (1509)	59.5 (451)**
Belief teeth 07				
yes	81.1 (2980)	87.0 (883)	71.4 (1391)	83.2 (631)
No	18.9 (696)	13.0 (132)**	28.6 (557)	16.8 (127)**
Belief teeth 12				
yes	67.5 (2456)	80.2 (816)	70.0 (1377)	84.1 (642)
No	32.5 (1183)	19.8 (202)**	30.0 (589)	15.9 (121)**
Dentist 07				
At least once a yr	85.8 (3157)	88.8 (903)	83.4 (1640)	91.2 (693)
Less than once a yr	14.2 (523)	11.2 (114)	16.6 (326)	8.8 (67)**
Dentist 12				
At least once a yr	86.2 (3141)	90.4 (918)	86.8 (1708)	91.9 (705)
Less than once a yr	13.8 (502)	9.6 (97)**	13.2 (260)	8.1 (767)**

Norway ( $n = 4211$  in 2007) and ( $n = 3733$  in 2012). Sweden ( $n = 6078$  in 2007) and ( $n = 5697$  in 2012).

Chi-square \*\* $p < .001$ , \* $p < .05$ .

than once a year associated significantly with tooth loss across time. The final QIC was 3358.715. OR for the association between education and tooth loss attenuated from OR = 2.6 (95% CI 2.1–3.3) in model I to OR = 1.9 (95% CI 1.6–2.4) in model IV.

To test whether educational differences in tooth loss across time varied statistically significantly with country, GEE analyses were conducted based on merged Norwegian and Swedish cohort data with country and a two-way interaction term between country and education as additional variables. This revealed a significant two-way interaction between education and country on tooth loss in unadjusted and adjusted analyses (Adjusted OR = 0.6 95% CI 0.5–0.9) (not shown in table). As shown in Tables 3 and 4, regression analyses stratified by country suggest that education related inequality in tooth loss was statistically significantly stronger in Norway than in Sweden with adjusted ORs of 1.9 and 1.4, respectively.

## Discussion

The present study is one of very few that examines the contribution of behavioural- and attitudinal factors in explaining education related inequality in tooth loss across time and countries focussing ageing populations. The findings revealed education gradients in the percentage of Swedish and Norwegian cohort participants who reported tooth loss at age 65 and 70, with the prevalence of tooth loss being consistently higher among lower than higher educated cohort participants. This supports knowledge that social inequality in tooth loss persist in high income countries with generous well fare regimens. Moreover, this study revealed that smoking, more seldom use of alcohol, poor oral hygiene, irregular dental attendance and negative beliefs in keeping teeth for life associated consistently with tooth loss and education across the two cohorts and survey years.

**Table 2.** Tooth loss at age 65 and 70 yrs among older people in Norway and Sweden by education and behavioural characteristics.

	Norway Toothloss 2007 % (n)	2012 % (n)	Sweden Toothloss 2007 % (n)	2012 % (n)
Sex (07)				
Male	22.4 (326)	25.0 (358)	25.7 (598)	27.3 (627)
Female	21.2 (288)	21.3 (286)*	26.1 (632)	27.3 (640)
Education (07)				
Lower	25.6 (498)	27.1 (521)	28.3 (1037)	29.5 (1062)
Higher	11.7 (88)**	12.6 (94)**	17.9 (182)**	19.5 (195)**
Social tie 2007				
Low	29.5 (155)	30.6 (156)	31.1 (307)	32.1 (312)
High	20.2 (457)**	21.7 (487)**	24.3 (981)*	25.8 (928)**
Social ties 12				
Low		26.6 (208)		35.0 (477)
High		21.9 (438)*		23.8 (751)**
Brushing 07				
≤once daily	35.1 (259)	36.2 (255)	30.9 (212)	35.3 (236)
At least twice daily	16.7 (334)	18.2 (357)**	24.8 (959)**	25.4 (963)**
Brushing 12				
≤once daily		34.4 (252)		37.8 (249)
At least twice daily		18.3 (359)**		24.8 (911)**
F-toothpaste 07				
≤once daily	32.2 (278)	33.5 (279)	29.1 (224)	33.9 (254)
At least twice daily	16.0 (284)*	17.5 (305)**	24.6 (926)*	25.2 (925)**
F-toothpaste 12				
≤once daily		29.9 (259)		35.6 (267)
At least twice daily		17.4 (301)**		24.4 (856)**
Smoking 07				
Smoking	36.0 (170)	39.4 (179)	32.0 (771)	33.9 (803)
No smoking	18.9 (446)**	20.0 (460)**	19.6 (449)**	20.5 (462)**
Smoking 12				
Smoking		41.6 (131)		34.1 (811)
No smoking		20.6 (511)**		20.3 (462)**
Alcohol 07				
Several times a week	15.3 (103)	16.5 (108)	21.0 (270)	21.5 (274)
More seldom	23.7 (507)**	25.2 (525)**	27.6 (932)**	29.2 (967)**
Alcohol 12				
Several times a week		17.2 (133)		22.4 (306)
More seldom		25.5 (507)**		29.3 (948)**
Belief teeth 07				
yes	8.7 (179)	10.5 (215)	15.3 (594)	18.0 (685)
No	55.0 (389)**	56.2 (386)**	74.5 (614)*	70.4 (555)**
Belief teeth 12				
yes		7.7 (158)		14.0 (457)
No		64.9 (467)**		57.9 (788)**
Dentist07				
At least once a yr	16.5 (394)	17.8 (420)	22.9 (932)	24.5 (978)
Less than once a yr	48.4 (194)**	51.2 (198)*	44.4 (281)**	43.9 (271)**
Dentist 12				
At least once a yr		18.4 (452)		24.4 (986)
Less than once a yr		53.6 (178)**		44.3 (266)**

Norway ( $n = 4211$  in 2007) and ( $n = 3733$  in 2012). Sweden ( $n = 6078$  in 2007) and ( $n = 5697$  in 2012).

Chi-square \*\* $p < .001$ , \* $p < .05$ .

Adjusting for oral health behaviours and beliefs attenuated the education gradients in tooth loss considerably, however, seemingly more strongly so in the Norwegian than in the Swedish cohort. Educational gradients in tooth loss remained significant in the fully adjusted GEE models indicating enduring influences from deprivation at earlier life course stages [22]. Thus, not all educational inequality in tooth loss was explained by the behavioural and attitudinal variables suggesting that other mechanisms are operating. Finally, the merged analyses, revealed a significantly weaker educational disparity in tooth loss among the Swedish than the Norwegian participants, although the prevalence of tooth loss was largest in Sweden at both survey occasions.

The present findings draw strengths from addressing cross-national data of ageing populations and from using

large population based prospective and comparable data sets. A further strength is the time variant or repeated measures of the potential mediators, which takes account of possible changes in behaviour and attitudinal beliefs over time. Nevertheless, the findings presented should be interpreted in the context of some limitations. Only few oral health related behaviours were included in the analyses, leaving out important others, such as for instance a sugary diet. Moreover, only one social exposure variable (education) and one oral outcome (tooth loss) was examined making it difficult to draw firm conclusions regarding why social inequalities in tooth loss exists. Another limitation is that this study did not discriminate between absolute and relative inequality. Previous studies have shown that relative and absolute inequality scales produce different results across the life

**Table 3.** Tooth loss 2007/2012 regressed on time invariant education (2007) and time variant social ties, oral behaviours, beliefs in keeping teeth and dental attendance (2007/2012) in the Swedish cohort.

	Model I OR (95% CI)	Model II OR (95% CI)	Model III OR (95% CI)	Model IV OR (95% CI)
Education (07)				
Higher	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
Lower	<b>1.8 (1.5–2.1)</b>	<b>1.6 (1.3–1.8)</b>	<b>1.4 (1.2–1.7)</b>	<b>1.4 (1.2–1.7)</b>
Social ties (07/12)				
Higher		1	1	1
Lower		1.2 (1.1–1.3)	1.1(1.0–1.3)	1.1 (1.0–1.3)
Brushing (07/12)				
≤once daily		1	1	1
At least twice daily		0.8 (0.6–1.1)	0.8 (0.6–1.1)	0.8 (0.6–1.1)
Fluoride (07/12)				
≤once daily		1	1	1
At least twice daily		0.9 (0.7–1.1)	0.9 (0.7–1.3)	0.9 (0.7–1.3)
Smoking (07/12)				
Smoking		1	1	1
No smoking		<b>0.5 (0.5–0.7)</b>	<b>0.6 (0.5–0.7)</b>	<b>0.6 (0.5–0.6)</b>
Alcohol (07/12)				
Several times a week		1	1	1
More seldom		<b>1.3 (1.1–1.4)</b>	<b>1.2 (1.0–1.3)</b>	<b>1.2 (1.0–1.3)</b>
Belief in teeth (07/12)				
No			1	1
Yes			<b>0.2 (0.1–0.2)</b>	<b>0.2 (0.1–0.2)</b>
Dentist (07/12)				
At least once a year				1
Less than once a year				<b>0.9 (0.8–1.1)</b>

All models adjusted for survey year and sex.  
Bold values indicate significance.

**Table 4.** Tooth loss 2007/2012 regressed on time invariant education (2007) and time variant oral behaviours, beliefs and dental attendance (2007/2012) in the Norwegian cohort.

	Model I OR (95% CI)	Model II OR (95% CI)	Model III OR (95% CI)	Model IV OR (95% CI)
Education (07)				
Higher	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>
Lower	<b>2.6 (2.1–3.3)</b>	<b>2.2 (1.8–2.8)</b>	<b>2.0 (1.6–2.5)</b>	<b>1.9 (1.6–2.4)</b>
Social ties (07/12)				
Higher		1	1	1
Lower		1.1 (0.9–1.3)	1.1 (0.9–1.3)	1.1 (0.9–1.3)
Brushing (07/12)				
≤once daily		1	1	1
At least twice daily		0.8 (0.6–1.1)	0.7 (0.6–1.1)	0.8 (0.6–1.1)
Fluoride (07/12)				
≤once daily		1	1	1
At least twice daily		0.8 (0.6–0.9)	0.6 (0.6–1.1)	0.7 (0.6–1.1)
Smoking (07/12)				
Smoking		1	1	1
No smoking		<b>0.5 (0.4–0.6)</b>	<b>0.5 (0.4–0.6)</b>	<b>0.5 (0.4–0.6)</b>
Alcohol (07/12)				
Several times a week		1	1	1
More seldom		<b>1.3 (1.3–1.6)</b>	<b>1.2 (1.1–1.5)</b>	<b>1.3 (1.1–1.5)</b>
Belief in teeth (07/12)				
No			1	1
Yes			<b>0.1 (0.1–0.2)</b>	<b>0.1 (0.1–0.2)</b>
Dentist (07/12)				
At least once a year				1
Less than once a year				<b>1.2 (1.0–1.4)</b>

All models adjusted for survey year and sex.  
Bold values indicate significance.

course [34]. Persons in lower socioeconomic status groups tend to die early creating a healthier population in the remaining cohorts. Selection bias might have occurred as individuals lost to follow-up tended to be more socially disadvantaged than those who remained across the survey years. However, inverse probability weights, IPW, were attached to individuals included in the analyses to restore representation of those lost to follow-up. Finally, the outcome of tooth loss was self-reported and did not follow

current clinical criteria, whereas social desirability bias may have distorted reports of oral hygiene measures, smoking and alcohol consumption. Nevertheless, self-reported health outcomes, including number of remaining teeth, have been found to be valid indicators of oral health and satisfactory measures in cross-national comparisons [35,36].

The present findings with the Norwegian and Swedish cohorts accord with previous studies suggesting that social disparities in tooth loss prevails into older ages and might

increase or decrease with ageing dependent on the social indicator and the type of scale used in analyses (8, 15-17). However, this study adds new information in that education related inequality appeared to be larger in Norway than in Sweden, two related Scandinavian well-fare states. Shen and Listl [29] reported strong differences in oral health inequalities of older people across Europe, especially among those countries with similar social security- and health care systems. In that study [29], including Denmark and Sweden but not Norway, Sweden occurred as the best performing country with the lowest degrees of inequality in oral health measures. The differences between Norway and Sweden on education related inequality in tooth loss observed in this study, might be attributed to country differences in organisation and financing of the dental health care services. Whereas Norway has social security- and well fare benefits schemes by which only particular groups are refunded but lacks reimbursement generally for the adult population, Sweden implements benefit schemes of a more universal nature [3]. Moreover, a free outreach system to actively seek those with most need of oral health care has been implemented in Sweden since 1999. Nevertheless, country variation in educational inequality might to some extent be attributed to slight differences in the social meaning of educational level between the two cohorts.

Tackling social inequalities in health must be based on an understanding of how social indicators influence disease risk as well as the consequences of diseases [37]. The present findings suggest that a number of oral health related behaviours and beliefs in keeping teeth for life may explain parts of the educational disparities in tooth loss because those behavioural and attitudinal risk factors are unevenly distributed across educational groups or more specifically, presented more frequently among lower educational- compared to higher educational participants. The only exception to this rule was alcohol consumption which was most prevalent among higher educated and associated with less tooth loss. This finding accord with those of previous studies (14-17) and suggest that the association between alcohol consumption and tooth loss is not fully understood. The present findings confirm those of previous studies, by suggesting behavioural and attitudinal factors as potential mediators of inequalities in oral health, but is discordant with others. Celeste et al. [38] published a study with longitudinal data showing that 1.4% of the ethnic inequality in tooth loss was explained by several oral health related behaviours. Sabbah et al. [26], in a prospective study of Finnish adults, found that education related inequality in caries increments completely disappeared after adjustment for behavioural and psychological factors. Vettore et al. [23] found no evidence of an indirect effect of smoking in the association between social position and tooth loss. Accordingly, Peres et al. [25] and Bernabe et al. [24] found little support for the role of behavioural and psychological factors in the explanation of social inequality in oral health. Guarnizo-Herreno et al. [28] investigated the extent to which behavioural factors accounted for occupational and educational inequalities in a functional dentition across European well fare regimens and

found higher contribution of those factors in the Scandinavian (Sweden, Denmark, Finland) countries compared to other well fare states. In an earlier national Swedish study, Wamala et al. [30] revealed that more than 60% of the socio-economic disparities in self-rated oral health was explained by lack of oral care availability. Discordance between study findings might be attributed to the fact that different statistical approaches have been utilised in the analyses. Whereas this study used a traditional approach, based on Baron and Kenny [39] where change in estimates with and without the proposed mediator (s) would indicate its significance as a mediator, others have used more developed approaches such as Structural Equation Models (SEM) [23] and counterfactual models allowing for causal interpretation [32]. Discordance between the present and previous studies might also be attributed to use of various oral health outcomes, behavioural factors, social measures as well as the populations included in the analyses.

## Conclusion

Education related inequality in tooth loss was stronger in the Norwegian than in the Swedish cohort across the survey years. Oral behaviours and attitudinal beliefs played a role in explaining the educational gradients across time. This illustrates a necessity to promote oral health enhancing behaviours and attitudinal beliefs, particularly so in lower educational groups.

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