

# A Multilevel Study of Socio-economic Inequalities in Self-reported Oral and General Health in South-east Norway

Heidi Lyshol (✉ [heidi.lyshol@fhi.no](mailto:heidi.lyshol@fhi.no))

Norwegian Institute of Public Health

Liv Grøtvedt

Norwegian Institute of Public Health

Tone Natland Fagerhaug

Center for Oral Health Services and Research (TkMidt)

Astrid J Feuerherm

Center for Oral Health Services and Research (TkMidt)

Gry Jakhelln

Norwegian Association of Dental Hygienists

Abhijit Sen

Norwegian University of Science and Technology

---

## Research Article

**Keywords:** Socio-economic Inequalities, General Health, socioeconomic gradients

**Posted Date:** December 29th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-1158808/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

This study assesses the association between socioeconomic determinants and self-reported health using data from a regional Norwegian health survey. A total of 9,068 participants 25+ were included. Survey data were linked to registry data on education and personal income. Self-reported oral health and general health were separately assessed and categorized into 'good' and 'poor'. The exposures were educational level, personal income, and economic security. Prevalence ratios (PRs) were computed to assess the associations between socioeconomic determinants and self-reported health using multilevel Poisson regression.

Participants with low education or income had poorer oral and general health than those with more education or higher income. Comparing the highest education level versus the lowest, adjusted PRs for poor oral and general health were 1.44 (95%CI 1.26-1.65) and 1.53 (95%CI 1.35-1.74). Correspondingly, with the highest income quintile versus the lowest, estimates were 1.64 (95%CI 1.39-1.94) and 2.34 (95%CI 1.97-2.79) for oral and general health. Lack of economic security was also significantly associated with poor self-reported oral and general health. Positive linear trends between levels of education and income were documented for both outcomes ( $P$ -linear trends  $<0.001$ ), including a pattern of socioeconomic gradients, both for oral and general health.

## Introduction

Oral health is an integral part of general health,<sup>1,2</sup> and a growing body of research has shown that both oral and general health vary with social determinants.<sup>2-6</sup> Good oral and general health are associated with higher socioeconomic status, and poor oral and general health with lower socioeconomic status.<sup>4,7,8</sup> These differences are often found to vary from top to bottom as gradients, with increasingly poor health with each lower category of the socioeconomic indicators.<sup>5,9</sup>

Despite being largely preventable, dental caries is the most common disease globally, with increasing prevalence in many countries.<sup>1,2</sup> In all countries, dentistry needs to be more integrated with primary care services, and more focused on promoting and maintaining oral health.<sup>2,9</sup> In 23 European countries, higher dental care coverage was found to be associated with smaller income inequalities in foregone dental care.<sup>10</sup> A recent Norwegian study found foregone dental visits due to financial reasons to be associated with poor self-assessed oral health, independent of age.<sup>11</sup> However, the importance of stratifying for age and gender when studying socioeconomic health inequalities was emphasized.<sup>8,11</sup>

Self-reported oral and general health have been suggested as reliable measures of health status. A study including data from 19 European countries found self-reported general health to be a valid and predictive measure for morbidity.<sup>12</sup> Another study from the USA demonstrated moderate to strong association of self-reported health with mortality.<sup>13</sup> Furthermore, a study found educational differences in the significance of self-reported general health for mortality in men, but not in women.<sup>14</sup>

Self-reported oral health has been found to be a valid estimate compared with clinical records, and with oral health-related quality of life.<sup>15-17</sup> Fewer studies have examined social inequalities in relation to oral health<sup>17-19</sup> than general health.<sup>9,12,20-22</sup> Inequalities persist across most health outcomes, and there exists a clear social gradient.<sup>9,22</sup>

Few studies have investigated the similarities between social gradients concerning self-reported oral health and general health.<sup>4,7,8,23</sup> Norway is an interesting country in this respect, since the financing systems for oral health care and general health care differ,<sup>24</sup> and because social stratification seems to be less pronounced than elsewhere.<sup>25</sup> The present health care system in Norway covers all major expenses for somatic and mental health care. In contrast, the great majority of adults aged over 20 are expected to cover their own oral care costs in full.<sup>24</sup> Due to the differences in the financing systems for oral and general health care, we wanted to investigate the association of socioeconomic factors in relation to self-reported oral and general health status of individuals dwelling in different municipalities of South-East Norway. The multilevel modelling approach was chosen due to the hierarchical or nested data structure, i.e., individuals (at a lower level) nested within different municipalities (at a higher level).

## Methods

From November 2015 to February 2016, a cross-sectional health interview survey was carried out in 44 municipalities of Vestfold, Aust-Agder, and Vest-Agder counties in Norway. As the main purpose of the survey was to support public health work at the local level, efforts were made to obtain a relatively large selection in each municipality, providing useful information at the administration level.<sup>26</sup> Our gross sample comprised around one-tenth of the Norwegian population, and was near the national average regarding education, individual income and age distribution.

A total of 22,700 adults aged 18 years or older living in the three counties were randomly selected from the Norwegian Population Registry, excluding individuals in prisons and nursing homes, and invited to participate. The response rate was 42.7% (9692 respondents).<sup>26</sup> Information from the population registry (municipality, age, and sex) was delivered along with the questionnaire data.

Questionnaire data were linked to registries in Statistics Norway for information about education and personal income, using the personal identification number assigned to every resident of Norway. The educational scales are regularly harmonized with the International Standard Classification of Education (ISCED).<sup>26,27</sup>

### Exposures

Highest achieved educational levels were grouped into three categories, primary school ( $\leq 10$  years of schooling; ISCED categories 0-2), high school (11-13 years of schooling; ISCED categories 3-4), and higher education (any college or university education;  $\geq 14$  years of schooling; ISCED categories 5+). Personal annual income after taxation was divided into quintiles, with Q1 as the lowest and Q5 as the

highest income group. In 1000 NOK, Q1 = <216 (<24,000 USD), Q2 = 216-277 (24 – 31,000 USD), Q3 = 277-335 (31 – 38,000 USD), Q4 = 335-417 (38 – 47,000 USD), and Q5 = >417 (>47,000 USD).

Previous studies have included a question on economic security, i.e., whether the respondents could manage to raise a specific sum to cover an unexpected expense within one month.<sup>7,28</sup> We used a comparable question: “Could your household afford to pay an unexpected bill of 10,000 NOK (ca 1,100 USD) without having to take out a loan or receive financial help?” Economic security was categorized as ‘yes’ (affording), and ‘no’ (not affording to pay).

## Outcome

Self-reported oral and general health were two different outcomes and were assessed by the questions “How do you rate your health in general?” and “How do you rate your oral health?” respectively, with five responses: ‘very good’, ‘good’, ‘fair’, ‘poor’, and ‘very poor’. This corresponds to the wording used by Eurostat<sup>29</sup> with ‘very good’ as the highest ranking. In line with previous studies,<sup>6,7</sup> we constructed binary outcomes separately for oral and general health. We combined ‘very good’ and ‘good’ into *good*, and ‘fair’, ‘poor’, and ‘very poor’ into *poor*.<sup>6</sup>

## Confounders

The centrality index reflects a municipality’s degree of centrality and is based on the population’s commuting time to workplaces and high-order service functions.<sup>30</sup> The centrality index has shown relevance regarding access to medical and dental services. Living in the more central municipalities increases the probability for visits at the dentist, as well as for receiving reimbursements for dental treatment.<sup>31</sup> Based on Statistic Norway’s report, the municipalities were grouped as *least central*, *less central*, *quite central* and *most central*.<sup>30</sup>

Ages were grouped into the categories: *25-44*, *45-66*, *67-79*, and *80+* years. Respondents aged 18-24 years were excluded from this study because most of them have not finished their tertiary education and similar considerations may be relevant regarding their income.<sup>8,20</sup> Marital status was asked by one question with two categories: *married or cohabiting*, and *single*.

## Statistical Analyses

All statistical analyses were performed using STATA v16. Descriptive statistics of categorical variables were presented as frequency and percentages. Binary outcome variables for general health and oral health (‘0’ as good health, and ‘1’ as poor health) were constructed. The exposure variables were: education, with higher education as reference group; income level, categorized into quintiles, with Q5 (highest) as reference group, and economic security, with yes (able to pay unforeseen expense) as reference group. As our outcomes of interest are very common (i.e. prevalence more than 10%) and thus Prevalence Ratio (PR) as a measure of association is generally suggested rather than Odds Ratio (OR) to avoid overestimation of our study results.<sup>32</sup> Furthermore, due to the hierarchical nature of the data, we

performed multilevel Poisson regression analyses with robust variance estimator.<sup>33</sup> We performed two-level analyses, with (a) individuals at level 1, and (b) municipalities (n=44) at level 2 using the same set of exposures in multivariable analyses. Model 1 was the empty model, Model 2 was adjusted for the confounders age, sex, and marital status, and included the exposures educational level, income level and economic security, and Model 3 contained all variables from Model 2 and additional adjustment for centrality index as confounder. The intraclass correlation coefficient,<sup>33</sup> a measure of the amount of variation due to a given level, was also computed. Separate analyses for each outcome were performed.

## Results

Descriptive data are presented in Table 1. The study population included 9,068 participants aged 25+. The mean age was 55.96 (Standard Deviation 15.55). Women were younger, had attained more education, had lower income level, less possibility to bear expenses of 10,000 NOK without resorting to loans, and had relatively better oral health than men. The levels of self-reported general health were very similar in men and women.

Table 1  
Baseline description of the study sample

	<b>Total n=9068</b>	<b>Male n=4290</b>	<b>Female n=4778</b>
Age categories, years			
25-44	2334 (25.7)	1027 (24.0)	1307 (27.4)
45-66	4174 (46.0)	2040 (47.6)	2134 (44.7)
67-79	1980 (21.8)	979 (22.8)	1001 (21.0)
≥80	580 (6.4)	244 (5.7)	336 (7.0)
Marital status			
Married, cohabiting	6770 (74.7)	3360 (78.3)	3410 (71.4)
Single	2203 (24.3)	885 (20.6)	1318 (27.6)
Missing	95 (1.1)	45 (1.1)	50 (1.1)
Education level			
Primary school, ≤ 10 years	1388 (15.3)	606 (14.1)	782 (16.4)
High School, 11-13 years	3858 (42.5)	1941 (45.2)	1917 (40.1)
Higher education, ≥ 14 years	3668 (40.4)	1656 (38.6)	2012 (42.1)
Missing	154 (1.7)	87 (2.03)	67 (1.4)
Personal annual income, quintiles <sup>a</sup> (1000 NOK)			
Q1: <216	1765 (19.5)	354 (8.3)	1411 (29.6)
Q2: 216-277	1765 (19.5)	647 (15.1)	1118 (23.4)
Q3: 277-335	1765 (19.5)	802 (18.7)	963 (20.2)
Q4: 335-417	1765 (19.5)	1004 (23.4)	761 (16.0)
Q5: >417	1765 (19.5)	1363 (31.8)	402 (8.4)
Missing	229 (2.5)	115 (2.7)	114 (2.4)
Economic security			

a 14 cases were incorrectly recorded, therefore they were excluded from the analysis for variable 'income'.

b Centrality (1-4) is influenced by travel time to work and the availability of service features.

	<b>Total</b> <b>n=9068</b>	<b>Male</b> <b>n=4290</b>	<b>Female</b> <b>n=4778</b>
Yes	7595 (83.8)	3699 (86.2)	3896 (81.5)
No	1318 (14.5)	531 (12.4)	787 (16.5)
Missing	155 (1.7)	60 (1.4)	95 (2.0)
<b>Centrality<sup>b</sup></b>			
Centrality 1, most central	939 (10.4)	431 (10.1)	508 (10.6)
Centrality 2, quite central	5977 (65.9)	2821 (65.8)	3156 (66.1)
Centrality 3, less central	1599 (17.6)	764 (17.8)	835 (17.5)
Centrality 4, least central	553 (6.1)	274 (6.4)	279 (5.8)
<b>Self-reported oral health</b>			
Very good	2268 (25.0)	908 (21.2)	1360 (28.5)
Good	4500 (49.6)	2179 (50.8)	2321 (48.6)
Fair	1500 (16.5)	781 (18.2)	719 (15.1)
Poor	555 (6.1)	304 (7.1)	251 (5.3)
Very poor	152 (1.7)	80 (1.9)	72 (1.5)
Missing	93 (1.0)	38 (0.9)	55 (1.2)
<b>Self-reported general health</b>			
Very good	2318 (25.6)	1056 (24.6)	1262 (26.4)
Good	4388 (48.4)	2115 (49.3)	2273 (47.6)
Fair	1542 (17.0)	719 (16.8)	823 (17.2)
Poor	644 (7.1)	320 (7.5)	324 (6.8)
Very poor	81 (0.9)	39 (0.9)	42 (0.9)
Missing	95 (1.1)	41 (0.1)	54 (1.1)
a 14 cases were incorrectly recorded, therefore they were excluded from the analysis for variable 'income'.			
b Centrality (1-4) is influenced by travel time to work and the availability of service features.			

Table 1:

Table 2:

Table 2  
Self-reported general and oral health by education, personal income and economic security

<b>Education level</b>	<b>Primary School</b>	<b>High School</b>	<b>Higher Education</b>		
	<b>≤ 10 years</b>	<b>11-13 years</b>	<b>≥ 14 years</b>		
Oral health <sup>a</sup>					
N (% with poor health)	482 (35.3)	1047 (27.4)	630 (17.3)		
N (% with good health)	884 (64.7)	2772 (72.6)	3010 (82.7)		
General health <sup>a</sup>					
N (% with poor health)	547 (40.1)	1088 (28.5)	597 (16.4)		
N (% with good health)	816 (59.9)	2728 (71.5)	3046 (83.6)		
<b>Personal annual income level, quintiles (1000 NOK)</b>	<b>Q1: &lt;216</b>	<b>Q2: 216-277</b>	<b>Q3: 277-335</b>	<b>Q4: 335-417</b>	<b>Q5: &gt;417</b>
Oral health <sup>a</sup>					
N (% with poor health)	552 (31.7)	522 (30.1)	425 (24.2)	343 (19.6)	295 (16.8)
N (% with good health)	1188 (68.3)	1215 (70.0)	1329 (75.8)	1410 (80.4)	1459 (83.2)
General health <sup>a</sup>					
N (% with poor health)	646 (37.0)	595 (34.3)	432 (24.7)	320 (18.3)	232 (13.2)
N (% with good health)	1098 (63.0)	1141 (65.7)	1320 (75.3)	1426 (81.7)	1522 (86.8)
<b>Economic security</b>	<b>Yes</b>	<b>No</b>			
Oral health <sup>a</sup>					
N (% with poor health)	1600 (21.2)	562 (43.1)			
N (% with good health)	5945 (78.8)	741 (56.9)			

<sup>a</sup> 'Poor' is defined as those who self-reported general health or oral health as fair, poor and very poor. 'Good' is defined as those who self-reported general health as good and very good.

<b>Education level</b>	<b>Primary School</b>	<b>High School</b>	<b>Higher Education</b>
	<i>≤ 10 years</i>	<i>11-13 years</i>	<i>≥ 14 years</i>
General health <sup>a</sup>			
N (% with poor health)	1690 (22.4)	522 (39.9)	
N (% with good health)	5845 (77.6)	787 (60.1)	
<sup>a</sup> 'Poor' is defined as those who self-reported general health or oral health as fair, poor and very poor. 'Good' is defined as those who self-reported general health as good and very good.			

Table 3:

Table 3

Multilevel analyses of socioeconomic determinants in relation to self-reported oral and general health.  
Prevalence ratio<sup>1</sup>

Variables	<i>Oral Health</i>			<i>General Health</i>		
	Model 1 PR (95% CI)	Model 2 PR (95% CI)	Model 3 PR (95% CI)	Model 1 PR (95% CI)	Model 2 PR (95% CI)	Model 3 PR (95% CI)
Fixed effect						
Intercept <sup>2</sup>	-1.379 (0.030)	-1.935 (0.100)	-1.977 (0.078)	-1.346 (0.029)	-2.532 (0.0862)	-2.487 (0.105)
<b>Individual-level factors</b>						
Education level						
Primary school ≤ 10 years		1.45 (1.27- 1.65)	1.44 (1.26- 1.65)		1.54 (1.35- 1.75)	1.53 (1.35- 1.74)
High school 11- 13 years		1.33 (1.19- 1.48)	1.32 (1.19- 1.47)		1.33 (1.20- 1.48)	1.32 (1.19- 1.47)
Higher education ≥ 14 years		1.00 (ref)	1.00 (ref)		1.00 (ref)	1.00 (ref)
p-linear trend		<0.001	<0.001		<0.001	<0.001
Personal annual income, quintiles						
Q1 (Lowest)		1.65 (1.40- 1.95)	1.64 (1.39- 1.94)		2.35 (1.98- 2.80)	2.34 (1.97- 2.79)
Q2		1.54 (1.32- 1.80)	1.53 (1.31- 1.80)		2.17 (1.84- 2.56)	2.16 (1.83- 2.55)

<sup>1</sup> Model 2 was adjusted for age (categories), sex and marital status. Model 3 includes variables in Model 2 plus centrality.

PR: Prevalence Ratio. SE: Standard Error. PVC: Proportional Change in Variance. ICC: Intra class correlation. AIC=Akaike information criterion, BIC = Bayesian information criterion. Proportion change in variance (PVC%), a measure of change in area level.

<sup>2</sup> Intercept is presented as coefficients (robust standard error).

	<i>Oral Health</i>		<i>General Health</i>			
Q3		1.32 (1.13- 1.54)	1.31 (1.12- 1.54)		1.71 (1.45- 2.02)	1.70 (1.44- 2.01)
Q4		1.16 (0.99- 1.35)	1.15 (0.99- 1.35)		1.38 (1.16- 1.64)	1.38 (1.16- 1.63)
Q5 (Highest)		1.00 (ref)	1.00 (ref)		1.00 (ref)	1.00 (ref)
p-linear trend		<0.001	<0.001		<0.001	<0.001
<b>Economic security</b>						
No		1.84 (1.65- 2.05)	1.85 (1.66- 2.06)		1.58 (1.42- 1.77)	1.59 (1.42- 1.77)
Yes		1.00 (ref)	1.00 (ref)		1.00 (ref)	1.00 (ref)
<b>Random-effect parameters</b>						
Level 1 (individuals)	8975	8589	8589	8973	8581	8581
Level 2 (municipalities)	44	44	44	44	44	44
Level 2, Variance, $\sigma^2_u$ (SE)	0.011 (0.007)	0.004 (0.005)	0.0005 (0.0034)	0.008 (0.005)	8.22x10 <sup>-34</sup> (2.51x10 <sup>-18</sup> )	2.09x10 <sup>-34</sup> (8.51x10 <sup>-34</sup> )
PVC (%)	Ref.	63.6	95.4	Ref.	99.9	99.9
ICC (%)	0.89	0.55	0.27	0.71	7.51x10 <sup>-32</sup>	7.36x10 <sup>-32</sup>
<b>Model fit statistics</b>						
AIC	10000.17	8946.109	8946.839	10134.67	8953.322	8953.681
BIC	10014.37	9055.983	9073.887	10148.88	9052.125	9073.655
<sup>1</sup> Model 2 was adjusted for age (categories), sex and marital status. Model 3 includes variables in Model 2 plus centrality.						
PR: Prevalence Ratio. SE: Standard Error. PVC: Proportional Change in Variance. ICC: Intra class correlation. AIC=Akaike information criterion, BIC = Bayesian information criterion. Proportion change in variance (PVC%), a measure of change in area level.						
<sup>2</sup> Intercept is presented as coefficients (robust standard error).						

Table 2 represents the distribution of socioeconomic determinants in relation to oral and general health. We observed that a higher proportion of individuals with less education reported poor oral or general health than those with more education. Similarly, a considerably higher proportion of individuals with poor oral and general health were found in the lowest quintile (Q1) of the income level than in the highest quintile (Q5). Furthermore, individuals who could afford to pay 10,000 NOK without resorting to loans reported considerably better oral and general health than those who could not.

Table 3 shows the results of multilevel Poisson regression with self-reported oral or general health as the outcome. Model 1 included no explanatory variables, i.e. only the outcome, and an intercept (constant) was used to illustrate the total variance in oral health as well as general health associated with municipality-level characteristics. After adjustments for age, sex, and marital status in Model 2, those with primary education were 1.45 times and 1.54 times more likely to report poor oral and general health, respectively, than the highest educational group. Regarding income, individuals within the lowest quintile (Q1) were 1.65 and 2.35 times more likely to report poor oral health and general health, respectively, than the highest quintile (Q5). The relatively higher PRs for general health than for oral health in the two lowest income groups indicate a stronger association with income for general health. Furthermore, individuals who could not afford to pay the sum of 10,000 NOK without resorting to loans were 1.84 times more likely to report poor oral health, and 1.58 times more likely to report poor general health, than those who could afford to pay. After further adjustment for the centrality variable in Model 3, the PRs from Model 2 for oral and general health remain almost unchanged. Overall, we observed positive linear trends between education level and oral and general health ( $P_{\text{linear trend}} < 0.001$  for both outcomes). Comparable trends were observed regarding income level.

In the multilevel analysis (random-effect parameters), the intercept and intra-class correlation coefficient<sup>33</sup> for municipalities were slightly different from zero in all the models, suggesting that the PR varied slightly between municipalities which suggests that multilevel modelling was not required. For Model 1 (empty model), the intra class correlation (ICC) for level 2 for oral health was 0.89%. This means that around 0.89% of the variance in oral health was explained by systematic differences between municipalities. Compared to Model 1 (as reference), a proportional change in the variation (PVC) of outcome *oral health* across municipalities after the inclusion of age, sex, marital status, education level, income, economic security in Model 2 was 63.6% and ICC value was 0.55%. Including the centrality variable in Model 3, proportional change in the variation of outcome was nearly 95% and decreased further the ICC value to 0.27%, suggesting that very little of the variation in oral health is explained by random differences between municipalities. The value of Akaike's information criteria (AIC) and Bayesian information criteria (BIC) were reduced with the addition of covariates in Model 2, suggesting that the latter model was an improvement. However, we observed that Model 2 was the best fitting model as suggested by the higher values of AIC and BIC in Model 3. Similar results were observed in context to general health. Compared to Model 1 (empty model), nearly 99.9% of the proportional change in the variance of the outcome *general health* was attributable to the differences in the characteristics of the individuals. These were age, sex, marital status, income quintiles, education, and centrality of

municipalities, the latter possibly implying improved access to hospitals and oral care clinics. Indeed, the value of ICC was also very low across all models. The smaller value of AIC and BIC observed in Model 2 suggests it to be the best fitted model (or, better explanatory model) among other models.

In the subgroup analyses for oral health by gender, we observed that the PRs for poor oral health by education level, income level and economic security were somewhat higher among women than among men. According to educational attainment, there was a slightly higher increase in the PRs for poor general health among women than among men (see Supplement Table 1).

In the subgroup analyses for oral health by age (dichotomized at median age, i.e., 55 years), we observed marginally higher PRs for poor health related to educational level, income level and economic security among those below 55. Likewise, for general health the results were comparable (see Supplement Table 2). Analysing for age as a continuous variable instead caused little to no change in the results (data not shown).

## Discussion

In this large cross-sectional study from Norway, we investigated the association between socioeconomic determinants and self-reported oral and general health using multilevel data. Overall, a multilevel modelling approach demonstrated that lower level of education, income, or lack of economic security were associated with an increased risk of reporting poor oral and general health at an individual level (level 1) after adjustments for age, sex, marital status, and centrality index. For all three socioeconomic determinants, we found small socioeconomic differences between self-reported oral and general health.

In line with our findings, a cross-sectional study from the United States (NHANES phase III, 1988-1994) including participants 17 years or older, suggested clear income and education gradients in both oral and general health, indicating that the same social determinants may be involved in both outcomes.<sup>4</sup> Another large cross-sectional study from the same NHANES Survey (phases I-VIII, 1999-2014) also suggested that higher levels of education and income were associated with higher odds of reporting *excellent* or *very good* oral and general health.<sup>3</sup> Furthermore, Borrell and Baquero's study from the United States also reported higher levels of education and income to be positively associated with self-reported oral and general health.<sup>23</sup>

The investigation led by Hakeberg and Boman<sup>7</sup> was conducted in a similar setting and reported similar findings to our study, except for a steeper gradient in ORs for poor general health according to income level. One of the reasons for this discrepancy could be their use of household income in four groups versus personal income in five groups in our study. Additionally, their sample included the age group 19-24 years, whereas in our study this group was excluded. Another reason could be presentation of ORs, which are more often overestimated than PRs. Hakeberg and Boman also reported positive associations between economic security and oral and general health, while the magnitude of effect measures regarding general health was slightly higher in their study than in ours. This could be explained by

different categorisation of the economic security variable, which might have led to underestimation of our study findings.

Generally, the health system in Norway covers all major expenses for somatic and mental health care except oral care, while only a few selected oral treatments are covered for small groups of the population. The Swedish general health care system is similar to the Norwegian system, while the Swedish oral care insurance scheme ensures that unexpectedly high oral treatment costs are reduced.<sup>24</sup> Economic security seems to be an important indicator for measuring socioeconomic inequalities in both oral health and general health in both countries, and may encompass another socioeconomic dimension of poverty than the lowest quintiles of income.<sup>34</sup> The variable *economic security* may therefore be of interest when comparing differences between oral and general health. In our study, lack of economic security was associated with poor oral and general health, and this association was stronger for oral health than for general health, though not significant.

Hadler-Olsen and Jönsson<sup>11</sup> studied self-reported oral health and the use of oral health services in the adult population in Northern Norway. Surprisingly, and in contrast to our study, they did not find education level to be significantly associated with self-reported oral health. This discrepancy may be influenced by their relatively smaller sample size, and possibly the use of education variables based on questionnaire rather than registry data, as in our study. Especially young adults faced financial barriers against receiving dental health services and also had poorer self-reported oral health.<sup>11</sup> In our study, the PR for self-reported poor oral health was nearly doubled (PR=1.85) in the population group which lacked economic security.

Maldi et al. reported time trends in income and educational inequalities using three waves of cross-sectional data and found marked sex differences, including more fluctuating trends in self-reported health outcomes for women than for men.<sup>8</sup> The overall sex differences in our study were found to be small, but the risk of poor oral health in the lowest income quintile was higher in women (PR 2.84) than in men (PR 1.47), indicating that women may be more vulnerable than men to having low income, possibly contributing to difficulties in consulting dental care.<sup>31</sup>

Overall, we found a similar socioeconomic distribution for self-reported oral and general health. The relatively generous social benefits for those in the lowest income groups in Norway may partly compensate for the dental treatment costs. Another reason for the similarity may be the mutual influence of health problems between two outcomes, in that poor general health will influence oral health negatively, and vice versa. Beyond the scope of this paper, additional questions about dental visits, and postponed dental visits for financial reasons, could have given opportunities to investigate other dimensions of socioeconomic differences in oral health.

Even in wealthy countries like Norway, social conditions influence individuals' choices, which are limited by nutrition policy, price levels and cultural traditions.<sup>35</sup> Education can be seen as a proxy for many lifestyle factors.<sup>36</sup> Most of the recommended measures to combat socioeconomic inequalities in health

are directed towards childhood, upbringing and education, but also advocate strengthened measures for smoking cessation and taxation of sweetened beverages.<sup>2,35</sup> Income and wealth may act as the direct, main determinants of health inequalities, but the influencing factors are also linked to position and social structure.<sup>37</sup> Long-term economic and social stress are believed to affect biological processes that can increase the predisposition to disease. Increased financial stress is found to be related to increased levels of stress hormones and cariogenic bacterial counts in dental caries.<sup>38</sup> Similar mechanisms may affect other disease courses as well. A better integration of dentistry with primary care services may be a tool with opportunities to reduce the social inequality gap in oral health.<sup>1,2,35</sup>

Our study has contributed with new knowledge in different ways. For instance, we applied a multilevel modelling approach to assess the influence both of municipality-level (higher level) and individual-level factors (lower level). Three exposures were used to measure different dimensions of socioeconomic inequality; education, income, and economic security. This study contributes to updating knowledge about the state of socioeconomic disparities in self-reported oral and general health in the Nordic countries, as we found few studies from this area,<sup>9,18,20,28</sup> and especially few recent studies.<sup>7,8,11</sup>

Our study has several strengths. First, we had adequate power to draw statistical inference of our study findings. Second, the sample was randomly drawn from three large counties, which made our study relatively representative for the Norwegian population<sup>26</sup>. Third, the data on education and personal income were obtained from the national population-based registers of Statistics Norway, which largely reduces the possibility of information bias. Fourth, our study examined the contribution of personal income rather than family income. In Norway, where the overwhelming majority of women are in paid work,<sup>39</sup> personal income may be a better indicator than family income. Fifth, for our outcomes, we used validated questions, corresponding with comparable objective variables.<sup>12,13,16,40</sup> Sixth, we included an important confounder, the *centrality index*, to assess the association between socioeconomic determinants and oral and general health, which – to our best knowledge – previously no study had included.

Our study also has several limitations. First, using self-reported questionnaires might have led to recall bias. Second, due to the cross-sectional nature of the study, the issue of reverse causality cannot be ruled out. Third, the issue of residual confounding cannot be ignored because of unmeasured, mismeasured or misspecified variables. Fourth, there might be a certain degree of selection bias in the direction of overrepresentation of middle aged, women and highly educated.<sup>26</sup> Fifth, information about the use of dental services and time since the last visit was not included in the questionnaire. This could have improved and expanded our analyses of socioeconomic differences in oral health.

## Conclusions

This study fills a gap of knowledge, as few recent studies of self-reported oral and general health have been carried out in the Nordic countries. Self-reported oral and general health were associated with

educational level, income level and economic security in a pattern of gradients with positive linear trends. Including oral health conditions along with other somatic and mental diseases within the health care system may contribute to improving both oral and general health among people in low socioeconomic groups.

## Declarations

### Acknowledgements

The previous county councils of Vestfold, Aust-Agder and Vest-Agder (now the County Councils of Vestfold and Telemark and the County Council of Agder) allowed us to perform the analyses and write the paper.

We owe sincere thanks to Rune Johansen at the Norwegian Institute of Public Health for his invaluable contribution to the original data collection as well as preparing the data file for analyses.

The data were collected by Kantar TNS (formerly TNS Gallup).

### Author contributions

HL, LG, TNF, AJF, GJ and AS contributed to the writing of the paper.

HL and LG helped plan the data collection and designed the questionnaire, LG managed data access, HL, LG, TNF, AJF, GJ and AS conceived and designed the analysis, AS and LG analysed the data, HL and LG wrote the manuscript, and TNF, AJF, GJ and AS commented on the development of the paper.

All authors read and approved the final manuscript.

### Additional information

### Funding

The data collection was co-funded by the county councils of Vestfold, Aust-Agder and Vest-Agder, the Norwegian Institute for Public Health and the Norwegian Ministry of Health and Care Services.

None of the authors received any funding for the work on the article.

### Competing interests

The authors declare no competing interests.

### Ethical approval and consent to participate

This study was conducted under license from the Norwegian Data Protection Authority, ref. 14/01453-3/GRA. A Data Protection Impact Assessment (DPIA) was conducted at the Norwegian Institute of Public

Health in 2019. Permission to merge survey data with national registry data was obtained from relevant data owners; Statistics Norway, the Norwegian labour and Welfare Administration (NAV) and the Norwegian Tax Administration. All methods were carried out in accordance with relevant guidelines and regulations.

#### Consent for publication

The participants were drawn from the National Population Registry and invited through a letter. The letter specified how data should be used, including for research. Consent was given upon participation in the survey.

#### Availability of data and materials

Anonymised data used in this study may be available upon request from the Norwegian Institute of Public Health (NIPH) and after permission from the county councils of Vestfold, Aust-Agder and Vest-Agder.

Extra restrictions apply to the availability of the data set used in this article linked to variables from national registries. This requires permission from the registry owners and the Norwegian Data Protection Authority.

## References

1. Petersen PE. Global policy for improvement of oral health in the 21st century–implications to oral health research of World Health Assembly 2007, WHO. *Community dentistry and oral epidemiology*. 2009;**37**(1):1-8.
2. Peres MA, Macpherson LM, Weyant RJ, et al. Oral diseases: a global public health challenge. *Lancet*. 2019;**394**(10194):249-260.
3. Li KY, Okunseri CE, McGrath C, Wong MC. Self-Reported General and Oral Health in Adults in the United States: NHANES 1999-2014. *Clinical, Cosmetic Investigational Dentistry*. 2019;**11**:399.
4. Sabbah W, Tsakos G, Chandola T, Sheiham A, Watt R. Social gradients in oral and general health. *J Dent Res*. 2007;**86**(10):992-996.
5. Marmot M, Bell R. Social determinants and dental health. *Adv Dent Res*. 2011;**23**(2):201-206.
6. Farmer J, Phillips RC, Singhal S, Quinonez C. Inequalities in oral health: Understanding the contributions of education and income. *Canadian J Public Health*. 2017;**108**(3):e240-e245.
7. Hakeberg M, Boman UW. Self-reported oral and general health in relation to socioeconomic position. *BMC Public Health*. 2018;**18**(1):63.

8. Maldi KD, San Sebastian M, Gustafsson PE, Jonsson F. Widespread and widely widening? Examining absolute socioeconomic health inequalities in northern Sweden across twelve health indicators. *International J for Equity in Health*. 2019;**18**(1):1-12.
9. Dahl E, Bergsli H, van der Wel KA. *Review of social inequalities in health in Norway*. Oslo, Norway: Høgskolen i Oslo og Akershus. Fakultet for Samfunnsfag/Sosialfag; 2014.
10. Elstad JI. Dental care coverage and income-related inequalities in foregone dental care in Europe during the great recession. *Community dentistry and oral epidemiology*. 2017;**45**(4):296-302.
11. Hadler-Olsen E, Jönsson B. Oral health and use of dental services in different stages of adulthood in Norway: a cross sectional study. *BMC Oral Health*. 2021;**21**(1):1-7.
12. Baćak V, Ólafsdóttir S. Gender and validity of self-rated health in nineteen European countries. *Scandinavian J Public Health*. 2017;**45**(6):647-653.
13. Benjamins MR, Hummer RA, Eberstein IW, Nam CB. Self-reported health and adult mortality risk: an analysis of cause-specific mortality. *Soc Sci Med*. 2004;**59**(6):1297-1306.
14. Huisman M, Van Lenthe F, Mackenbach J. The predictive ability of self-assessed health for mortality in different educational groups. *Int J Epidemiol*. 2007;**36**(6):1207-1213.
15. Pitiphat W, Garcia RI, Douglass CW, Joshipura KJ. Validation of self-reported oral health measures. *J Public Health Dent*. 2002;**62**(2):122-128.
16. Jones JA, Kressin NR, Spiro III A, et al. Self-reported and clinical oral health in users of VA health care. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. 2001;**56**(1):M55-M62.
17. Dahl KE, Wang NJ, Skau I, Öhrn K. Oral health-related quality of life and associated factors in Norwegian adults. *Acta Odont Scandinavica*. 2011;**69**(4):208-214.
18. Gülcan F, Nasir E, Klock KS, Eckbäck G, Åström AN. Sosiale forskjeller i tannhelse og bruk av tannhelsetjenester fra 65-til 70 års alder-et livsløpsperspektiv. *Nor Tannlegeforen Tid*. 2014(124):192-199.
19. Holst D. Oral health equality during 30 years in Norway. *Community dentistry and oral epidemiology*. 2008;**36**(4):326-334.
20. Krokstad S, Kunst A, Westin S. Trends in health inequalities by educational level in a Norwegian total population study. *J Epidemiol Community Health*. 2002;**56**(5):375-380.
21. Sihvonen A-P, Kunst AE, Lahelma E, Valkonen T, Mackenbach JP. Socioeconomic inequalities in health expectancy in Finland and Norway in the late 1980s. *Soc Sci Med*. 1998;**47**(3):303-315.
22. Fosse E, Helgesen M, Hagen S, Torp S. Addressing the social determinants of health at the local level: Opportunities and challenges. *Scandinavian J Public Health*. 2018;**46**(20\_suppl):47-52.

23. Borrell LN, Baquero MCJ Cd. Self-rated general and oral health in New York City adults: assessing the effect of individual and neighborhood social factors. *Community dentistry and oral epidemiology*. 2011;**39**(4):361-371.
24. Mossialos E, Wenzl M, Osborn R, Sarnak D. *2015 international profiles of health care systems*. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2016.
25. Chan TW, Birkelund GE, Aas AK, Wiborg Ø. Social status in Norway. *European sociological review*. 2011;**27**(4):451-468.
26. Johansen R, Grøtvedt L, Lyshol H. *Folkehelseundersøkelser i fylkene – Pilot. Dokumentasjonsrapport*. Oslo, Norway: Norwegian Institute of Public Health; 2017.
27. UNESCO. *International standard classification of education*. Montreal, Quebec, Canada: UNESCO Institute for Statistics; 2012.
28. Molarius A, Engström S, Flink H, Simonsson B, Tegelberg Å. Socioeconomic differences in self-rated oral health and dental care utilisation after the dental care reform in 2008 in Sweden. *BMC Oral Health*. 2014;**14**(1):134.
29. Hintzpeter B, Finger JD, Allen J, Kuhnert R. European Health Interview Survey (EHIS) 2– Background and study methodology. *Journal of Health Monitoring*. 2019;**4**(4):66-79.
30. Høydahl E. *Ny sentralitetsindeks for kommunene*. Oslo - Kongsvinger: Statistics Norway; 2017. Notater 2017/40.
31. Ekornrud T, Skjøstad O, Texmon I. *Utgifter til behandling hos tannlege og tannpleier 2014-2016. En sosioøkonomisk analyse av voksne mottakere av folketrygdrefusjoner*. Oslo, Norway: Statistics Norway; 2017. Rapporter 2017/42.
32. Santos CAS, Fiaccone RL, Oliveira NF, et al. Estimating adjusted prevalence ratio in clustered cross-sectional epidemiological data. *BMC Med Res Methodol*. 2008;**8**(1):1-10.
33. Espelt A, Marí-Dell’Olmo M, Penelo E, Bosque-Prous MJA. Applied Prevalence Ratio estimation with different Regression models: An example from a cross-national study on substance use research. *Addiciones*. 2016;**29**(2):105-112.
34. Bond Huie SA, Krueger PM, Rogers RG, Hummer RA. Wealth, race, and mortality. *Social Science Quarterly*. 2003;**84**(3):667-684.
35. Arntzen A, Bøe T, Dahl E, et al. 29 recommendations to combat social inequalities in health. The Norwegian Council on Social Inequalities in Health. *Scandinavian J Public Health*. 2019;**47**(6):598-605.

36. Stephens CR, Easton JF, Robles-Cabrera A, et al. The impact of education and age on metabolic disorders. *J Frontiers in Public Health*. 2020;**8**:20.
37. Sisson KL. Theoretical explanations for social inequalities in oral health. *Community dentistry and oral epidemiology*. 2007;**35**(2):81-88.
38. Gomaa N, Glogauer M, Tenenbaum H, Siddiqi A, Quiñonez C. Social-biological interactions in oral disease: A 'cells to society' view. *PLoS One*. 2016;**11**(1):e0146218.
39. Statistics Norway. Labour force survey. Statistics Norway. <https://www.ssb.no/en/arbeid-og-lonn/statistikker/aku/kvartal> Published 2020. Updated 23 July 2020. Accessed 21 September 2020, 2020.
40. Atchison K, Gift H. Perceived oral health in a diverse sample. *Adv Dent Res*. 1997;**11**(2):272-280.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementTablesLyshol.docx](#)