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ORIGINAL ARTICLE

Inequality in access to dental services in a market-based dental care system: A population study from Norway 1975–2018

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Abstract

Objective: To examine income-related inequalities in access to dental services from 1975 to 2018. In Norway, dental care services for adults are privately financed. This may lead to income-related inequalities in access. In the early 1970s, that is, at the beginning of the study period, there were marked inequalities in access to dental services according to personal income. However, from the beginning of the 1970s, there has been a large increase in gross national income per capita in Norway as a result of the growth of the oil and gas industry. This increase in income also meant that people with a low income in 1975 had a rise in their level of income. According to the law of diminishing utility, an increase in income leads to higher consumption of dental services for people with a low level of income compared to people with a high level of income. The study hypothesis is that the inequalities in access to dental services that existed in 1975 became less over time.

Methods: Statistics Norway collected samples of cross-sectional health survey data for the following years: 1975, 1985, 1995, 2002, 2008, 2012 and 2018. For each sample, individuals 21 years and older were drawn randomly from the non-institutionalized adult population using a two-stage stratified cluster sample technique. Inequalities were measured using the concentration index. The dependent variable was the use of dental services during the last year, and the key independent variable was equivalized household income.

Results: The concentration index for inequalities in use of dental services according to income decreased from 0.10 (95% CI = 0.09, 0.11) in 1975 to 0.04 (95% CI = 0.03, 0.05) in 2018. The decrease was particularly large from 2002 to 2012. This was a period with a large growth in gross national income.

Conclusion: People with a low income had a marked increase in their purchasing power from 1975 to 2018. This coincided with an increase in demand for dental care for this low-income group.

KEYWORDS
dental care, dental health services, economics, health care disparities, health care inequalities, health equity, health services accessibility, income

1 | INTRODUCTION

Equality in access to health services, dental services included, is an important part of Norwegian welfare policy.[1,2] This policy goal is an important justification for free dental care for children up to the age of 18.[1] It is undesirable that children's access to dental services should be limited by their parents' financial situation. The regular, out-reaching service provided by the public dental service helps to ensure that all children and young people have equal access to dental services and that inequalities in dental health are minimized.[3]

In Norway, there has been an ongoing debate since the late 1970s whether dental care for adults should be subsidized by the State.[4-6] So far, no universal public insurance scheme for dental care has been introduced.

The argument put forward in favour of a subsidy scheme is that it could help to reduce or eliminate inequalities in access to dental services. On the other hand, differences in income in the Norwegian population are relatively small and among the lowest in the OECD countries.[7] Further, gross national income (GNI) per capita increased from the early 1970s as a result of the growth of the oil and gas industry.[8,9] This benefitted everyone, including people with a low income, who were then more able to afford dental services.[7] Our hypothesis is that this may have led to a reduction in inequalities in access to dental services over time, even without a specific dental subsidy scheme. This hypothesis is based on predictions from the Grossman model, which is briefly outlined in the next section.

We examined inequalities in access to dental services according to household income over a period of more than 40 years. We analysed large samples of survey data that were representative of the non-institutionalized adult Norwegian population. The first sample was from 1975 and the last sample from 2018. This covers a period in which all people, including people with a low income, had a marked increase in their purchasing power.

2 | THEORETICAL FRAMEWORK

The theory of dental care utilization that we used in the study is based on the assumption that consumption of dental services is derived from demand for oral health. Oral health is demanded for two reasons, either for its consumption benefits (enjoying good oral health) or for its investment benefits (freedom from illness to participate in market and non-market activities).[10-14] Dental services are treated as a durable good that is consumed in order to produce oral health. The main constraint on consumption of dental services is consumers' income level. Basically, the consumer has to allocate his or her income between buying dental care and buying other commodities.[15]

This approach to the study of consumption of dental services reflects the work of Becker in the 1960s on the household production theory of allocation of time, and the work of Grossman, who in the early 1970s applied the household production theory to demand for health care.[16,17] Becker's theory was first applied by Holtmann and Olsen in 1976 to study the use of dental services.[10] Since then several empirical studies on the use of dental services have been carried out within this framework.[10-14] A consistent finding from these studies is that people with a low income have a lower level of consumption of dental services than people with a high income.[11,14,18-24] In the early 1970s, which is the beginning of the study period, this was also the case in Norway.[25-27] For example, in 1975 only 27% of individuals with the lowest level of income (<NOK 15 000) had visited the dentist during the last year compared to 75% of individuals with the highest level of income (>NOK 80 000).[26]

The Grossman model builds on two key assumptions: first, that consumers are utility maximizers, second, that their marginal utility from consumption of dental services decreases the more services they consume (Supplementary Material S1). This is the law of diminishing utility.

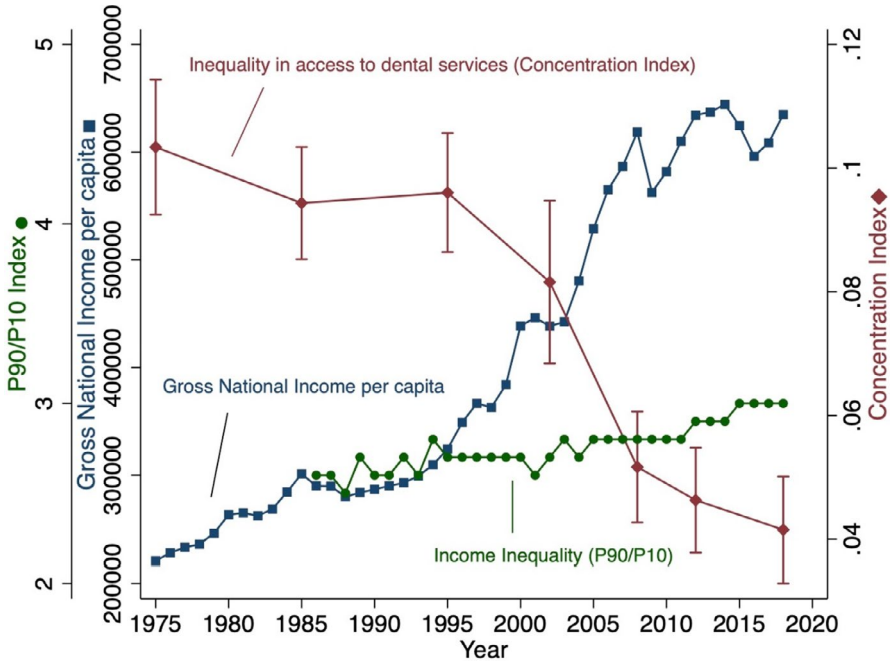

FIGURE 1 Gross national income per capita in NOK (GNI), income inequality measured by the P90/P10 Index and inequalities in access to dental services measured by the unstandardized concentration index with a 95% CI according to year

In real terms, income per capita was about three times higher at the end of the study period (2018) than at the beginning (1975) (Figure 1).[8,9] This increase in income also meant that people with a low income in 1975 had a rise in their level of income.[7] According to the law of diminishing utility, an increase in income leads to higher consumption of dental care for people with a low level of income compared to people with a high level of income (Supplementary Material S1). Therefore, the study hypothesis is that inequalities in access to dental services that existed in 1975 became less over time.

The Grossman model has been influential for studying demand for health and medical care over the last 40 years, despite criticism of the model.[28-31] Some of the criticism is as follows.[32-37]

First, the Grossman model assumes that patients are sufficiently informed to make utility-maximizing choices with respect to depreciation of their health stock and efficiency of their investment in health. This may be an inaccurate description of demand for health, as it ignores the role of uncertainty. A distinguishing feature of health is uncertainty both with respect to present and future health status and the efficiency of treatment.

Second, the Grossman model assumes that there is no imbalance in information between the provider and the consumer, that is, the agency relationship is perfect. This may not be the case. Several studies have shown that the medical care market is characterized by information impactedness and supplier-induced demand.[38-43]

Third, the Grossman model assumes that consumers choose a lower level of health as they get older. In the end, they decide the time of death. This is not necessarily the case.

Grossman was one of the first researchers to describe the relationship between household income and demand for health care within a formal mathematical model. We used this part of his model as the theoretical framework for our study. This part of the model has not been criticized and is still valid.

3 | MATERIALS AND METHODS

3.1 | The study population

Statistics Norway collected samples of cross-sectional health survey data for the following years: 1975, 1985, 1995, 2002, 2008, 2012 and 2018. For each sample, individuals were drawn randomly from the non-institutionalized population using a two-stage stratified cluster sample technique. The sample sizes and drop-out rates according to year are given in Table 1. In each health survey, the percentage of non-responders increased during the study period. For example, in 1975 the percentage of non-responders was 11.5%. In 2018 the percentage of non-responders was 47.5%. Statistics Norway has published figures on the representativeness of the samples with respect to gender, age and place of residence (for detailed references to each of the surveys see notes in Table 1). For all samples, there were only minor deviations between the sample and the population. These deviations were taken into account in our analyses, using the sample weights given by Statistics Norway. The distributions of the population according to gender, age and place of residence were used to construct the sample weights.

The aim of the study was to examine inequalities in access to dental services according to household income for individuals who met all the costs for dental services themselves. By including those aged 21 years and older, our samples included only individuals who met all the costs for dental services themselves. Individuals up to the age of 18 years have free dental care, and some individuals aged 19–20 years have some of their costs covered by a dental subsidy scheme run by the counties.[1] In our data, there was no information about whether those aged 19–20 years had some of their dental care costs covered or not. Therefore, we excluded this age group from our samples. The sample sizes for the modified samples are given in Table 1.

3.2 | Variables

The data were collected by personal interviews, using a pre-coded questionnaire. In all surveys, the respondents were asked when they had last visited the dentist. Several reply options were available, which were slightly different in each survey. In four of the seven health surveys (1995, 2002, 2012 and 2018), there were only two response options: those who had visited the dentist during the last year, and those who had last visited the dentist more than a year ago. In three of the seven health surveys, more detailed response options were available. In these surveys, the following response options for the dental visiting pattern were used: less than 6 months ago, 6–12 months ago, 13–24 months ago and more than 24 months ago. In order to have the same dependent variable in our analyses, we classified these response options into two categories: those who had visited the dentist during the last year, and those who had last visited the dentist more than a year ago.

The two categories for our dependent variable coincide with good practice guidance on dental visiting in Norway. According to national guidelines, a regular dental check-up should be done once during a 12-month period.[44] An infrequent attender is a person who has last visited the dentist more than a year ago.

Our key independent variable was household income before tax, which consisted of labour income, capital income and all transfers from the government. The content of each type of income is:

- Labour income: wages and self-employment income
- Capital income: interest, share dividends, realized capital gains or losses and income from property
- Transfers from the government:
- Income from taxable transfers: pensions, benefits from social security, unemployment benefits, alimonies and child support
- Income from tax-free transfers: child allowance, dwelling support, grants, social assistance, basic and attendance benefits

All persons who live in Norway have a unique personal identification number. This made it possible to merge the data from the health surveys with the tax records from The Tax Administration of

TABLE 1 Sample sizes according to year

	All ages				21 years and older			
	Gross sample[a]	Non-response		Net sample[b]		Missing information on key variables[c]		
Year of survey	Number of respondents	Number of respondents	Per cent	Number of respondents	Number of respondents	Number of respondents	Per cent	Number of respondents used in the analyses
1975	12 438	1424	11.5	11014	7384	310	4.2	7074
1985	13 438	2862	21.3	10 576	7322	211	3.4	7070
1995	14 000	3752	26.8	10 248	7347	2	0.0	7345
2002	4839	1442	29.8	3397	3149	1	0.0	3148
2008	9684	3219	33.2	6465	5914	24	0.4	5890
2012	11 387	5201	44.4	6186	5701	474	8.3	5227
2018	11 393	5412	47.5	5981	5595	410	7.4	5185

Notes: All surveys were carried out by Statistics Norway, Oslo and were made available by Norwegian Centre for Research Data.

The references to the surveys are as follows:

Health Survey 1975 (https://doi.org/10.18712/NSD-NSD0015-V3)

Health Survey 1985 (https://doi.org/10.18712/NSD-NSD0016-V4)

Health Survey 1995 (https://doi.org/10.18712/NSD-NSD0349-V4)

Level of Living 2002 – Cross-sectional study - Health (https://doi.org/10.18712/NSD-NSD0669-V4)

Level of Living 2008 – Cross-sectional study - Health (https://doi.org/10.18712/NSD-NSD1327-V7)

Level of Living Survey EU SILC, 2012 (https://doi.org/10.18712/NSD-NSD1967-V2)

Level of Living Survey EU SILC, 2018 (https://doi.org/10.18712/NSD-NSD2671-V6)

[a]Number of individuals who were asked to participate.

[b]Number of individuals who actually participated.

[c]Equivalized household income and use of dental services during the last year.

Norway. In our analyses, household income was equivalized to account for household composition using the square root scale.[45,46]

$$\text{Equivalized household income} = \frac{\text{household income}}{\sqrt{\text{number of household members}}} \quad (1)$$

We have used equivalized household income (pre-tax) for several reasons. First, it is the standard measure used in the national and international literature on income inequality. Both Statistics Norway and OECD use equivalized household income to measure income dispersion in populations.[45,47-49] Second, within dentistry, equalized pre-tax household income is used in most studies where inequalities in access to dental services have been examined.[50-58] By using the same measure to describe inequalities, results can be compared across studies. Third, household income (pre-tax) was the only income variable that was available, and defined in the same way, in all seven sets of our data. This ensured that our results were not biased due to measurement error in the income variable.

Disposable equivalized after-tax household income was available for the following years: 2002, 2008, 2012 and 2018. For these years, we have re-estimated Equation (2) and calculated the concentration indices using after-tax household income. This was done to test the robustness of our main results, where pre-tax household income was used as the independent variable.

In each survey, some of the respondents had missing information on the variable measuring when they last visited the dentist and on household income. These respondents were excluded from the analyses. The sizes of the final samples that we analysed are given in Table 1.

3.3 | Statistical analyses

To investigate the association between use of dental services and household income, we ran the following equation using a linear probability model:

$$\text{Use}_{it} = \alpha + \beta_t y_{it} + \chi\prime\delta + \varepsilon_{it} \quad (2)$$

where *Use* is a binary-dependent variable taking the value one if an individual, denoted by the subscript *i*, had visited the dentist during the last year, and zero otherwise. *y* is equivalized household income in the calendar year, denoted by subscript *t*. $\chi\prime$ is a row vector of age, age squared and gender. We stratified the analysis by calendar year denoted by *t*. To simplify the interpretation of the magnitude of the association between equivalized household income and use of services, we also estimated the following regression:

$$\text{Use}_{it} = \alpha + \lambda_t \textit{Mediany}_{it} + \chi\prime\delta + \varepsilon_{it} \quad (3)$$

where Mediany_{it} is a dummy variable that equals one if the individual's equivalized household income was above the median equivalized household income in the sample, and 0 otherwise.

3.4 | Inequalities measured using concentration indices

We measured inequalities using the concentration index, which is commonly used to measure socioeconomic inequality in health and health care utilization.[59,60] The index is defined with reference to the concentration curve. This curve models the cumulative proportion of individuals who had used dental services against the cumulative proportion of individuals with different levels of household income ranked from the lowest to the highest. If everyone, irrespective of household income, had exactly the same level of use of services, the concentration curve would be a 45-degree line. This is the line of equality. If the level of use of services is higher among those with a high household income, the curve would be below the line of equality, and the concentration index would be positive. The index can be in the range −1 to 1. The further the concentration curve is below the line of equality, the closer the index will be to 1.[60] Our hypothesis is that inequalities in access to dental services according to equivalized household income decreased from 1975 to 2018. This hypothesis would be supported if the concentration index decreased over time. The way the concentration index is calculated is given in Supplementary Material S2.

The concentration index takes into account both the direct effect that household income has on use of dental services, and the indirect effects that are transmitted through age and gender.[61] In our model, the indirect effects will be the component of the association between use and income that is due to the intervening variables age and gender. The associations between the intervening variables and use of dental services and income are described in Supplementary Material S2.

In the literature, it is common to estimate the partial concentration index.[59,61] This is a measure of income-related inequality in health after removing the indirect effects of income that are transmitted through age and gender. In our case, the partial concentration index would be a measure of the direct effect of income on use of dental services. We used the method of indirect standardization to estimate the partial concentration index. The estimation was done in three main steps, which are described in Supplementary Material S2.[61] If the unstandardized concentration index is similar to the partial concentration index, then inequalities in use of dental services are a result of a direct effect of income on use. If the indices are different, some of the effects are transmitted thorough age and gender.

The unstandardized and the partial concentration indices measure relative inequality. An alternative approach is to measure absolute inequality, which quantifies the absolute differences in use of dental services between income groups. Wagstaff (2005) and Erregyers (2009) have developed indices that measure absolute inequality.[62,63] These indices are particularly useful when the outcome is binary, as in our case. With binary outcomes, the minimum and maximum values of the concentration indices depend on the mean of the outcome variable.[62] This complicates the comparison of the values of the concentration indices across populations in which the mean of the outcome variable varies. In the study, the proportion

of individuals who visited the dentist during the last year increased from 1975 to 2018. Therefore, to take account of the fact that the mean of the outcome variable varied across the samples, we also measured inequalities using the corrected concentration index proposed by Erregyers (2009).[63] The way this index is calculated is given in Supplementary Material S2.

4 | RESULTS

4.1 | Descriptive statistics

The following changes took place during the study period, 1975–2018 (Table 2).

- The percentage of individuals who had visited the dentist during the last year increased from 59.2% to 80.4%
- Equivalized household income increased from USD 14 503 in 1975 to USD 47 777
- The mean number of individuals in the household decreased from 3.1 to 2.4
- The mean age of the respondents increased slightly

The pattern of use varied according to the respondents' age, gender and year of the survey (Table 3). For those aged 39 or younger, the percentage of individuals who had visited the dentist during the last year decreased from 76.7% in 1975 to 68.1% in 2018. For those 60 or older, the percentage who had visited the dentist increased from 32.9% in 1975 to 88.0% in 2018. In the age group 40–59 years, the percentage of individuals who had used dental services increased from 61.0% in 1975 to 82.7% in 2018. For all years, the proportion of men who had visited the dentist during the last year was slightly lower than for women.

4.2 | Has the association between use of dental services and household income decreased over time?

For all the years of the survey, equivalized household income was positively associated with use of dental services (Table 4). This shows that individuals with an income above the median income in the sample, used more services than those with an income below the median income in the sample. The regression coefficients decreased from 0.14 in 1975 to 0.06 in 2018. The 95% CIs for the later years did not overlap with those for the earlier years. This implies that the association between equivalized household income and use of dental services decreased over time.

4.3 | Have income-related inequalities in use of dental services decreased over time?

Inequalities in use of dental services according to income decreased over time (Table 5). This was a consistent finding, independent of the way in which inequalities were measured.

During the period from 1975 to 2018, the unstandardized concentration index decreased from 0.10 to 0.04. The decrease was particularly large from 2002 to 2008. For the earlier years of the survey, the indices were in the range of 0.10 (1975) to 0.08 (2002). For the later years, the indices were in the range of 0.05 (2008) to 0.04 (2018). The 95% CIs for the earlier years did not overlap with those for the later years.

Over time, the partial concentration index decreased in the same way as the unstandardized concentration index. From 1995 and onwards, the sizes of the two indices were nearly identical. For 1975 and 1985, the partial indices were slightly lower than the unstandardized indices. For every year of the survey, the 95% CIs for the two indices overlapped. These results show that equivalized household income has a direct effect on use of dental services, but does not have an indirect effect transmitted through age and gender.

For all years, the values for the corrected concentration indices were higher than the values for the unstandardized concentration indices and the partial concentration indices (Table 5). However, during the period from 1975 to 2018, the corrected indices decreased in the same way as the other two indices. For example, the decrease was largest at the end of the period. The 95% CIs for the corrected indices for the earlier years did not overlap with those for the later years.

TABLE 2 Descriptive statistics of the key variables according to year of survey

Year of survey	Use of dental services during the last year (%)	Number of individuals in the household (median)	Equivalized household income (USD) (median)	Men (%)	Age in years (mean)
1975	59.2	3.1	14 503	48.4	47.7
1985	67.5	2.9	16 975	47.9	47.4
1995	66.8	2.7	26 146	48.1	49.5
2002	71.6	2.6	36 753	48.1	49.5
2008	76.2	2.6	44 383	49.5	49.1
2012	79.2	2.5	47 332	52.7	50.5
2018	80.4	2.4	47 777	52.2	51.3

TABLE 3 Use of dental services according to age and gender for the years 1975, 1995 and 2018

	1975 Use of dental services			1995 Use of dental services			2018 Use of dental services		
Independent variables	**Yes (%)**	**No (%)**	**Total (*n*)**	**Yes (%)**	**No (%)**	**Total (*n*)**	**Yes (%)**	**No (%)**	**Total (*n*)**
Age (in years)									
21–39	76.7	23.3	2624	67.8	32.2	2537	68.1	31.9	1446
40–59	61.0	39.0	2543	78.4	21.6	2660	82.7	17.3	1963
≥60	32.9	67.1	1907	51.4	48.6	2148	88.0	12.0	1776
Gender									
Men	56.7	43.3	3424	65.3	34.7	3531	78.6	21.4	2708
Women	62.2	37.8	3650	68.3	31.7	3814	82.4	17.6	2477

TABLE 4 The association between equivalized household income[a] and use of dental services according to year of survey

Year of survey	Regression coefficient [95% CI]
1975	0.15 [0.13–0.17]***
1985	0.10 [0.08–0.13]***
1995	0.11 [0.09–0.14]***
2002	0.12 [0.09–0.16]***
2008	0.08 [0.06–0.11]***
2018	0.07 [0.04–0.09]***

[a]Equals 1 if the individual's equivalized household income was above the median equivalized household income in the sample and 0 otherwise.

***$p < .001$.

4.4 | Have income-related inequalities in use of dental services according to age and gender decreased over time?

In Supplementary Material S3, we show the unstandardized concentration indices according to the respondents' age and gender for the period 1975–2018.

For the age group 21 to 39 years, the indices were small. The value was 0.04 for four years (1975, 1995, 2012 and 2018). In 1985, the value was 0.02. For the age group 40–59 years, the index decreased from 0.10 in 1975 to 0.02 in 2018. For the age group 60 years or older, there was a marked decrease in the index from 0.20 in 1975 to 0.03 in 2018. The largest decrease for this age group was from 0.13 in 2002 to 0.06 in 2008.

There was no difference in the unstandardized concentration index according to gender from 1975 to 2012 (Supplementary Material S3). In 2018, the index was 0.06 for men and 0.02 for women, and the 95% CIs did not overlap.

4.5 | Are the results robust when a different income measure is used?

In Supplementary Material S4, we show the regression coefficients and the unstandardized concentration indices using equalized after-tax household income as the independent variable. The coefficients and the indices were nearly identical to those estimated using equivalized pre-tax household income. For each year, the 95% CIs overlapped. This is reassuring, as it indicates that our results are robust and not dependent on which income measure we used (pre- or after-tax income).

4.6 | Have GNI per capita and the distribution of income increased over time?

There has been a large increase in GNI per capita from NOK 220 400 in 1975 (deflated by 2015 figures) to NOK 634 800 in 2018 (Figure 1).[8,9]

During the period 1986–2018, income distribution, measured using the P90/P10 Index, showed a fairly stable trend. P90/P10 gives the ratio of the upper value of the ninth decile (=the 10% of people with highest income) to that of the first decile (=the 10% of people with lowest income).[64] The exception was the period 2000–2006 in which the P90/P10 increased. This was due to a tax reform, which led to increased inequality due to tax-avoiding behaviour among the rich.[65] For the periods 1986–1999 and 2007–2019, the P90/P10 varied in the range 2.5 (1988) to 3.0 (2015–2018). No official data are available for the P90/P10 Index before 1986.

In Figure 1, we also present figures for the unstandardized concentration indices for all the years of the survey. This shows the negative association between GNI per capita and the concentration indices.

5 | DISCUSSION

To our knowledge, this is the first study in which inequalities in use of dental services according to income have been examined over a long time span. The analyses were carried out on seven large samples of survey data that were collected in different years. All samples were representative of the non-institutionalized adult population in Norway. This made it possible to describe changes in inequalities in use of dental services at a national level. Previous studies within this

TABLE 5 Different types of concentration indices according to year of survey. 95% CIs in brackets

Year of survey	Unstandardized concentration index	Partial (standardized) concentration index	Corrected concentration index (Erregyers)
1975	0.10 [0.09–0.12]	0.09 [0.08–0.10]	0.25 [0.22–0.27]
1985	0.09 [0.08–0.10]	0.07 [0.06–0.08]	0.25 [0.23–0.28]
1995	0.10 [0.09–0.11]	0.09 [0.08–0.10]	0.26 [0.23–0.28]
2002	0.08 [0.07–0.10]	0.08 [0.07–0.10]	0.23 [0.19–0.26]
2008	0.05 [0.04–0.06]	0.06 [0.05–0.07]	0.16 [0.13–0.18]
2012	0.05 [0.04–0.06]	0.05 [0.04–0.06]	0.14 [0.11–0.16]
2018	0.04 [0.03–0.05]	0.04 [0.03–0.05]	0.13 [0.11–0.16]

field have mainly been carried out at one point in time or on selected groups of the population, for example in samples of young adults or elderly people.[50,52-55,66-70]

The main finding from this study is that inequalities in use of dental services according to income have decreased over time. This is an interesting result, considering that there is no public or private insurance for dental services for adults in Norway.[1,2] Throughout our whole study period, systematic dental care was provided by the Public Dental Services to the following groups of people, in the following order of priority[1]: (a) children 0–18 years of age, (b) people with mental and physical disabilities, (c) elderly people who receive care in an institution or from home nursing care and (d) 19–20 year-olds. Free care is provided for individuals in groups (a–c). Usually all children aged 3–18 years have regular check-ups once a year. Statistics Norway provides statistics on the use of voluntary health insurance, including dental insurance. Expenditure on voluntary health insurance is low, about 0.69% of total health expenditure.[2]

Our results can be explained in the following ways:

First, during the study period, there has been a large increase in GNI.[8,9] This increase has benefitted all income groups.[7] Differences in income in the Norwegian population have been relatively small during our whole study period (Figure 1). The increase in GNI has increased the purchasing power of the population, which has further increased demand for dental care.[71] Several studies have shown that demand for dental care is responsive to income.[72] Our results indicate that this response may have been larger for low-income groups than for high-income groups.

Second, the supply of dentists has been adequate to meet the increase in demand for dental services. The number of dentists in relation to the population is higher in Norway than in most countries in the world.[73,74] Throughout our whole study period, the number of dentists per person-labour year has been about 1100.[75,76] Dentists are distributed evenly according to region.[77] The waiting time for a dental appointment is short, less than a week for non-emergency appointments.[78,79] The dental care market is competitive, and most patients can afford dental care at the present level of fees.[80-82] Thus, when demand for dental services increased for people with a low income, these services were easily available for them.

Above, we argued that the increase in demand for dental care for people with a low income could be explained by a marked increase in their purchasing power from 1975 to 2018. There may also be other explanations. These can be discussed within the framework of the model developed by Andersen in 1968.[83,84] His model has been used in several studies to explain differences in use of dental services.[50,85-89] Anderson categorized the determinants of use of medical care into predisposing, enabling and system factors and need.[83,84] Predisposing factors include individual characteristics such as age and gender and attitudes towards seeking dental care. Enabling factors include characteristics that may be barriers to use of care, such as low income and lack of dental insurance. System factors include the way delivery of care is organized and the geographical distribution of dental health personnel.

Some of the determinants of use of dental services described by Anderson have been taken into account in our analyses, for example age and gender. We lacked data for the number of dentists per person-labour year and the geographical distribution of dentists. However, these variables are unlikely to explain our results, as they did not change during the study period.[75-77] We had no data about attitudes to seeking dental care. Attitudes may have changed from 1975 to 2018, partly because dental health improved.[90,91] When dental health improves people value their teeth more. This leads to more regular use of dental services.[87,92]

In our theoretical framework, improvements in dental health and changes in attitudes towards seeking dental care are intervening variables. Some of the effect that household income has on use of dental services may be transmitted through these two intervening variables. The total effect of household income reported in Table 4 would still be the same, but it can be decomposed into one direct and two indirect effects. The indirect effects are the components of the association between household income and use of dental services that are due to the two intervening variables: attitudes towards seeking dental care and dental health. The sizes of the indirect effects give information about the mechanisms through which household income exerts its effect on use of dental services. Due to lack of data, we were not able to examine these mechanisms any further. This is a limitation of the study.

The concentration index has become a standard measurement tool in studies on equity and inequalities in health care. One limitation of these indices is that they do not have an intuitive interpretation.[59,93] For example, it is not clear whether an estimated index

value reflects a large or a small inequality. This is because the index value is not expressed in natural units. Therefore, we cannot say that our index value of 0.10 (1975) is 2.5 times as unequal as 0.04 (2018). This is problematic, since from a dental health policy point of view, we want to know how much dental care should be transferred from the rich to the poor in order to remove all income-related inequalities in use of dental services.

Koolman and van Doorslaer (2004) have suggested that the index value can be given a meaningful interpretation by multiplying it by 0.75.[94] In our case, this gives the percentage of users of dental services that would need to be redistributed from the richer half of the population to the poorer half of the population in order to arrive at a distribution with an index value of zero, ie no inequality.[59] For 2018, 3% of users would have to be redistributed. This is a small percentage, which indicates that inequalities in access to dental services are not a serious problem, even without a subsidy scheme. It can be argued that equity in access does not necessarily mean that dental care should be transferred from the rich to the poor. Equity can also be achieved by improving access for the poor so that they have the same use of dental services as the rich.

Income-related inequalities in use of dental services for the age group 21–39 years were particularly small (Supplementary Material S3). This was the case for all the years of the survey. Most likely, this is because free dental care in childhood has contributed to regular use of dental services in adulthood. In Norway, well over 90 per cent of children and young adults under 19 years of age have annual appointments with a public dentist.[76] All their dental treatment is free, and they receive information and guidance about how to prevent dental disease.[95] This means that positive dental behaviour can be established in childhood and lead to good oral health in adult life.[96-98] This has contributed to an increase in regular use of dental services for all people in the age group 21–39 years, independent of their level of income.

In conclusion, we found that from the beginning of the study period in 1975 until the end in 2018, differences in use of dental services according to income decreased. The study was carried out in a population for which there was no public or private insurance for dental treatment. All dental treatment had to be paid for by the patient. A possible explanation for our finding is that people with a low income had a marked increase in their purchasing power from the early 1970s and onwards. This resulted in increased demand for dental care.

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CONFLICT OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

JG and JMK contributed to the concept and design and supervised the study. JG, JMK and NJ contributed to acquisition, analyses and interpretation of data and critically revised the manuscript for important intellectual content. NJ was involved in statistical analyses. JG and NJ contributed to drafting of the manuscript.

DATA AVAILABILITY STATEMENT

Data are available from the authors with the permission of Norwegian Centre for Research Data.

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SUPPORTING INFORMATION

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