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Deep carious lesions and other consequences of caries among 18-year-olds at Public Dental Health Service in Northern Norway: A cross-sectional age cohort study

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Abstract

Objectives. To document deep carious lesions and other consequences of caries (DCL-CC) in molars of 18-year olds leaving the free-of-charge Public Dental Health Service (PDHS). To explore the association between background factors and DCL-CC. ***Materials and methods.*** The final study sample ($n = 1876$) comprised 95% of individuals born in 1993 and registered in the PDHS in Troms County, Northern Norway. The most recent digital bitewing radiographs of each subject were examined for DCL-CC (deep untreated carious lesions, deep restorations, root canal obturations or extractions due to caries). Inter- and intra-observer kappa scores were 0.62 and 0.87, respectively. Information on background factors (gender, clinic location, history of medical problems, bitewing examination interval, DMFT score and planned recalls) were retrieved from dental records. ***Results.*** About one-quarter of subjects (488) had at least one molar with DCL-CC. There were 848 molars in total with DCL-CC; the majority were deep restorations (70%), but 4% were deep untreated carious lesions. More than a quarter of DCL-CC were either root canal obturations (14%) or extractions (12%). Multivariable logistic regression analyses showed that a 1-unit increase in DMFT score was associated with deep untreated carious lesions and extractions due to caries. There was no association between urban/rural clinic location, which indicated socio-economic status, and either DMFT score or DCL-CC. ***Conclusions.*** Despite the existence of a free-of-charge dental service, more than one-quarter of the subjects in the present study had at least one molar with DCL-CC.

Key Words: *radiography, bitewing, dental restoration, DMF index, root canal obturation, tooth loss*

Introduction

The prevalence of dental caries in Norway was one of the highest in Europe in the mid-20th century, but has since decreased to very low levels [1,2]. According to the Norwegian National Bureau of Statistics (SSB) the mean DMFT score among 18-year-olds in the country in 2011 was 4.3 [3]. Up to 18 years of age, Norwegian children receive free and systematic dental care within the framework of the free-of-charge Norwegian Public Dental Health Service (PDHS) [4]. However, not all children benefit equally from the program. Indeed, according to the SSB, 15–23% of 18-year-olds in Northern Norway have a DMFT score higher than 9 [5] and DMFT score has been directly linked to the number of pulpal involvements and other consequences of untreated dental caries [6].

Short dental recalls have been challenged as having no scientific basis [7] and several studies on recall intervals from Norway did not show any significant adverse effect of longer recall intervals on dental health [8,9]. Numerous studies have documented differences in dental health between genders [10–12]. Medical conditions such as asthma, epilepsy and eating disorders can also increase the prevalence of dental diseases [13–15], but socio-economic status has been reported to be one of the most significant determinants of dental health [16].

One of the important goals for the PDHS is the early detection and management of carious lesions, which is the key to minimizing the number of teeth with deep carious lesions and other consequences of caries (DCL-CC), which in this study refers to deep carious lesions, deep restorations,

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root canal obturations and extractions due to caries. Therefore, the aim of this study was to document the prevalence of DCL-CC, in the molars of 18-year olds, as it is at this age that people must leave the free-of charge PDHS. We also explored the association between background factors and DCL-CC.

Materials and methods

The present cross-sectional age cohort study was carried out in Troms County (which has 26 dental clinics included in the PDHS), Northern Norway, during the spring of 2012. The population of Troms County is close to 160,000, with 2229 children born in 1993. A total of 1978 individuals matched the inclusion criteria: born in 1993 (the location of birth was not indicated) and registered in Norwegian PDHS at the time of the study. We excluded 102 individuals due to the lack of digital bitewing radiographs, leaving a final study sample of 1876 subjects.

Data on the most recent digital bitewing radiographs for all subjects were retrieved from electronic dental records (Opus Dental software, Opus Systemer AS, Nesbru, Norway), entered into Excel data-entry software (Microsoft Office 365, Microsoft Corporation, Redmond, WA) using molar as the unit and analyzed in SPSS version 21.0 (IBM, Somers, NY). No digital bitewing radiographs were excluded from the study due to poor quality. The bitewing radiographs were assessed visually, using image size with a display ratio of 1:1 [17]. The contrast and brightness were adjusted manually for optimal visualization. Third molars were not included. Deep untreated carious lesions and deep restorations (reaching the inner quarter of the dentineor deeper) were recorded. In case of uncertainty, a line was drawn on the radiograph, as shown in Figure 1, and measured. The ratio AB/AC was used to define the maximum depth of the untreated carious lesion and restoration (adopted from Bjørndal et al. [18]) (Figure 1). Interference from a buccal/lingual restoration was avoided by cross-checking with dental records. When visible radiopaque material was seen in the pulp chamber and further in the canal it was recorded as a root canal obturation, after confirmation with dental records. Missing molars were recorded and the reason for extraction was confirmed in dental records. Gender, clinic location, history of medical problems (self-reported), dates of all digital bitewing radiographs (used to calculate bitewing examination intervals), DMFT score (of the whole dentition) and dates of planned recalls (visit indicated as a recall by the dentist and used to calculate recall intervals) were also retrieved from dental records. The cities of Tromsø, Harstad and Finnsnes have recently received city status from the Norwegian Authorities and were classified as urban clinic locations.

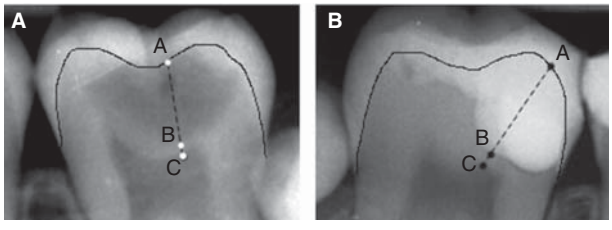

Figure 1. Method of assessing the depth of deep untreated carious lesion/deep restoration on digital bitewing radiographs, adopted from Bjørndal et al. [18]. Point A is in the middle of the distance of the deep untreated carious lesion/deep restoration along the enamel-dentine junction (line). Point B is at the pulpal border of the deep carious lesion/deep restoration. Point C is at the border of the pulp. (A) Deep untreated carious lesion on the occlusal surface of a lower left second molar. (B) Deep restoration on the mesial surface of a lower right second molar.

Digital bitewing radiographs were examined by the main investigator (LS) after calibration with a maxillofacial radiologist (NLB). The inter- and intra-observer reliability were calculated after an interval of 2 weeks by re-examining 20 radiographs with 34 molars intentionally selected to present untreated carious lesion or restoration reaching at least the inner half of the dentine. The inter-observer reliability rendered a Cohen's kappa value of 0.62 and intra-observer reliability (LS) showed a kappa value of 0.87 [19].

A Mann-Whitney test was used to analyze the difference in DMFT scores between subjects with and without DCL-CC. The chi-square test was used to examine the associations between DCL-CC and background factors (gender, clinic location and history of medical problems). Subjects were then dichotomized as follows: (i) those with at least one deep untreated carious lesion and those without any DCL-CC; (ii) those with at least one deep restoration and those without any DCL-CC; (iii) those with at least one root canal obturation and those without any DCL-CC; and finally (iv) those with at least one extraction due to caries and those without any DCL-CC. Univariable binary logistic regression analyses were used to determine associations between dependent variables (deep untreated carious lesions, deep restorations, root canal obturations and extractions due to caries) and gender, clinic location, history of medical problems, bitewing examination intervals as a continuous variable using 6 months as a unit and DMFT score as a continuous variable. Multivariable binary logistic regression models were calculated separately for all four components of the DCL-CC. Only models where 'deep untreated carious lesions' and 'molars extracted due to caries' were used as dependent variables yielded acceptable results in Hosmer-Lemeshow goodness-of-fit test ($p > 0.05$). Multivariable binary logistic regression analysis was used to examine the association between DMFT score (dependent variable) and background factors. The level of significance was set at $p = 0.05$ and 95% CI.

Table I. Distribution of 18-year-olds according to the presence/absence of deep carious lesions and other consequences of caries (DCL-CC) in permanent molars and background factors. The mean bitewing examination intervals and DMFT score according to the presence/absence of DCL-CC.

	Subjects with at least one molar with DCL-CC (n = 488)					
	Deep restorations, n (%)	Deep untreated carious lesions, n (%)	Root canal obturations, n (%)	Extractions due to caries, n (%)	Subjects without DCL-CC, n (%)	Total, n (%)
Gender						
Male	186 (9.9)*	21 (1.1)*	43 (2.3)	39 (2.1)	722 (38.5)	958 (51.1)
Female	218 (11.6)	9 (0.5)	52 (2.8)	29 (1.5)	666 (35.4)	918 (48.9)
Clinic location						
Urban	276 (14.7)	24 (1.3)	71 (3.8)	38 (2.0)*	960 (51.2)	1296 (69.1)
Rural	128 (6.8)	6 (0.3)	24 (1.3)	30 (1.6)	428 (22.7)	580 (30.9)
History of medical problems						
Yes	41 (2.2)*	3 (0.2)	13 (0.7)*	13 (0.7)*	92 (4.9)	146 (7.8)
No	363 (19.3)	27 (1.4)	82 (4.4)	55 (2.9)	1296 (69.0)	1730 (92.2)
Bitewing examination interval, mean (SD) in months	16 (5.9)	19.1 (10.6)	16.9 (6.7)	15.4 (8.3)	16.9 (5.3)	16.8 (5.6)
DMFT score mean (SD)	9.2 (4.7)	11.8 (4.7)	9.4 (4.8)	11.4 (5.5)	4.5 (4.0)	5.7 (4.6)
Prevalence	404 (21.5%)	30 (1.6%)	95 (5.1%)	68 (3.6%)	1388 (73.9%)	1876 (100%)

*Statistical analysis with Chi-square test, $p < 0.05$: female/male vs subjects with deep restorations/subjects without any DCL-CC; presence/absence of history of medical problems vs subjects with deep restorations/subjects without any DCL-CC; female/male vs subjects with untreated deep carious lesions/subjects without any DCL-CC; presence/absence of history of medical problems vs subjects with root canal obturations/subjects without any DCL-CC; rural/urban clinic location vs subjects with extractions due to caries/subjects without any DCL-CC; presence/absence of history of medical problems vs subjects with extractions due to caries/subjects without DCL-CC.

According to the Regional Ethical Committee of Northern Norway (2011/2492/REK nord) this study complied with the guidelines for a quality assurance project. Consequently, ethical approval was considered unnecessary.

Results

More than one-quarter of the subjects (488) had a total of 848 molars with DCL-CC (Table I). Most subjects had one or two affected molars (Table II). Subjects with DCL-CC had a mean (SD) DMFT score of 9.1 (4.6), which was more than double that of subjects without DCL-CC (4.5 (4.0); $p < 0.001$).

Of the 848 molars with DCL-CC (comprising 6% of all molars analyzed) a majority had deep restorations (70%). More than one-quarter of these molars had either root canal obturation (14%) or were extracted (12%), whereas 4% had deep untreated carious lesions (Table II). Deep untreated carious lesions were located as follows: 16 distal, four mesial, 10 occlusal and eight mesial-occlusal-distal surfaces.

Among 488 subjects with DCL-CC, 93 had planned recall dates. Recall intervals could be calculated for 83 subjects and varied between 5–40 months, with a mean (SD) of 16.1 (7.1) months. Past recall dates and dates of digital bitewing radiographs matched for 85 subjects, among whom the actual

Table II. Distribution of permanent molars with deep carious lesions and other consequences of caries (DCL-CC) according to the number of molars involved per subject.

	Molars with DCL-CC				
Number of molars involved per subject	Deep restorations, n (%)	Deep untreated carious lesions, n (%)	Root canal obturations, n (%)	Extractions due to caries, n (%)	Total number of molars with DCL-CC, n (%)
1	224 (26%)	9 (1%)	34 (4%)	12 (2%)	279 (33%)
2	190 (22%)	12 (1%)	34 (4%)	30 (4%)	266 (31%)
3	72 (8%)	2 (0.2%)	15 (2%)	13 (1.8%)	102 (12%)
≥4	106 (13%)	15 (2%)	34 (4%)	46 (5%)	201 (24%)
Total	592 (70%)	38 (4%)	117 (14%)	101 (12%)	848 (100%)

Table III. Odds ratios for having at least one molar with deep untreated carious lesions (vs no deep carious lesions and other consequences of caries) according to background factors retrieved by binary logistic regression.

Independent variable	Crude odds ratio Univariable analysis OR (95% CI), p	Adjusted odds ratio† Multivariable analysis OR (95% CI), p
Female gender (vs male)	0.5 (0.2–1.02), NS	0.5 (0.2–1.2), NS
Rural location of clinic (vs urban)	0.6 (0.2–1.4), NS	0.6 (0.2–1.8), NS
History of medical problems present (vs healthy)	1.6 (0.5–5.3), NS	2.0 (0.5–7.5), NS
DMFT score (cont.)	1.3 (1.2–1.4), 0.000*	1.4 (1.3–1.5), 0.000*
Bitewing examination interval (every 6 months) cont.	1.3 (1.004–1.8), 0.047*	1.6 (1.2–2.1), 0.005*
Explained variance Nagelkerke R^2	—	0.318

*$p < 0.05$.
†Adjusted for all independent variables.

bitewing examination interval varied from 6–34 months, with a mean (SD) of 14.8 (4.5) months.

According to multivariable analyses, a 1-unit increase in DMFT score resulted in statistically significantly higher adjusted odds ratios (ORs) for having deep untreated carious lesions (OR = 1.4) and for having extractions due to caries (OR = 1.3) (Tables III and IV). For deep untreated carious lesions, a 6-month increase in bitewing examination intervals led to a higher adjusted OR (1.6) (Table III). History of medical problems was available for 146 subjects (6.5% of the study sample). The most common medical problem reported was allergy (28%), followed by asthma (13%) and circulatory system diseases (10%). Epilepsy and diabetes both occurred in 7%, rheumatic disorders in 3% and eating disorders in 2% among subjects having history of medical problems. High blood pressure, dental fear, ulcerative colitis, hepatitis, cancer, psychiatric disorder and eating disorder each occurred in 2% or less of the subjects having history of medical problems. Twenty-five per cent of the subjects reported having 'other' conditions, but did not give further information. Having a history of medical problems led to a higher adjusted OR (2.6) for extractions due to caries (Table IV).

Multivariable binary logistic regression analysis showed no statistically significant association between DMFT score (when the cut-off point was set at 5) between gender and urban/rural clinic location. A DMFT score higher than 5 was associated with a history of medical problems (OR = 1.5, $p < 0.05$) and with a 6-month decrease in bitewing examination intervals (OR = 0.7, $p = 0.000$).

Discussion

The final study sample consisted of 95% of 18-year-olds registered in the PDHS in Troms County at the time of this study. According to the annual report of The Norwegian Board of Health for the year 1991, 81% of 18-year-olds in the country attended the PDHS [20]. Thus, the study sample can be interpreted as highly representative and it is reasonable to assume that the results of the present study can be used to draw conclusions about the prevalence of

Table IV. Odds ratios for having at least one molar extracted due to caries (vs no deep carious lesions and other consequences of caries) according to background factors retrieved by binary logistic regression.

Independent variable	Crude odds ratio Univariable analysis OR (95% CI), p	Adjusted odds ratio† Multivariable analysis OR (95% CI), p
Female gender (vs male)	0.8 (0.4–1.3), NS	1.1 (0.6–2.1), NS
Rural location of clinic (vs urban)	1.8 (1.1–2.9), 0.023*	1.5 (0.8–2.8), NS
History of medical problems present (vs healthy)	3.3 (1.7–6.3), 0.000*	2.6 (1.1–5.9), 0.022*
DMFT score (cont.)	1.3 (1.2–1.3), 0.000*	1.3 (1.2–1.4), 0.000*
Bitewing examination interval (every 6 months) cont.	0.6 (0.4–0.9), 0.021*	0.9 (0.7–1.3), NS
Explained variance Nagelkerke R^2	—	0.271

*$p < 0.05$.
†Adjusted for all independent variables.

DCL-CC among 18-year-olds in Northern Norway. These results may also interest other free-of-charge PDHS.

A systematic review showed a radiographic prevalence of dentine caries using only bitewing radiographs that was either exact or slightly under-estimated compared with total radiographic and clinical prevalence [21]. To our knowledge there are no studies showing the sensitivity of digital bitewing radiographs to detect deep carious lesions and deep restorations, but it is logical to assume the sensitivity is higher for deep than for shallow dentine carious lesions. It has been shown that over-exposed radiographs result in a more correct diagnosis of dentine caries, but also in an increased number of false-positive diagnoses, which could have led to an over-estimation of the prevalence. Light radiographs have been shown to result in under-estimation of occlusal caries [22]. To overcome these limitations, the brightness and contrast of digital bitewing radiographs were adjusted manually before recording DCL-CC.

The most recent digital bitewing radiographs for 14% of the subjects were taken before 2011. This more than 1-year gap between the recording of the data and actual radiographic examination might have led to an under-estimation of the prevalence of DCL-CC at 18 years of age in this study. The inter-observer reliability had a Cohen's kappa value of 0.62, which is generally considered substantial; intra-observer reliability corresponded to a kappa value of 0.87, which is considered almost perfect [23].

In the present study, 30 (1.6%) subjects had at least one molar with deep untreated carious lesion, i.e. reaching the inner quarter of the dentineor deeper. The mean number of proximal deep carious lesions was 0.02 per subject in the 16 molar surfaces surveyed. A study performed two decades ago among 18-year-olds in Northern and Southern Norway included 24 proximal surfaces of the posterior teeth and reported a mean number of untreated proximal surfaces in the inner half of the dentine of 0.11 and 0.02, respectively [9]. A more recent study among 18-year-olds from Southern Norway also included 24 proximal surfaces of the posterior teeth and found a mean number of carious lesions in the inner third of the dentine of 0.04 in 1999 and 0.05 in 2006 [24]. However, the aforementioned studies cannot be directly compared with ours due to differences in the number of surfaces surveyed and the depth of the carious lesion considered. The ratios of deep untreated carious lesions with half or inner third depth are not equivalent to our findings, which might indicate a more severe caries situation in Northern Norway.

Every fifth subject (21.5%) in our study sample had one or more deep restorations. A prevalence of deep restorations of 22% has been reported among 15-year-olds enrolled in the PDHS in Sweden [25]. However, in the latter study deep restorations were defined as being halfway or more into the dentine and premolars were also analyzed. Thus, once again, taking into account the discrepancy in the age groups and limiting the detection to much deeper (inner quarter) lesions in molars only, our data might suggest a more severe caries situation in Northern Norway.

In the present study 5.1% of 18-year-olds had root canal obturated molars. In a study from Southern Sweden [26], 4.2% of 19-year-olds had received endodontic treatment in one or more molars. This finding suggests a slightly higher prevalence of endodontic treatment in Northern Norway. However, few molars were extracted due to caries in the present study, resulting in a mean number of molars per subject of 7.95. This finding is in line with another study from Scandinavia, where in 2003 the mean number of molars among 20-year-olds was 7.9 [27]. The M-component in our study (0.05) was only slightly higher than that in a 1998 study among 18-year-olds from Southern Norway (0.04) [28]. However, instead of molars only, the latter study calculated the M-component for the whole dentition, suggesting more molar extractions in Northern Norway.

Our study sample represents a young population from a well-educated society receiving systematic free dental care. A prevalence of 26% of subjects with DCL-CC is therefore of concern. Only 93 out of the 488 subjects with DCL-CC (19%) had a documented recall strategy. This is surprising considering that this sub-sample presented with mean DMFT score that was twice that of subjects without DCL-CC. However, a recent study from Sweden showed that individualized recall intervals did not eliminate root canal obturations and extractions due to caries [29].

In the present study data on missed appointments were not available. Another study from Norway reported the proportion of missed and cancelled dental appointments among 18-year-olds to be ~17% [30]. The same study also indicated that subjects with missed appointments had a higher mean DMFT score at 18 years of age [30]. Indeed, according to the SSB, the age cohort born in 1993 in Troms County already had slightly higher mean DMFT score (2.0) at age 12 years compared to that of the whole country (1.6) [3]. The same tendency was observed at 18 years of age, with a mean DMFT score of 5.3 for Troms County and 4.3 for the whole country.

There is no separate written policy document for caries prevention measures (such as fluoride therapy and fissure sealing) in Troms County, only knowledge transfer between universities and dentists (personal communication, Chief Dental Officer of Troms County), but current prevention practices seem to be in accordance with the recent updated clinical

recommendations and supporting systematic review and Cochrane review used in high-risk subjects [31,32]. High dentist turnover might be among the reasons for the present, non-optimal caries situation in Northern Norway.

The cross-sectional study design limits the ability to identify causative factors. In the present study deep untreated carious lesions and extractions due to caries were associated with a higher DMFT score. This finding is in line with Benzian et al. [6], who showed that the DMFT score is directly linked to the number of pulpal involvements in the mixed dentition. In addition, longer bitewing examination intervals were positively associated with deep untreated carious lesions (OR = 1.6). It is logical to assume that bitewing examination intervals reflect recall intervals in our study, since the majority of recall dates and dates of digital bitewing radiographs matched. The reasons for longer bitewing examination intervals are unknown. According to the Chief Dental Officer there are two different recall routines in Troms County. In Tromsø district (Tromsø and Karlsøy kommune) recall intervals are determined by age, according to the risk to develop caries in that age group, and vary between 13 and 24 months. When recall intervals are long, high-risk patients may receive an extra screening and/or prophylaxis between two ordinary examinations. In the rest of Troms County recalls are based on risk assessment by the dentist or dental hygienist and vary between 12–24 months. This system might function worse due to the aforementioned irregular recruitment of dentists, which leads to recall intervals that are shorter than optimal, because the assessors want to compensate for the risk of vacant dental positions.

History of medical problems increased the adjusted OR (2.6) for extractions due to caries. In the present study history of medical problems were self-reported. More than half of the subjects with such a history (53%) indicated allergy or 'other' conditions that have no proven scientific relationship with caries. Therefore, our findings here should be interpreted with caution. Socio-economic status is one of the most significant determinants of dental health [16] and it has been shown that socio-economic status is significantly lower in rural areas of Norway compared with urban areas [33]. The variable clinic location was included in multivariable binary logistic regression analyses, but showed no association with either DCL-CC or DMFT score. This might indicate that the free-of-charge PDHS successfully eliminates socio-economic disparities in dental care delivery. Other socio-economic indicators, such as parents' educational level, occupation and income, were not available in the present study.

A recent questionnaire study showed that 20–50% of the dentists in Northern Norway preferred total caries excavation and, if exposure occurred, more than half preferred direct pulp capping, mainly with calcium hydroxide [34]. Total caries excavation has been shown to result in more pulpal exposures compared to a stepwise approach, and the success rate for direct capping with calcium hydroxide in adults has been shown to be low, indicating a future need for endodontic treatment [18].

As practically all of the molar teeth are restored with composite in the PDHS in Norway, the shorter median survival time of composite compared to amalgam or cast crowns will comprise a considerable amount of replacements of previous restorations in the near future [35–37]. Consequently, placing/replacing deep restorations for more than one-fifth of the subjects will comprise a potential risk of endodontic treatment.

Despite the existence of a free-of-charge PDHS, more than one-quarter of the subjects in the present study had at least one molar with DCL-CC. Of the molars with DCL-CC, more than one in four had either received a root canal obturation or been extracted. The overall management of carious lesions needs to be improved in order to avoid deep carious lesions and alleviate the financial burden for those no longer eligible for the PHDS, whereas the improved management of deep carious lesions could save the teeth from the most severe consequences.

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References

[1] Renson CE, Crielaers PJA, Ibikunle SAJ, Pinto VG, Ross CB, Sardo Infirri J, et al. Report of a Working Group convened jointly by the Fédération Dentaire Internationale and the World Health Organisation. Changing patterns of oral health and implications for oral health manpower: Part I. Int Dent J 1985;35:235–51.

[2] Marthaler T, O'Mullane D, Vrbic V. The prevalence of dental caries in Europe 1990-1995. ORCA Saturday afternoon symposium 1995. Caries Res 1996;30:237–55.

[3] Statistics Norway. Statistikkbanken Tannhelsetenesta. Oslo: Statistisk sentralbyrå; 2013. Available online at https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=&ProductId=&MainTable=TannstatEtAlder&nvl=&PLanguage=0&nyTmpVar=true&CMSSubjectArea=helse&KortNavnWeb=tannhelse&StatVariant=&checked=true.accessed 25 June 2014.

[4] Ministry of Health and Social Affairs. Lov om tannhelsetjenesten. Act no. 54. Oslo: Ministry of Health and Social Affairs; 1983.

[5] Statistics Norway. Over 2,9 milliardar til tannhelse i Noreg. Oslo: Statistisk sentralbyrå. 2012. Available online at http://www.ssb.no/helse/statistikker/tannhelse/aar/2012-07-17. accessed 25 June 2014.

[6] Benzian H, Monse B, Heinrich-Weltzien R, Hobdell M, Mulder J, van Palenstein Helderman W. Untreated severe dental decay: a neglected determinant of low Body Mass

Index in 12-year-old Filipino children. BMC Public Health 2011;11:558.
[7] Sheiham A. Is there a scientific basis for six-monthly dental examinations? Lancet 1977;2:442–4.
[8] Wang N, Marstrander P, Holst D, Ovrum L, Dahle T. Extending recall intervals–effect on resource consumption and dental health. Community Dent Oral Epidemiol 1992;20: 122–4.
[9] Wang NJ, Riordan PJ. Recall intervals, dental hygienists and quality in child dental care. Community Dent Oral Epidemiol 1995;23:8–14.
[10] Bertea PC, Staehelin K, Dratva J, Stutz EZ. Female gender is associated with dental care and dental hygiene, but not with complete dentition in the Swiss adult population. J Public Health 2007;15:361–7.
[11] Tada A, Hanada N. Sexual differences in oral health behaviour and factors associated with oral health behaviour in Japanese young adults. Public Health 2004;118:104–9.
[12] Lukacs JR, Largaespada LL. Explaining sex differences in dental caries prevalence: saliva, hormones, and "life-history" etiologies. Am J Hum Biol 2006;18:540–55.
[13] Little JW. Eating disorders: dental implications. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:138–43.
[14] Anjomshoaa I, Cooper ME, Vieira AR. Caries is associated with asthma and epilepsy. Eur J Dent 2009;3: 297–303.
[15] Alavaikko S, Jaakkola MS, Tjäderhane L, Jaakkola JJ. Asthma and caries: a systematic review and meta-analysis. Am J Epidemiol 2011;174:631–41.
[16] World Health Organization. The World Oral Health Report 2003. Continuous improvement of oral health in the 21st century - the approach of the WHO Global Oral Health Programme. Geneva: World Health Organization; 2003.
[17] Haak R, Wicht M, Nowak G, Hellmich M. Influence of displayed image size on radiographic detection of approximal caries. Dentomaxillofac Radiol 2003;32:242–6.
[18] Bjørndal L, Reit C, Bruun G, Markvart M, Kjældgaard M, Nasman P, et al. Treatment of deep caries lesions in adults: randomized clinical trials comparing stepwise vs. direct complete excavation, and direct pulp capping vs. partial pulpotomy. Eur J Oral Sci 2010;118:290–7.
[19] Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas 1960;20:37–46.
[20] Norwegian Board of Health. Tannhelsetjenesten i Norge. Annual report 1991. Oslo: Norwegian Board of Health; 1992.
[21] Bloemendal E, de Vet HC, Bouter LM. The value of bitewing radiographs in epidemiological caries research: a systematic review of the literature. J Dent 2004;32:255–64.
[22] Skodje F, Espelid I, Kvile K, Tveit AB. The influence of radiographic exposure factors on the diagnosis of occlusal caries. Dentomaxillofac Radiol 1998;27:75–9.
[23] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–74.
[24] Grytten J, Holst D, Skau I. Per capita remuneration of dentists and the quality of dental services. Community Dent Oral Epidemiol 2013;41:395–400.
[25] Ridell K, Olsson H, Mejàre I. Unrestored dentin caries and deep dentin restorations in Swedish adolescents. Caries Res 2008;42:164–70.
[26] Ridell K, Sundin B, Matsson L. Endodontic treatment during childhood and adolescence. A survey of 19-year-olds living in the city of Malmö, Sweden. Swed Dent J 2003;27:83–9.
[27] Hugoson A, Koch G, Gothberg C, Helkimo A, Lundin S, Norderyd O, et al. Oral health of individuals aged 3-80 years in Jönköping, Sweden during 30 years (1973-2003). II. Review of clinical and radiographic findings. Swed Dent J 2005;29:139–55.
[28] Amarante E, Raadal M, Espelid I. Impact of diagnostic criteria on the prevalence of dental caries in Norwegian children aged 5, 12 and 18 years. Community Dent Oral Epidemiol 1998; 26:87–94.
[29] Flink H, Tegelberg Å, Arnetz J, Birkhed D. Correlation between perceived experience of caries disease and recorded caries activity among adult patients at a Swedish Public Dental Clinic: a longitudinal study. Acta Odontol Scand 2013;71: 1486–92.
[30] Skaret E, Raadal M, Kvale G, Berg E. Missed and cancelled appointments among 12-18-year-olds in the Norwegian Public Dental Service. Eur J Oral Sci 1998;106:1006–12.
[31] Ahovuo-Saloranta A, Forss H, Walsh T, Hiiri A, Nordblad A, Mäkelä M, et al. Sealants for preventing dental decay in the permanent teeth. Cochrane Database Syst Rev 2013;28: CD001830.
[32] Weyant RJ, Tracy SL, Anselmo TT, Beltrán-Aguilar ED, Donly KJ, Frese WA, et al. Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. J Am Dent Assoc 2013;144:1279–91.
[33] Sjolie AN, Thuen F. School journeys and leisure activities in rural and urban adolescents in Norway. Health Promot Int 2002;17:21–30.
[34] Stangvaltaite L, Kundzina R, Eriksen HM, Kerosuo E. Treatment preferences of deep carious lesions in mature teeth: questionnaire study among dentists in Northern Norway. Acta Odontol Scand 2013;71:1532–7.
[35] Mjör IA, Dahl JE, Moorhead JE. Age of restorations at replacement in permanent teeth in general dental practice. Acta Odontol Scand 2000;58:97–101.
[36] Van Nieuwenhuysen JP, D'Hoore W, Carvalho J, Qvist V. Long-term evaluation of extensive restorations in permanent teeth. J Dent 2003;31:395–405.
[37] Vähänikkilä H, Käkilehto T, Pihlaja J, Päkkilä J, Tjäderhane L, Suni J, et al. A data-based study on survival of permanent molar restorations in adolescents. Acta Odontol Scand 2014;72:380–5.