ACTA ODONTOLOGICA SCANDINAVICA, 2016
VOL. 74, NO. 4, 291–297
http://dx.doi.org/10.3109/00016357.2015.1119306

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Prevalence, risk surfaces and inter-municipality variations in caries experience in Danish children and adolescents in 2012

Pia Elisabeth Nørrisgaard, Vibeke Qvist and Kim Ekstrand

Department of Odontology, Section for Cariology and Endodontics, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark

ABSTRACT

Objective The aim of this study was to describe the caries experience, prevalence and distribution related to tooth type and surfaces in the primary and permanent dentition in children and adolescents in Denmark in 2012. In addition, to examine if explanatory factors influence the inter-municipality variation in caries experience. **Materials and methods** Data was collected in the public Child Dental Health Service. In total, 5636 caries registrations on 3-, 9-, 15- and 18-year-olds were collected in 35 of the 98 Danish municipalities. Caries experience was expressed by mean def-s/DMF-S and caries prevalence by def-s = 0/DMF-S = 0. Inter-municipality variations were illustrated. Multivariate regression analyses were applied to assess the influence of fluoride concentration in drinking water, proportion of immigrants and personal income on the inter-municipality variation in mean def-s/DMF-S. **Results** Only 4.6% of 3-year-olds had def-s (mean = 0.25), compared to 44.9% of 9-year-olds (mean = 3.07), primarily located occlusally and interproximally on the primary molars. Mean DMF-S for the 9-, 15- and 18-year-olds were 0.27, 1.97 and 4.40, respectively. Caries were primarily located occlusally and in pits on the permanent molars, which also showed high frequencies of sealings. Mean def-s/DMF-S showed substantial inter-municipality variations, while the caries location in both dentitions was rather stable. The three background factors explained less than 25% of the variation in mean def-s/DMF. **Conclusions** The caries distribution within the primary and permanent dentition among 3-, 9-, 15- and 18-year-olds followed definite patterns concerning location on teeth and surfaces. Background factors only explained a minor part of the variation.

ARTICLE HISTORY
Received 27 March 2015
Revised 4 November 2015
Accepted 5 November 2015
Published online
11 December 2015

KEYWORDS
Caries experience; Child Dental Health Service; cross-sectional; epidemiology; primary and permanent dentition

Introduction

Systematic oral healthcare for Danish children and adolescents was instituted by the Child Oral Health Care Act in 1972. The act required that all municipalities should implement Child Dental Health Service (CDHS) for all school children free of charge, starting in 1972. From 1989 the CDHS included all children from 0–18 years.[1,2]

An important element of the act was to implement a national epidemiological database, termed SCOR (Sundhedsstyrelsens Centrale Odontologiske Register). The municipalities were obligated to submit data annually on the oral health of children participating in CDHS, i.e., more than 95% of all children.[2,3] The National Board of Health (NBH) devised a registration form which the dentists had to fill out the first time the child appeared on the clinic every year. In co-operation with the two dental schools, NBH had defined criteria for how to record caries and other conditions (Table 1).[4] By that, the caries experience of the individual child could be expressed by the def-t/s and the DMF-T/S indices (def-s: decayed, extracted, filled surfaces, primary teeth; DMF-S: Decayed, Missed, Filled Surfaces, permanent teeth). Furthermore, the mean caries experience at each age group at the municipality level, the county level, as well as the National level could be calculated.[5–9]

Due to the significant decline in caries experience, NBH in 1993 decided that the municipality should only report the dental status on 5-, 7-, 12- and 15-year-olds. However, NBH made it voluntary for the municipalities to continue annual reporting of dental status for all age groups.[4] Further, NBH did not continue to publish data obtained in CDHS about the occurrence of early childhood caries at the age of 3. Neither were data published about the final outcome concerning the primary dentition for the 9-year-olds and the permanent dentition for the 18-year-olds, when the adolescents are to leave CDHS. Peculiarly, no detailed data has ever been published from the NBH concerning caries risk surfaces,[6–9] although such information is important to initiate primary—as well as secondary preventive care in a cost-effective way.

It is worth noticing that the indication for using resin sealants to control for caries progression on occlusal surfaces in permanent molar and pre-molar teeth has changed during the last decades from routine use in all pre-molar and molar teeth

CONTACT Pia Elisabeth Nørrisgaard pengd@sund.ku.dk Department of Odontology, Section for Cariology and Endodontics, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Nørre Allé 20, 2200 Copenhagen N, Denmark

to a more risk-orientated use.[9] A Danish study from the turn of the millennium indicated a high use of sealants on molar teeth, a very large inter-municipality variation and no correlation between sealants and DMF-S.[10] These findings reflect the vague NBH guidelines for use of sealants in the CDHS in Denmark, which came in force in 1997 and still are in force. According to these guidelines, sealings are recommended for use on sound occlusal surfaces in individuals with high caries risk and surfaces with initial caries lesions without cavity formation. Consequently, a sealant could be an indication of an identified early caries lesion or an indication of high/increased risk for decay. However, sealants are not mandatory registrations in CDHS and they are not included in the def-s/DMF-S indices. In spite of the fact that Denmark is recognized as being a country with low caries experience among the child population, a rather great inter-municipality variation existed around the millennium.[10,11] In a study using data from 2004, Ekstrand et al.[11] showed an inter-municipality variation among 15-year-olds in mean DMF-S ranging from 0.6–6.2. Ecological studies showed that nearly 50% of this inter-municipality variation in DMF-S could be explained by variations in the natural fluoride concentration in the drinking water and the education level of the mothers.[10–12]

Objective

The objective of this study was to describe (a) the prevalence, the caries experience and caries distribution related to tooth type and surfaces in the primary and permanent dentition in 3-, 9-, 15- and 18-year-olds in Denmark 2012 and (b) the influence of relevant background factors on the inter-municipality variation in the caries experience.

Materials and methods

Design

This study is a cross-sectional study using public register data from NBH (National SCOR caries data),[13] Geological Survey of Denmark and Greenland (GEUS) (fluoride concentration in drinking water) [14] and Statistic Denmark (mean personal income and proportion of immigrants and decedents in each municipality),[15] together with individual SCOR caries data from the chief dental officer in the individual municipalities. The study was approved by the Danish Data Protection Agency no. 2012-41-1049.

Caries recordings

The individual SCOR data includes caries registrations on 3-, 9-, 15- and 18-year-olds participating in the CDHS in 2012. Thus, the children and adolescents were born in 2009, 2003, 1997 and 1994. Late in 2012 the 98 Danish municipalities were invited to participate in the study by a written request from the authors to the chief dental officer in the individual municipalities. If they accepted, they were asked to send a copy of the SCOR-forms completed for each child/adolescent during two randomly selected weeks on the selected age groups of children and adolescents in the spring of 2012. At least 50 children/adolescents should be included in each age group. If necessary, the recording period was extended by 1 or 2 weeks until at least 50 children/adolescents were included.

The SCOR recordings of caries and caries sequelae are conducted on each tooth surface using the criteria shown in Table 1. Apart from recordings of arrested caries and fissure sealings, all recordings are mandatory. A total of 35 out of 98 municipalities submitted the requested SCOR-forms.

Background variables

The three background factors were all collected at municipality level. The mean concentration of fluoride in the drinking water was based on measurements obtained from each waterworks in the municipalities in 2013. The values were weighted according to the inhabitants supplied by the individual waterworks.[14] Mean and range of personal income and proportion of immigrants and decedents in each municipality in spring 2012 were extracted from Statistic Denmark.[15]

Table 1. Condition, score and diagnostic criteria used in the NBH registration form.

Condition	Score	Diagnostic criteria
Initial caries	0	The enamel is marked rough, dull and opaque No enamel breakdown visible
Manifest caries	1	The enamel is marked rough, dull and opaque Cavitation assessed clinically or by means of other diagnostic tools Alternatively, there is a clear shadow below a clinically intact enamel surface (previously referred to as hidden caries)
Secondary caries Insufficient or lost restoration	2	Manifest caries on a surface previously restored due to caries Restoration insufficient or partly/totally lost
Arrested caries *Not mandatory registration*	9	The enamel is hard, smooth and shiny, with whitish or brownish discolouration
Restoration	4	Any restoration, inlay or crown performed due to caries
Trauma *Trauma and related treatments is not a part of the def/DMF index*	3	Injury on hard tissues, pulp or peridontium due to acute mechanical trauma Any restoration, inlay, crown or endodontics performed due to trauma
Endodontic treated tooth, caries causa	5	Direct capping, amputation or root canal treatment due to caries, the score is only recorded on the occlusal or the oral surface
Extraction, caries causa	6	Extraction due to caries
Lost tooth, not due to caries	7	Trauma or extraction due to orthodontic treatment
Fissure sealants *Not mandatory registration*	8	Fissure sealants covering parts of or all the grooves

Table 2. Caries experience expressed by mean def-s/DMF-S and prevalence expressed by def-s = 0/DMF-S = 0 among 3-, 9-, 15- and 18-year-olds based on individual values.

Age group	Number of children and adolescents (Municipalities)	def-s = 0%	def-s mean	def-s range	DMF-S = 0%	DMF-S mean	DMF-S range
3-year-olds	1506 (34)	95.4	0.22	0.0–3.70			
9-year-olds	1453 (32)	55.1	3.40	1.22–7.18			
9-year-olds	1398 (32)				86.8	0.27	0.0–0.6
15-year-olds	1509 (31)				54.7	2.06	0.50–3.41
18-year-olds	1168 (31)				33.6	3.92	1.36–8.83

def-s: decayed, extracted, filled surfaces, primary teeth; DMF-S: Decayed, Missed, Filled Surfaces, permanent teeth (Table 1).

Statistical procedures

All data from the received SCOR-forms were manually transformed to Excel sheets. To express the reproducibility of the data transfer, data for 100 randomly selected children were entered twice 1 week apart. For the 100 children a total number of 14 800 recordings were possible and the percentage of failures was 0.02% (3/14 800). As the majority of the cells on the forms were empty (sound surfaces), we also calculated the percentage of failures of cells keeping scores was 0.17% (3/1.763).

Age-specific dataset from the municipalities were excluded from the final calculations if there were significant discrepancies (Student's *t*-test) between the mean def-s/DMF-S in the collected sample and the mean reported to NBH for the total age group from the individual municipality.[13] We got access to these data during the spring of 2013. Thus, datasets from 31–34 of the 35 municipalities could be included in the final calculations representing 3-, 9-, 15- and 18-year-olds.

The caries outcomes are based on the def/DMF indices, which include score 1, 2, 4, 5 and 6 in Table 1. Caries in an initial stage scored as 0 is not a part of the indices. Thus, the d/D component corresponds to score 1 and 2 in Table 1, e/M to score 6 and f/F to scores 4 and 5 (endodontics due to caries). In each municipality the mean def/DMF were calculated as the averages of all surfaces with def/DMF scores per child/adolescent for each age group. Children/adolescents with def-s = 0/DMF-S = 0 were included in the calculation of the mean values. Caries experience was expressed by mean def-s/DMF-S and caries prevalence by percentage of children/adolescents with def-s = 0/DMF-S = 0. To express caries risk surfaces score 8 (sealed surfaces) were also used, although sealed surfaces were not included in the def/DMF indices. Data from the right and left side were merged, as previous analysis has shown no significant differences in caries experience between the right and left side at the tooth level.[16,17]

To illustrate the inter-municipality variation in the distribution of def-s/DMF-S according to the individual teeth and surfaces in our samples, data were expressed by the average for all reporting municipalities as well as the range for the municipalities, i.e. the two municipalities with the lowest and the highest mean def-s/DMF-S. The inter-municipality variation in the caries distributions for the 3- and 15-year-olds are not illustrated, because of the very low average def-s among the 3-year-olds and the similarity in the caries distributions for the 15- and 18-year-olds. Multivariate, linear regression analyses were applied to assess how the three independent variables: fluoride concentration in drinking water, proportion of immigrants and personal income simultaneously affected mean def-s/DMF-S in the four age groups. As the independent variables were collected at municipality level, caries as outcome was also aggregated to municipality level for the regression analyses.[18] Backward stepwise multiple linear regression were used to exclude a variable one by one from the model until a possible significant level was obtained. The adjusted correlation coefficient (R^2) described the variation in the proportion of def-s/DMF-S, which is attributable to the model with significant independent variables. The analyses were performed by means of the IBM-SPSS software, version 20.0, Chicago, IL. *p*-values less than 0.05 were considered statistically significant.

Results

Outcome variables def-s/DMF-S = 0 and mean def-s/DMF-S

From Table 2 it appears that datasets from 34, 32, 31, 31 of the 35 municipalities could be included in the final calculations for the 3-, 9-, 15- and 18-year-olds and that the number of children and adolescents varied with age group from 1168–1509, in total 5636 individuals, which corresponds to 5.7% of the total Danish population in the four age groups in 2012.[15]

From a caries point of view, it is notable that less than 5% of the 3-year-olds had def-s ≥ 1 compared to 45% of the 9-year-olds in the primary dentition and the mean def-s increased from 0.22 to 3.40 between 3- and 9-year-olds (Table 2). This indicates that caries in the primary dentition accumulates after toddler's age. For the 9-year-olds less than 15% had DMF-S ≥ 1 in the permanent dentition, with a mean on 0.27. The percentage increased to 45%, the mean to 2.06, for the 15-year-olds, and to 66%, the mean to 3.92, for the 18-year-olds.

The internal distribution of the components of the def-s/DMF-S index also varied with age groups (Table 3). Among the 3-year-olds 84% of the def-s index was related to the d component (score 1 + 2), 11% were fillings (score 4 + 5 = f component) and 5% were extractions due to caries (score 6 = e component). Among the 9-year-olds this pattern had changed with 57% of the index in the primary dentition related to the f component, 15% to the d component and 20% to the e component. In the permanent teeth, among the 9-year-olds 33% of the DMF-S in the permanent dentition was related to the D component, a figure which decreased to 23% among the 18-year-olds. In contrast, the F component was relatively stable in the three age groups. Caries resulted in very few extractions in the permanent dentition.

Table 3. Components of the def-s/DMF-S index in relation to age group (%).

Scores def-s/DMF-S component	1 d/D	2 d/D	4 f/F	5 f/F	6 e/M
3-year-olds	81	3	11	—	5
9-year-olds	15[a]/33[b]	6[a]/4[b]	57[a]/61[b]	2[a]/0[b]	20[a]/2[b]
15-year-olds	15	2	76	1	6
18-year-olds	23	7	64	1	5

def-s: decayed, extracted, filled surfaces.
[a]primary teeth.
[b]DMF-S: Decayed, Missed, Filled Surfaces, permanent teeth (Table 1).

Distribution of def-s/DMF-S related to surfaces

The caries experience in the primary and permanent dentition among children and adolescents is illustrated in Figure 1 in relation to teeth and surfaces.

Concerning the 3-year-olds, the caries risk surfaces were the occlusal surfaces on the molar teeth and especially the mesial surfaces on the incisors in the upper jaw of which ~1.5% in this sample had def > 0. The major part of caries lesions in toddlers was not restored.

For the 9-year-olds, only the primary first and second molars and the first permanent molars are shown in Figure 1, as 98% and 93% of def-s and DMF-S, respectively, in this age group was located on these teeth. Figure 1a shows, that 16–17% of the occlusal surfaces on both primary molar teeth, 18% of the distal surfaces on the first primary molar tooth and 13% of the mesial surfaces on the second primary molar tooth had def > 0. The distribution of def and sealings among the 9-year-olds related to tooth type and tooth surface was the same in the municipality with the lowest mean def-s (Figure 1b) and the municipality with the highest mean def-s in the sample (Figure 1c). So, the inter-municipality variation was primarily related to differences in the frequencies of teeth/surfaces with def and the proportions of untreated (d) and operatively treated (e,f) caries lesions, the black and red parts of the columns, respectively.

Sealed surfaces, the green part of the columns, hardly occurred in the primary dentition, while 41% of the occlusal surfaces on permanent first molar teeth were sealed on the 9-year-olds together with 11% of the lingual and buccal pits in the upper and lower first permanent molars, respectively (Figures 1a–c). It is notable that only 4% of first permanent molar teeth showed decay or restoration in this age group, mostly located on the occlusal surfaces (Figure 1a).

The caries risk surface number one for the 15-year-olds was the occlusal surface on first and second permanent molar teeth, of which 38% were sealed and a further 18% and 5%, respectively, were with DMF scores. Other caries risk surfaces in this age group were the mesial surface on first molar teeth, of which 9% were with DMF scores in the upper jaw and 5% in the lower jaw, together with the lingual surface on the upper first molars and the buccal pit in the lower firstmolars, where 5% were with DMF scores. The average distribution pattern was reflected in the two municipalities with the lowest and highest caries experience.

For the 18-year-olds DMF related to the tooth type and surfaces are shown in Figures 1d–f. Corresponding to the findings for the younger age groups, the majority of the DMF were located occlusally on the molar teeth. Thus, 26% of the occlusal surfaces of first molar teeth were with DMF scores and 29% were sealed. DMF were present on 12% of the occlusal surfaces of the second molar teeth and in addition 36% of these surfaces were sealed. Further surfaces with DMF scores were the mesial surfaces on the upper first molar teeth (12%), the buccal pits in the lower first molar teeth (9%), the mesial and distal surfaces in the lower first molar teeth (7% and 6%) and the occlusal surfaces on the second premolars and the upper first premolars (4–5%). Very few premolar teeth were sealed. Only 1–3% of the proximal surfaces of the incisors in the upper jaw showed DMF scores. Data from the municipality with the lowest caries experience for the 18 year-olds sample revealed the same risk surfaces as the average sample, but in that municipality the frequency of sealings was increased (Figure 1e). For the municipality with the highest caries experience (Figure 1f), there were significantly more restored teeth/surfaces compared to that seen on the average sample.

Influence of explanatory factors on inter-municipality variation

The fluoride concentration in the drinking water varied between 0.12–1.45 ppm among the 34 municipalities, with a mean of 0.42 ppm. The proportion of immigrants varied between 4.4–34.2%, mean = 11.7%. The average personal income varied between 254 000–389 000 DKK, mean = 286 000 DKK.

The three background factors explained less than 25% of the variation in def-s/DMF-S for the four age groups. The fluoride concentration in the drinking water showed a significant influence on the caries experience for the 9-year-olds in both dentitions ($p < 0.05$) and a borderline significance in the permanent dentition for the 15 year-olds ($p = 0.07$). The proportion of immigrants showed borderline significance with DMF-S for the 15-year-olds ($p = 0.11$) and the personal income showed borderline significance with DMF-S for the 15-year-olds ($p = 0.11$) and 18-year-olds ($p = 0.12$).

Discussion

The present study is based on caries registrations collected in the CDHS in 35 of the 98 Danish municipalities. The reporting municipalities are scattered across Denmark, with all regions represented, and the complete sample comprised 5–6% of the total Danish population in the four age groups investigated. The study material amounted data from the municipalities that agreed to participate ($n = 35$). It is unclear whether the reporting municipalities differs from the remaining municipalities in the country, but the caries experience found for the 15-year-old (DMF-S = 1.97) in this study does not differ significantly from the national average (DMF-S = 1.92) for the same age group.[13] The reporting municipalities are scattered across the country and each of the five regions Denmark is divided into is represented by several municipalities. We, therefore, assumed that, although the study does not include data from all the municipalities, the material is representative for the whole country. Although studies from Denmark and the other Scandinavian countries have disclosed some calibration

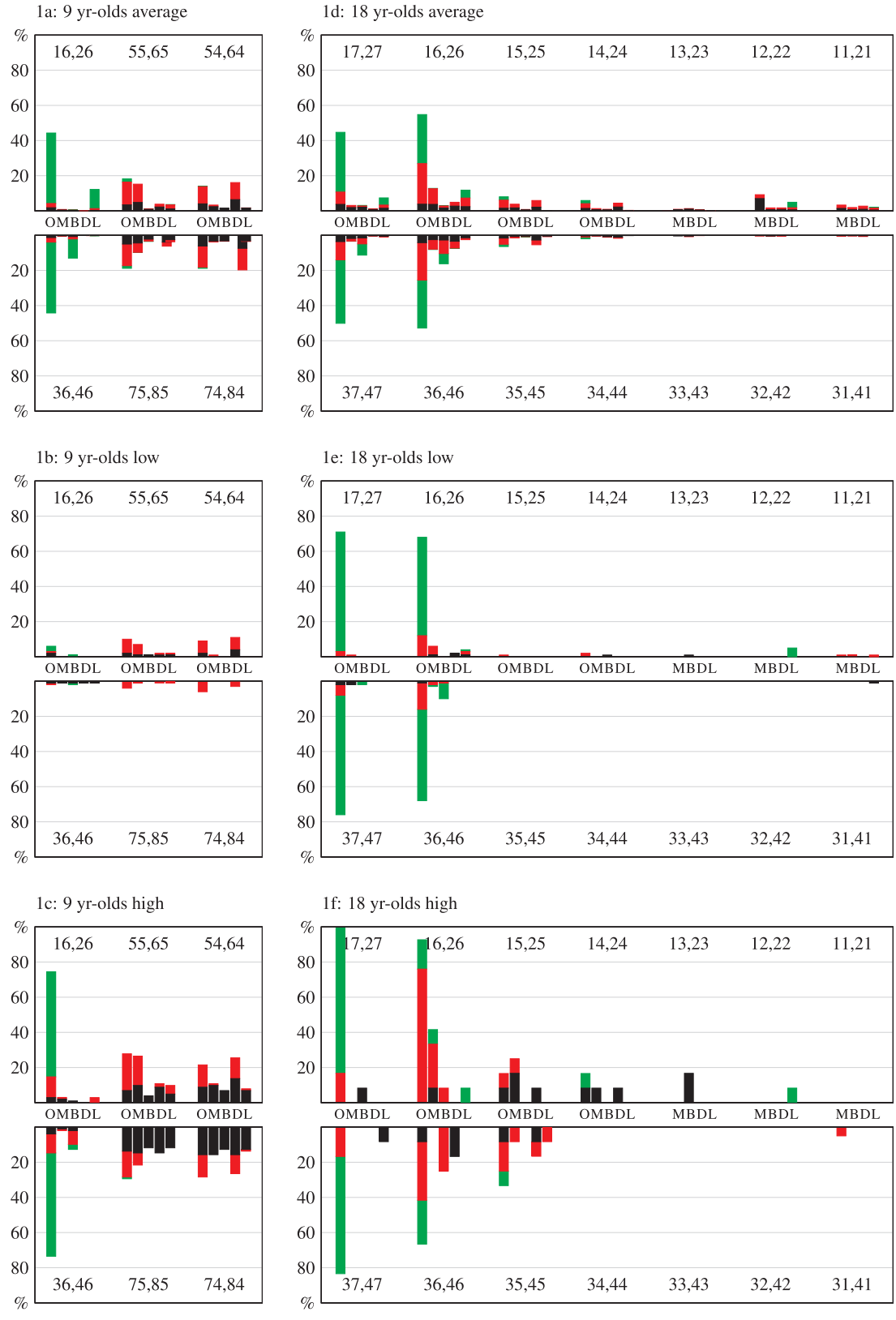

Figure 1. Caries experience in relation to teeth and surfaces in the primary and permanent dentition for 9-year-olds and 18-year-olds expressed by def-s and DMF-S, respectively. (a) and (d) The average distributions for the 31 and 32 municipalities for the two age groups. (b) and (e) The distributions for the two municipalities with the lowest caries experience. (c) and (f) The distributions for the two municipalities with the highest caries experience in the same age groups, respectively. Teeth are coded according to FDI. O = occlusal, M = mesial, B = buccal, D = distal, L = lingual. The black part of the columns are untreated caries lesions (d/D), the red part operatively treated caries lesions (e/E, f/F), and the green part-sealed surfaces.

problems regarding SCOR data reliability, SCOR records are relatively simple scores of caries, resulting in a robustness of the registrations.[19–21] Therefore, we consider the results to be reliable and generalizable.

Studies have documented that using X-ray as a diagnostic tool for caries detection increases the frequency of identified proximal carious lesions significantly, particularly in the primary dentition in which almost half of the proximal caries lesions in 5-year-old children will be ignored if clinical examinations are not combined with x-rays.[22,23] In the CDHS radiographs are not mandatory at each obligate recording, but if they are taken the dentists and hygienists will, if they detect on the radiograph a lesion confined to the enamel or an early dentinal lesion, which is not recorded at the clinical level, score it as 0. If the dentist/hygienist finds that the lesion requires a restoration it will be scored as 1, which then at the next obligatory registration will be changed to a score of 4 if the lesion has been restored. Inter-municipality differences in policy for taken radiographs may explain a part of the rather huge inter-municipality variations in caries experience which existed in the three eldest groups of children and adolescents in this study. Well defined guidelines for taking X-rays might increase the accuracy of SCOR data for identifying caries lesions.

During the last decades there has been an improvement in dental health not only due to the decline in the caries disease, but also because of changed treatment strategies.[24] Especially, the indications for restorative treatment have changed in recent years [24–26] and disease registration on SCOR may also have changed. Today, enamel caries as well as early dentin caries, both recorded as score 0, will often be treated by preventive measures including sealants.[25,26] However, initial caries and sealed surfaces are not included in the def-s/DMF-S. Measuring caries only when cavitation or clear shadows can be detected (score 1) leaving out the initial lesions and all the sealed lesions, thus under-estimates the true extent of caries. Taking this into consideration, we decided to illustrate the caries distributions within teeth and surfaces by including sealings (score 8), lesion scored as 1 and 2 as well as restored surfaces (score 4), endodontic treated surfaces/teeth (due to caries = score 5) and extractions (due to caries = score 6) all together.

In spite of the possible changes in the level for caries recordings, there is evidence that the average caries experience at the National level is lower than ever before and the proportion of children with caries has declined significantly over the last decades.[13] Most industrialized countries have reached a level where it is relevant and important to concentrate on the individual surfaces for further improvements in dental health. However, to our knowledge very few studies have been published on the distribution of caries risk surfaces.[27] Thus, the objective of this study was to create a detailed description of the caries distribution within the two dentitions and to gain an understanding of the variation that exists in children and adolescents.

The prevalence of early childhood caries was low and in the primary dentition caries were mainly located to the occlusal surfaces and the adjacent proximal surfaces between first- and second primary molar teeth. This distribution is consistent with the results from a Danish pilot study from 2005 by Ekstrand.[27] However, the proportion of fillings was higher in 2005, where 25–30% of the occlusal surfaces, 30% of the distal surfaces on the first primary molar teeth and 20% of the mesial surfaces of the second primary molar teeth were restored, compared to 12%, 11% and 8%, respectively, in our 2012 sample. Accordingly, the mean def-s for the 9-year-olds was 6.5 in 2005, while the present study showed an average def-s on 3.07. In both studies, the most frequent locations for caries in the permanent dentition among children and adolescents up to 18 years of age was the occlusal surfaces and the pits of first and second molar teeth.

In the present study we tried to gather information about the same background variables as previous Danish studies from CDHS did.[10,11] However, we failed to get reliable data about the mothers educational level, cost and resources spent in manpower in the CDHS, ending up with only three background variables; the fluoride concentration in drinking water-, the personal income- and proportion of immigrants at the municipality level. All together the three variables explained less than 25% of the variation in caries experience in the four age groups compared to an explained part of the variation on ~40% in the previous studies based on data from 1999.[10] and 2004.[11]

A contributing factor to the low explanation may be that the use of data aggregated at the municipality level implies an inability to control for potential confounding factors. In Denmark in 2006 the hitherto 298 municipalities were merged into 98 larger municipalities. Consequently, the intra-municipality variation in caries experience and relevant background variables have increased, while the inter-municipality variation has levelled. So that might be the major reason why the level of influence of the background variables included in this study do not have the same magnitude of influence as in previous studies.[10,11] Still, variation in the fluoride content in the drinking water was the background variable which explained most of the variation. Therefore, the CDHS's should plan their preventive strategies, taking into consideration the local fluoride content in the drinking water. Thus, if one part of a municipality have >0.3 ppm F in the drinking water and another part <0.1 ppm F, the preventive strategy should be more intense in that part with the lowest level of fluoride in the drinking water. Similarly, our data also suggest that the preventive interventions should be more intense in municipalities with a high proportion of immigrants compared to municipalities with a lower proportion of immigrants.

Our results showed that, irrespective of substantial inter-municipality variations in caries experience in each of the four age groups in the present study, the distribution of def-s/DMF-S within teeth and surfaces was rather constant in both dentitions. This information is important in a preventive point of view as focus of attention for the preventive initiatives should be targeted to the risk surfaces. For example proximal caries in the primary molar teeth, if developing, will start after full proximal contact has been established between first and secend primary molar teeth, which happens at the age of ~3.5 years.[28] Similarly, caries on the occlusal surfaces on permanent molar teeth starts during the long lasting eruption period from 6–8 and 12–14 years of age.[29–32] Several papers

have described the benefit of introducing a particular tooth brushing technique to the parents of 5–6 year old children to be used on the erupting first molar teeth [30–33] or to the child themselves when the second molar teeth erupt.[32,34,35] Furthermore, it is important that our study has shown that the caries prevalence nearly doubled between 15–18 years of age, although the lesions are located at the same risk surfaces.

In conclusion, the caries distribution within the primary and permanent dentition among 3-, 9-, 15- and 18-year-olds followed definite patterns concerning location on teeth and surfaces. In the primary dentition caries was preferably located to the occlusal surfaces and the adjacent proximal surfaces between first and second primary molars and the prevalence of early childhood caries was low. The major location for caries in the permanent dentition was the occlusal surfaces and pits of first and second molars. The distribution within teeth and surfaces was rather constant in both dentitions, irrespective of a significant inter-municipality variation in def-s and DMF-S. Only a minor part of the variation could be explained by the background factors, concentration of fluoride in drinking water, proportion of immigrants and average personal income in the municipality.

Acknowledgements

The authors thank the chief dental officers from the CDHS in the participating municipalities for their readiness to provide the present data.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Friis-Hasche E, Kirkegaard E. Historical perspectives of child oral health care in Denmark. In Friss-Hasche ed. Child Oral Health Care in Denmark. Copenhagen University Press; 1994. p. 12–16.
[2] Vigild M, Skak-Iversen L, Friis-Hasche E. Danish child oral health care service: legislation, registration system, and organization. In Friss-Hasche ed. Child Oral Health Care in Denmark. Copenhagen University Press; 1994. p. 17–20.
[3] Schwarz E, Skak-Iversen L, Helm S. Børnetandpleje i Danmark 1980-81 og 1981-82 - status og udviklingslinjer. Sundhedsstyrelsen, 1983.
[4] Indberetning på børne- og ungdomstandplejeområdet. Sundhedsstyrelsen; 1999.
[5] Helm S. Recording system for the Danish Child Dental Health Services. Community Dent Oral Epidemiol. 1973;1:3–8.
[6] Poulsen S. Dental caries in Danish children and adolescents 1988–94. Community Dent Oral Epidemiol. 1996;24:282–285.
[7] Poulsen S, Scheutz F. Dental caries in Danish children and adolescents 1988-1997. Community Dent Health. 1999;16:166–170.
[8] Poulsen S, Malling Pedersen M. Dental caries in Danish children: 1988–2001. Eur J Paediatr Dent. 2002;4:195–198.
[9] Schwarz E, Vigild M, Skak-Iversen L. Danish child oral health status in two decades of organized child oral health care. Child Oral Health Care in Denmark. Copenhagen University Press, 1994, pp. 38–44.
[10] Ekstrand KR, Christiansen ME, Qvist V. Influence of different variables on the inter-municipality variation in caries experience in Danish adolescents. Caries Res. 2003;37:130–141.
[11] Ekstrand KR, Christiansen ME, Qvist V, Ismail A. Factors associated with inter-municipality differences in dental caries experience among Danish adolescents. An ecological study. Community Dent Oral Epidemiol. 2010;38:29–42.
[12] Kirkeskov L, Kristiansen E, Bøggild H, et al. The association between fluoride in drinking water and dental caries in Danish children. Linking data from health registers, environmental registers and administrative registers. Community Dent Oral Epidemiol. 2010;38:206–212.
[13] https://sundhedsstyrelsen.dk/~/media/19A7B23209CE406ABF396EDEBFBB4F39.ashx
[14] http://www.geus.dk/
[15] http://www.danmarksstatistik.dk/
[16] Burnside G, Pine CM, Williamson PR. Modelling the bilateral symmetry of caries incidence. Caries Res. 2008;42:291–296.
[17] Ekstrand KR1, Carvalho JC, Thylstrup A. Restorative caries treatment patterns in Danish 20-year-old males in 1986 and 1991. Community Dent Oral Epidemiol. 1994;22:75–79.
[18] Douglas DG. Practical statistics for medical research. 1st edn. London: Chapman & Hall/CRC; 1991. p. 325–64.
[19] Heidmann J. Inconsistencies in a nationwide caries recording system. Community Dent Oral Epidemiol. 1985;13:216–218.
[20] Poulsen S, Bille J, Rugg-Gunn AJ. Evaluation of a calibration trial to increase interexaminer reliability of radiographic diagnosis of approximal carious lesions. Community Dent Oral Epidemiol. 1980;8:135–138.
[21] Skeie MS, Klock KS. Scandinavian systems monitoring the oral health in children and adolescents; an evaluation of their quality and utility in the light of modern perspectives of caries management. BMC Oral Health. 2014;14:43.
[22] Espelid I, Mejàre I, Weerheijm K. EAPD. EAPD guidelines for use of radiographs in children. Eur J Paediatr Dent. 2003;4:40–48.
[23] Lillehagen M, Grindefjord M, Mejàre I. Detection of approximal caries by clinical and radiographic examination in 9-year-old Swedish children. Caries Res. 2007;41:177–185.
[24] Heidmann J, Helm S, Helm T, Poulsen S. Changes in prevalence of approximal caries in 17-year-olds and related restorative treatment strategies over a 6-year period. Community Dent Oral Epidemiol. 1988;16:167–170.
[25] Qvist V, Larsen U, Andersen TR, et al. Sealing or restoring manifest occlusal caries in young permanent teeth – 5-yr results. Int J Paediatric Dent. 2013;23 Suppl 1:7 (Abstract O04-22).
[26] Bakhshandeh A, Qvist V, Ekstrand KR. Sealing occlusal caries lesions in adults referred for restorative treatment: 2-3 years of follow-up. Clin Oral Investig. 2012;16:521–529.
[27] Ekstrand K. Cariologi Tandplejeren. 2007;32:20–29.
[28] Kurol J, Rasmussen P. Occlusal development, preventive and interceptive orthodontics. In: Koch G, Poulsen S, editors. Pediatric dentistry. A clinical approach. Copenhagen: Munksgaard; 2001. p. 321–349.
[29] Carvalho JC, Ekstrand KR, Thylstrup A. Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. J Dent Research. 1989;68:773–779.
[30] Carvalho JC, Ekstrand KR, Thylstrup A. Results after1 year of non-operative occlusal caries treatment of erupting permanent first molars. Community Dent Oral Epidemiol. 1991;19:23–28.
[31] Carvalho JC, Thylstrup A, Ekstrand KR. Results after 3 years of non-operative occlusal caries treatment of erupting permanent first molars. Community Dent Oral Epidemiol. 1992;20:187–192.
[32] Carvalho JC. Caries process on occlusal surfaces: evolving evidence and understanding. Caries Res. 2014;48:339–46 (Review).
[33] Vermaire JH, Poorterman JH, van Herwijnen L, van Loveren C. A three-year randomized controlled trial in 6-year-old children on caries-preventive strategies in a general dental practice in the Netherlands. Caries Res. 2014;48:524–533.
[34] Ekstrand KR, Kuzmina IN, Kuzmina E, Christiansen ME. Two and a half-year outcome of caries-preventive programs offered to groups of children in the Solntsevsky district of Moscow. Caries Res. 2000;34:8–19.
[35] Kuzmina I, Ekstrand KR. Outcomes 18 years after implementation of a nonoperative caries preventive program-the Nexö-method-on children in Moscow, Russia. Community Dent Oral Epidemiol. 2015;43:308–316.