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The Caries Experience in Child and Youth Oral Health Care in Denmark from 1972-2022. A Narrative Interpretation of Success

Ekstrand KR[1*]; Christiansen J[2]; Christiansen MEC[2]; Bakhshandeh A[1]

[1]Section for Cariology and Endodontics Department of Odontology, Faculty of Health and Medical Science, University of Copenhagen, Denmark

[2]Former Dental Officers in the Child Dental Health Service in the Municipality of Nexø, Denmark

***Corresponding author: Kim Rud Ekstrand**

Section for Cariology and Endodontics Department of Odontology, Faculty of Health and Medical Science, University of Copenhagen, Denmark, Nørre Alle 20, 2200 Copenhagen N. Denmark.

Tel: +4524431177

Email: kek@sund.ku.dk

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Abstract

Background: The Danish parliament passed by law in 1971 that the municipalities (n=277) should introduce free and outreach oral health care for school children in Denmark in 1986 extended to all children aged between 0 and 18 years of age.

Purpose: To illustrate the improvements in caries experience expressed through defs/DMFS of 7- and 15-year-olds in the period over 50 years from 1972-2022 and to discuss which initiatives have most likely had the greatest influence on the development.

Material and Methods: National data for 7- and 15-yr-olds from the National Board of Health were collected from every 10 years from 1972/3 to 2022. Relevant clinical studies are traced from Danish dental journals, supplemented with international literature.

Results: Average defs in 7-yr-olds was 12.5 in 1972/73, falling to 6.6 in 1992 and to 1.78 in 2022. In 15-yr-olds, the average DMFS in 1982/83 was 11.4, falling to 4.36 in 1992 to 1.02 in 2022. Longitudinal data confirmed a significant reduction of caries during the 50 years observation. The literature indicates that especially the establishment of the child and youth oral health care scheme in 1972 and its expansion over the years; the continuous focus on quality toothbrushing with fluoride containing toothpaste; use of fluoride-containing products; use of fissure sealants, changed views on when filling therapy should be performed; and caries risk-related programs, according to individual needs, e.g. the Nexoe method and the Odder model have all had a significant effect on the caries reduction achieved.

Conclusion: The above-mentioned factors have very likely contributed to reducing caries experience from being extremely high to extremely low over 50 years.

Keywords: Caries; Prevention; Toothbrushing; Fluoride; Fissure sealants; Caries preventive programmes

Abbreviations: Tandlægebladet: Danish Journal of Dentistry; PCM: Public Clinics in the Municipalities; PDCM/PCM: Private Clinics in the Municipalities

Introduction

Several articles and reports have described the prelude to and establishment of municipally organized child oral health care in Denmark [1-4]. In short, a unanimous Parliament (Danish) supported the law in 1971, which stated that from 1st August 1972 municipalities should establish free oral health care in public clinics, mainly established at the schools, for everyone of compulsory school age. The scheme was called the municipal child oral health care scheme at the time. All schoolchildren (7-15 yr of age) were to be under the scheme by 1980. To achieve this goal, from August 1972 new 1st grades were gradually included in the scheme each year. It is important to mention that a number of mainly very small municipalities were not ready in 1972 for the challenge and got dispensation for some years. In 1981 to 1985 the scheme was extended to include 0- to 6-yr-olds, and in 1986 and 1987 16- and 17-yr-olds were also included in the scheme. In 1988, the scheme covered all children and

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young people from 0-18 years of age and the scheme changed its name to *Child and Youth Oral Health Care*. In 2021, it was decided that 18- to 21-yr-olds should also join the scheme.

From its establishment in 1972, the scheme covered 1) regular dental examinations, 2) general and individual preventive measures, and 3) dental treatment, including orthodontics, necessary to keep the mouth and teeth in good working order [2,4]. An extremely important facet of the scheme was that the municipality (receptionist at the clinics), through the oral health care scheme, contacted parents and children (outreach dentistry), by telephone or by letter, aiming at calling for regular examinations at the clinic.

At the same time, a registration system for child oral status was established; The Danish Health Authority's Central Dentistry Register (In Danish abbreviated to SCOR). Locally, each child had their dental health information once a year recorded on the form seen in Figure 1. Copies of the foms were then sent to the Danish Health Authority Statistics which treated the data and expressed the oral health data yearly on national-, regional- and municipality level in reports as well as stored the data in the Danish Health Authority's data bank. The annual SCOR data as they were named in Denmark, have proved extremely valuable for evaluation and planning purposes [5].

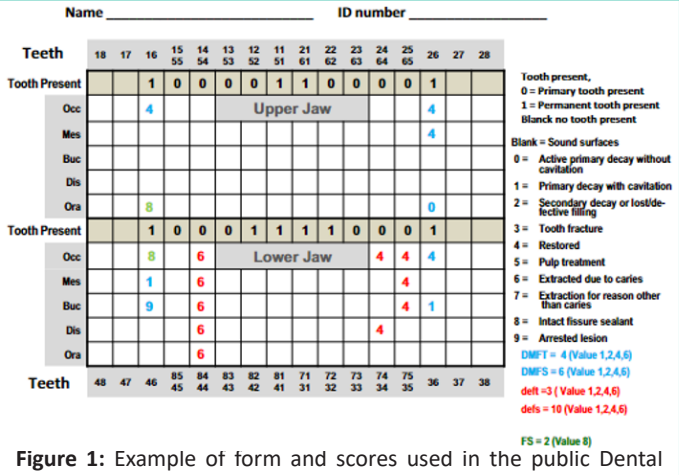

Figure 1: Example of form and scores used in the public Dental Health System in Denmark for recording caries. The scores and descriptions are shown to the right. The form illustrates the caries status of a 9-year-old child who has both primary (0) and permanent teeth (1) present. Absence of scores in the boxes indicates that the surface is sound in terms of caries. The child has had tooth 84 extracted (score 6) and restorations on 74 and 75 (score 4). In the permanent teeth, there are restorations (score 4) on the occlusal surface on 16, 26, 36, and on the mesial surface on 26. The occlusal surface on tooth 46 and the palatinal pit on 16 are sealed (score 8). The mesial surface on tooth 46 and buccal pit on 36 have active, cavitated caries lesions (score 1), whereas the palatinal pit on 26 has an initial caries lesion (score 0). Finally, the buccal pit on tooth 46 has an arrested caries lesion (score 9). The total deft/s and DMFT/S are given to the right. The d/D component indicates active caries lesions with cavitation (score 1) requiring restorative treatment: the e/M component indicates teeth extracted due to caries (score 6), and f/F restored tooth/surface (score 4) due to caries. Note that scores 0, 7, 8, and 9 are not a part of the def/DMF index.

Aim

To illustrate the improvements in caries experience expressed through defs/DMFS in children/adolescents achieved from 1972/73-2022, expressed in 7- and 15-yr-olds, and discuss which initiatives are most likely to have had the greatest impact on development.

Material and Method

All defs/DMFS data used in this paper come from the Danish Health Authority's data bank. The literature used in this article is primarily clinical studies carried out on children and adolescents from municipal dentistry during the 50 years, published in Danish Dental Journals supplemented with international literature when relevant.

Results

Number of Municipalities in Denmark and Registration of Oral Status of Children and Adolescents

In 1972/73, according to Helm, 127 municipalities out of 277 municipalities had reported valid data to the Danish Health Authority on caries, gingivitis and plaque [1]. In 1981/82, 207 out of 277 municipalities provided oral health care for children and adolescents in Public Clinics in the Municipalities (PCM), while oral health care in the rest of the municipalities was still provided by private dentists (PDCM) [6]. In 2006 came the new municipal reform, where the country's 277 municipalities were merged into 98 municipalities, of which 94 were PCM's and 4 were PDCM's. The 16 regions were merged into 5 regions.

The intention was that all children in the scheme should have an annual reporting of their oral status submitted to the Danish Health Authority. From 1993 it was decided that only the 5-, 7-, 12- and 15-yr-olds should be registered annually, but it was made voluntary for the municipalities to register the other cohorts as well. This means that in the compulsory cohorts, registrations covered > 80% of the national size of the cohort year after year.

Analyses of SCOR data published by the Danish Health Authority show that there was considerable inter-municipal variation in average defs and mean DMFS over the years [4].

In the Danish caries registration system, the d/D component is predominantly used to indicate that primary and secondary caries lesions require restoration. This was also the cases on radiographs, when the lesions cannot be clinically identified. In addition, initial, active caries lesions were also recorded, but as mentioned, was not a part of the defs/t/DMFS/T index.

Caries Experience in Danish Children and Adolescents Expressed through defs/DMFS on 7- and 15-yr-olds in the Period 1972/73-2022 (cross-sectional and cohort data)

Figure 2 illustrates cross sectional defs data on 7-yr-olds from 1972/73 and every 10 years, until 2022. In addition, the figure also illustrates cohort data on the 3-5-7-yr-olds from 1992 (cohort a, Figure 2) and forward (cohort b-d).

Table 1: Plaque and gingivitis indices of 1st grade pupils (7-year-olds) in 1972/73 [3].

1972/1973	Girls average	Girls SD	Girls Minimum	Piger Maximum	Boys average	Boys SD	Boys Minimum	Boys Maximum
Plaque Index	**4,6**	2,6	1,2	7,0	**5,0**	2,7	0,8	7,6
Gingivitis Index	**3,0**	2,4	0,3	5,3	**3,1**	2,4	0,7	6,1

Table 2: Plaque and gingivitis indices on 1st grade pupils (approx. 7 years old) 1976/77 and in 1986/87 (National Board of Health [16]. Number of registered pupils was >39,000.

1976/77	Average	SD	1986/87	Average	SD	p-value
Plaque Index	4,6	2,6	Plaque Index	3,8	2,5	p<0,05
Gingivitis Index	3,3	2,3	Gingivitis Index	2,9	2,1	p<0,05

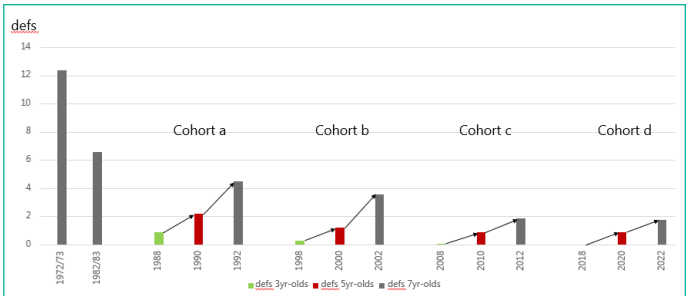

Figure 2: Average defs of **7-year-olds** every **10 years** from **1972/73** to **2022**, supplemented with data covering **3- and 5-year-olds** to establish cohorts a-d.

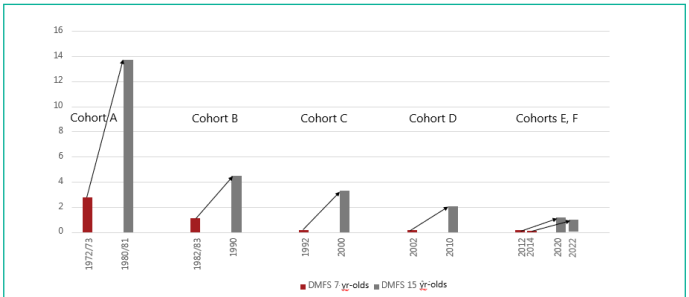

Figure 3: Average DMFS of **15-year-old**s every **10 years** from **1982/83** to **2022**, supplemented with data from **7-year-olds** to establish cohorts A-E.

Table 3: Plaque and gingivitis indices on 9th grade pupils in 1976/77 and in 1986/87 (National Board of Health [16]). The number of registered pupils in 1976/77 was 7,352 and in 1986/87 45,852 pupils were registered for plaque occurrence and 51,762 pupils for gingivitis.

1976/1977	Average	SD	1986/87	Average	SD	p-value
Plaque Index	3,6	2,3	Plaque Index	3,0	2,5	p<0,05
Gingivitis Index	3,1	2,4	Gingivitis Index	2,9	2,2	p<0,05

Table 4: DMFS growth data from the study [18] calculated on teeth that erupted at baseline and on teeth that erupted after baseline.

DMFS reference	Duraphat varnish Group	Fluoride rinse Group
On teeth erupted at baseline	2,96	2,77
On teeth erupted after baseline	2,20	2,30
Radiological on teeth erupted at baseline	1,01	0,82
Radiological on teeth erupted after baseline	0,59	0,45

In 1972/73 the average defs of 7-yr-olds was 12.4 (1sd = 10.6) [3]. The caries experience fell by almost 50% over the next 10 years, so that in 1982/83 the average defs was 6.6. In 1992, 2002 and 2012, average defs fell further to 4.5, 3.6 and 1.9 and in 2022 to 1.8 (1SD=4.6). The percentage decrease from 1972/73 to 2022 was 86%. As for the percentage of 7-yr-olds with a defs=0 in municipalities, which was first measured in 1992, the level increased from 40% gradually to 71% in 2022.

As can also be seen from the plotted lines, on the 4 cohorts (a-d), the slope of the lines decreases significantly from 3- to 5-yr-olds and even more markedly from 5- to 7-yr-olds, especially from cohort b to c. Figure 3 is structured as Figure 2, but the starting point was to begin with 1980/81, when average DMFS for 15-yr-olds was first published by the Danish Health Authority. Average DMFS that year was 13.7. Ten years later in 1990, average DMFS had fallen to 4.5 (67%), in 2000 to 3.3, in 2010 and 2020 to 2.1 and 1.2 respectively, and in 2022 on to 1.0 (1SD=2.8). The percentage decrease from 1980/81 to 2022 corresponds to 93%. The number of 15-yr-olds classified with a DMFS=0 increased from 3.6% in 1982/83 to 70% in 2022. Cohort data, through the plotted lines, illustrate a gradual reduction of the growth of caries from 7- to 15-yr-olds in the 6 cohorts included in Figure 3 from 1972/73 to 2022.

Figure 4 shows the municipalities' percentage of 15-yr-olds with a DMFS=0 in 2022 arranged with decreasing value. All eight 15-yr-olds on Læsø municipality had a DMFS=0, therefore a DMFS=100% for Læsø. In the next 3 municipalities, just over 80% of 15-yr-olds had a DMFS=0. The national average that year was 69.6%. The figure illustrates that in about 90% of the municipalities in Denmark, despite different demographic and social conditions, efforts in child and youth oral health care had resulted in between 60% and 80% of 15-yr-olds having a DMFS=0.

Possible Explanations for the Reduction in Caries Experience when Reviewing Available Scientific Literature

Initially, the following should be mentioned. Systematic reviews have shown that fluoride in drinking water and in toothpaste has played a significant caries prevention role over the years, not only in Denmark but also globally [7,8]. In this connection, it should be mentioned that with some inter-municipal variation (from 0.08 ppm to 1.2 ppm [9]) both before and after the establishment of child oral health care in 1972, there has been naturally occurring fluoride in the municipalities' drinking water. Thylstrup and colleagues described that >80% of toothpaste sold since the early 70s contained fluoride [10]. This means that precisely these two fluoride-containing methods can be taken out of the equation to explain the marked improvement that has occurred, with regard to the caries experience from 1972/73 to 2022 in Denmark (Figure 2,3). However, there are indications that the fluoride content in the toothpaste in the first years after the introduction of child oral health care scheme was max. 1050 ppm fluoride and subsequently it became possible to buy toothpaste with 1450 ppm fluoride. Twetman and colleagues [11] conducted a systematic review in 2003 which showed that using 1450 ppm F toothpaste instead of 1050 ppm F toothpaste resulted in a caries reduction equivalent to 9%.

Establishment Versus Not Establishment of Child Oral Health Care

In Friis-Hasché's book entitled "Child Oral Health Care in Denmark", which was published in 1994, there is at the end a reference list dating from 1971 to 1991 [12]. During this period, 374 articles have been published, which mainly deal with studies carried out in the Danish Child and Youth Oral Health Care scheme or describe the development of oral health care. Almost 50 articles from that period deal with the importance of organization of the of Child and Youth Oral Health Care for better oral health, including caries experience.

One question is whether another organizational model than PCM, for example the PDCM model, which a number of municipalities, at least from 1972 to 2006 chose to use, could show the same reduction in caries as in the PCM. The 207 PCM's in 1981-82 treated approximately 520,000 pupils from grades 1-9. The number of pupils in grades 1-9 in PDCM's was approximately 70,000 [6].

In 1977, Bille and colleagues found in a study [13] involving 559 schoolchildren in 2nd and 4th grade from PCM's as well as PDCM's the following caries data; that there was 1.5 times as much untreated caries in the urban areas and 2 to 2.5 times as much in the rural areas in the children in PPM's as in children who followed the oral health care in PCM's. In the 4th grade, the children had slightly more fillings in PCM's than the chil-

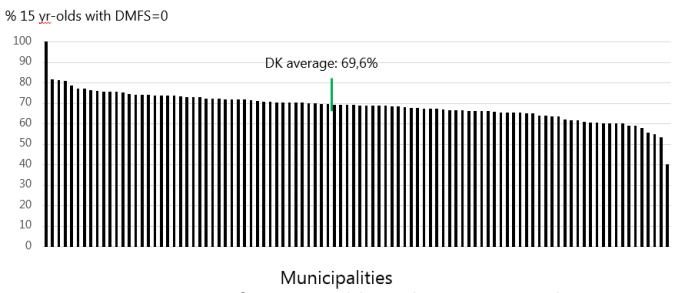

Figure 4: Percentage of 15-year-olds with DMFS=0 in the municipalities in 2022 distributed from highest to lowest value.

dren in PDCM's, while the children from PDCM's had extracted an average of one tooth per child compared with 1/3 tooth in the PCM's. Plaque incidence was broadly similar in the two systems (score between 5 and 6). On average, children in PCM's came to the dentist 1.5 times more often than the children on PCDM's, which was one of the reasons why the price per child in PCM's was more expensive than in PDCM's. Bille and employees emphasized that if the PDCM's was to achieve the same caries reduction as in PCM's, then PDCM's should perform outreach dentistry.

Other studies, for example by Hansen [14] found results similar to Bille and colleagues, although with a significantly greater difference in caries experience favoring children in PCM's compared to children in PPM's.

Movement in Plaque and Gingivitis

Plaque is well known to be a necessary factor for caries to develop, and Von der Fehr and colleague elegantly illustrated this in a clinical study in 1970 [15]. Perhaps that is why it was chosen to register plaque on children and adolescents in Child and Youth Oral Health Care in Denmark (both at the PCM and PPM level) right from the establishment in 1972. In his 1973 paper, Helm [3], based on SCOR, presented the following information and data regarding plaque and gingivitis index in pupils in 1st grade (n>20,000, Table 1). The plaque and gingivitis indices were based on clinical data measured on the reference teeth 16, 12, -32, and 36. For both the plaque and gingivitis indices, scores from 0-3 were used, so the minimum and maximum were 0 or 12, respectively, on each child studied, and this applied to both the plaque and gingivitis indices.

The plaque indices for girls and boys were 4.6 and 5.0, respectively, corresponding values for the gingivitis indices were 3.0 and 3.1 (see values in bold in Table 1). Thus, the scores were slightly lower in the girls in both indices than the boys.

Similar indices are used in Tables 2 and 3, but here the plaque and gingivitis indices are combined for boys and girls. Table 2 shows average values for the plaque and gingivitis indices in 1976/1977 and 10 years later in 1986/87 for 1st grade pupils. Nearly 40,000 1st grade pupils were surveyed that year [16]. Movements in indices can be tested statistically and it appears that both the plaque and gingivitis indices have decreased significantly over the 10 years (t-tests for unpaired groups; t-value > 5.19, $p<0.05$).

In Table 3, similar data are obtained only for pupils in 9th grade (approximately 15-yr-olds) as in Table 2 (16). Again, it is seen that both the plaque index and the gingivitis index have fallen statistically significantly from 1976/77 to 1986/1987. The registrations for plaque were removed from the SCOR data in 1987, as it was chosen to register only diseases and not causes of diseases. The registrations for gingivitis were made non-mandatory. Therefore, after 1987, information about the level of oral hygiene in children and adolescents in Denmark is scarce. In 2019, the 1st author participated as a registrar in a study of 5-8-yr-old children (n=330) in 4 municipalities on Zealand, [17] and found an average plaque index of 0.37(1SD=0.30). The gingivitis index was 0.32 (1sd=0.28).

Fluoride-Containing Mouth Rinses and Local Application of Fluoride-Containing Varnish

Fluoride rinses were introduced in schools in the 1960s [18]. The background for this was that a number of well-controlled international clinical studies, e.g. conducted in Sweden from 1961 to 1973, (see overview by Poulsen and colleagues in reference 18) documented that there was a caries reducing effect of between 20-40% with systematic fluoride rinsing compared to no fluoride rinsing. This was independent of whether small concentration (0.05%) was used, where daily rinsing was required, or higher concentration up to 0.5%, where rinsing was to be done every 14 days. The article from Poulsen and colleagues also showed that it was highly unlikely that side effects, such as acute poisoning or skeletal fluorosis would occur when rinsing at school.

In the mid-eighties, the effect of fluoride rinsing versus Duraphat varnish was tested [19]. The participants (n=426) were 3rd grade pupils from the child oral health care in Horsens (PCM). The fluoride concentration in the municipality's drinking water was between 0.1-0.2ppm. The duration of the study was 3 to 5 years and caries was assessed both clinically and radiologically. Participants were allocated per class to either receive Duraphat varnish every 6 months + a placebo rinse every two weeks or receive placebo varnish every 6 months and fluoride rinsing every two weeks. The DMFS increment during the study was very close to each other (Table 4), where e.g. the DMFS increment in the Duraphat group calculated on erupted teeth after 5 years was 2.96 compared to 2.77 in the fluoride rinsing group. Data processing showed no statistical difference between the two treatments, neither clinically nor radiologically (Table 4), but the cost of the Duraphat treatment was more expensive than the fluoride rinsing.

In 1992 [20], Heidmann and colleagues investigated the development of caries after it had been decided to stop fluoride rinsing in the municipality of Værløse (PCM) (the F concentration in drinking water was between 0.2-0.3 ppm). For the 3-year double-blind study, those interested in participating (1306 out of 1736) were randomized into 2 groups: Group 1 who continued with fluoride rinsing and Group 2 who rinsed with a placebo liquid. Both groups otherwise followed the offers that Værløse municipal oral health care included. The outcome was caries increment, measured clinically (DMFS) and radiologically. Therefore, only permanent molars and premolars were included in the study. Sealed teeth were not included in the data processing. Data were expressed both on teeth erupted at baseline and on teeth erupted during the study. At 5% significant levels, baseline DMFS and final DMFS were similar in the two groups, but on teeth that erupted after baseline, significantly more radiologically identified lesions developed in the placebo group, than in the fluoride rinsing group.

Fissure Sealings

In 1955, Buonocore developed the etching technique [21] and it was the beginning of a completely new non-operative treatment principle, namely fissure sealing. Fissure sealing be-

came known in Denmark in the 70s. Thus, in 1976 and 1978 [22,23], Thylstrup & Poulsen investigated the effectiveness of fissure sealing after 1 and 2 years under Danish child oral health care conditions. The study took place in Hillerød (PCM) and the design was a split-mouth study. The effect after 1 and 2 years was 68.5% and 50.3%, respectively, and was, of course, completely dependent on the retention rate of the sealing material, which in this case was Concise Enamel Bond. Thylstrup and colleagues were already advocating that fissure sealing should not be used routinely as a mass prophylactic, but more as an individual treatment.

In 1991, Ekstrand et al., [24] showed in a questionnaire survey involving 82% of the PCM's (n=162) representing all 16 regions at the time, that 1/3 indicated that 8- and 13-yr-olds had routinely received fissure sealants, 43% indicated that they had fissure sealed, 30-80% of 8- and 13-yr-olds and 15% indicated that they sealed less than 10% of their 8- and 13-yr-olds.

The most frequent fissure sealed surfaces were the occlusal surfaces of permanent 1. molar teeth, including buccal and palatinale pits. Furthermore, the occusal surfaces of the premolar had hardly been sealed.

Interestingly, the picture was different for PPM's, where the majority of dentists sealed the teeth of < 30% of 8- and 13-yr-olds.

Based on 2012 and copies of the formula seen in Figure 1 from 35 PCM's distributed in all 5 regions (after the in Denmark, Nørrisgaard [25] was able to show defs/% defs=0 in 3- and 9-yr-olds and DMFS/%DMFS=0 in 9-, 15- and 18 yr-olds. For example, the average DMFS was 1.97 in 15-yr-olds [25] versus an average DMFS at the national level of 1.92. Thus, it appeared that Nørrisgaard's data was a representative sample of the country. Fissure sealings were also recorded. Very few primary teeth were sealed. In contrast, 41% of occlusal surfaces on the permanent 1. molar teeth were sealed on the 9-yr-olds, along with 11% of the palatine and buccal pits.

In conclusion, systematic reviews with meta-analyses have found that the use of fissure sealing reduces the risk of developing filling-requiring caries on permanent 1. Molar teeth between 11% and 51% over a period of up to 4 years compared to no treatment (Moderate confidence in the outcome) [26].

Change in the Requirements for Filling Therapy

In a radiological study from Randers municipality (PCM), Heidmann and colleagues [27] showed that 15-yr-olds in 1983/1984 had approximately 6% fewer approximal surfaces filled in the enamel than in corresponding 15-yr-olds10 years before. The research group around Espelid and Tveit from Norway [28], showed in a questionnaire survey that 2/3 of the dentists who answered the questionnaire in 1983 would perform surgical therapy of enamel caries lesions identified on X-rays, compared to only 18% in 1995 and 7% in 2009.

The group around Qvist and Bakhshandeh [29] as well as chief dentists and the staff of 9 PCM's showed in a practice randomized clinical study initiated in 2007, that the indication range of fissure sealings could be extended to the treatment of occlusal caries lesions, where dentists would normally perform filling therapy. The inclusion criterion was that radiologically the lesions should be in the dentin, but limited to the outer 1/2 part towards the pulp. After 7 years, the status was that 50% of the sealings had been converted to fillings. This meant that in 50% of sealed teeth, the dentist had judged that filling therapy was still not necessary. Furthermore, there were no teeth that had been endodontically treated.

Caries Risk Surfaces in the Dentitions and Times of Eruption of Permanent 1st and 2nd Molar Teeth

As shown by Nørrisgård [25], analyses of SCOR data from the 70s to present also show that approximal caries between the primary molars and that the occlusal surfaces of the 1st and 2nd permanent molars including the facial and lingual pits on these teeth made up the majority of the defs/DMFS index. In 2019 at national level, 66.8% of 15-yr-olds had a DMFS=0 (Zone 1), 16.9% had fissure caries (Zone 2), 9.4% had approximal caries (Zone 3) and 6.8% had incisive and smooth-surface caries (Zone 4) [30].

In the late 80s, the group around Professor Anders Thylstrup and Nexoe municipal oral health care (PCM) showed that the eruption phase of 1st permanent molars and corresponding 2nd permanent molars should be seen as a risk factor for developing caries on occlusal surfaces [31-33]. A study conducted in the Oral health care in Nexoe [34] found that the time of eruption for girls and boys and the duration of the eruption period for girls and boys for both the 1st and 2nd permanent molars varied extremely widely.

The variations are presented in Table 5, e.g. for 1st molars in girls, the earliest observed eruption time is 5 years and 3 months and the latest eruption is 7 years and 8 months (see data in bold in the table). Similarly, with the eruption period (def. all 4 molars are fully erupted), see column 5 of Table 5, which takes on average about 15 months for the 1st permanent molars and close to 28 months for the 2nd permanent molars (Table 5).

The Nexoe method

Based on these facts, the first part of the Nexoe method was developed, in which the children in the oral health care scheme came for examinations at the clinics at fixed intervals that did not exceed 4 months when there were erupting permanent molars [32-33]. Already in 1988 [35,36] the Nexoe method was extended to include 3 areas of action (Tables 6 A and B).

The interval length was determined from the sum of points in Table 6B. One month (8 points), 2 months (7 points), 3 months (6 points), 4 months (5 points) and 6 months or more (4 points).

Table 5: Eruption time and duration of eruption for 1st and 2nd permanent molars on a Danish material [34].

1st molars permanent	Time of eruption Earliest	Time of eruption Recently	Eruption average	Duration of eruption in months	Average duration of eruption
Girls	5 years, 3 months	7 years, 8 months	6 years, 1 month	5-32 months	15.4 months
Boys	5 years, 2 months	7 years, 10 months	6 years, 3 months	7-28 months	15.0 months
2nd molars permanent					
Girls	8 years, 11 months	14 years, 4 months	11 years, 3 months	12-24 months	2.,1 months
Boys	9 years, 11 months	13years, 11 months	12 years, 0 months	9-45 months	27.9 months

In 1988, impact targets were set for 15- and 18-yr-olds at the dawn of the new millennium, i.e. 12 years after implementation. Impact targets for 15-yr-olds were an average DMFS<1.5 and >2/3 should have a DMFS=0. For the 18-yr-olds, the impact target was an average DMFS<2 and > 50% of the 18-yr-olds should have a DMFS=0. These targets were met in 1999 [35], when the average DMFS in 15-yr-olds in Nexoe municipal dentistry was 0.88 and 71% had a DMFS=0.For the 18-yr-olds, the average DMFS=1.23 and 55% had a DMFS=0.

The Odder model

The Odder model [37], which was implemented in Odder municipal oral health care (PCM) the mid-2005 to 2006, operated with virtually the same risk parameters as in the Nexoe method, but with slightly longer intervals between calls. In contrast to the Nexoe method, the Odder model succeeded in expanding cooperation with the municipality within general health and a health coordinator was appointed. The focus of the health plan was the first 4 years on diet and physical activity. For example, there was zero sugar tolerance in kindergartens and schools.

The Odder model was also distinguished by the dentists being team leaders, while the dental hygienists were key people in examinations and risk assessment and the dental assistants took care of controls and preventive measures. In line with the Nexoe method, the Odder model achieved a large reduction in DMFS, e.g. average DMFS of 15-yr-olds in 2002 in Odder municipality was approx. 3, which fell to <1 in 2012.

Discussion

Figures 2-3 show that the caries experience expressed by the defs/DMF-S indices has decreased significantly among children and adolescents in parallel with the establishment of first the municipal child oral health care scheme in 1972 later replaced by Child and Youth Oral Health Care scheme. Using cross-sectional data, there is a decrease of >85% in average defs on 7 yr-olds from 1972 /73 to 20022 and >90% in average DMFS on 15-yr-olds from 1980/81 to 2022. Similarly, we can see a significant increase in the number of 7- and 15-year-olds with a defs=0/DMFS=0. About 70% of 15-yr-olds had a DMFS=0 in 2022. Data from the Danish Health Authority shows that approximately 20% of the 30% had a DMFS=1-2 and 6% had a DMFS= 3-4. This means that less than 5% had a DMFS of >4. At cohort level (a,b,c,d, Figure 2) and (A-F, Figure 3), there is also a marked reduction in defs/DMFS increment, expressed through the decreasing slopes of the lines towards 2022. The inter-municipal variation in child and adolescents' caries experience, which has been significant over the years [38], has been significantly reduced, at least if you look at data from 2022 (Figure 4), where 94 out of 98 municipalities reported that DMFS=0 in 15-yr-olds was between 60- and 80%. We have only used standard deviations on average defs/DMFS data in this article in the years 1972/73 (for 7-yr-olds) and in 2022 for both 7- and 15-yr olds. This is because standard deviations only became part of SCOR from the year 2000. Standard deviations for 7-yr olds in 1972/73 are due to a special study, conducted by Helm [3].

Data also show that the 4 so-called practice municipalities (where the child and youth oral health care was delivered by Private Practices (PPM's) over the years) they have achieved the same success in terms of lowering the caries experiences as the PCM's. In 2019, just before the onset of the COVID-19 pandemic, defs=0 in the 7-yr-olds was 78.8% in the PPM's (n=551) against 72.8% in the clinic municipalities (n=46645) and for the

Table 6A: The 3 focus areas in the Nexoe method.

Parents and children are taught the local nature of caries disease
Intensive training in home treatment (toothbrushing) and
Professional plaque removal, diagnostics, and individualized risk assessment

Table 6B: The criteria for use for the interval planning.

	1 point	2 points
Childs/parent's cooperation (risk indicator)	God	Bad
Caries in progression generally (diagnosis)	No	Yes
Eruption stage of permanent molars (risk factor)	Full occlusion	Partial occlusion
Caries in progression occlusally on the erupting molars (diagnosis)	No	Yes

15-yr-olds, the figures were 64.7% (n=621) in the PPM's against 66.8% in the PCM's (n=48399) [30]. Here it is important to emphasize that dentists and dental hygienists working in the PPM'S must work according to the same regulations as in the PCM's, including reporting to the SCOR system and perform outreaching (have to contact and treat the children in the municipality) dentistry.

In this article, we have tried to identify initiatives that have played a major role in the improvements achieved over the 50 years and to show that clinical data from municipal dentistry have been able to confirm this (9,13-14,18-20,22-25,27,29,31-39).

As can be seen from Figure 2 and 3, the major significant reduction in defs occurred in the primary teeth of the 7-yr-olds from 1972/73 until 1992 (reduction~64%) and for DMFS in the 15-yr-olds from 1980/81 until 2000 (reduction~73%). From literature review, it can reasonably be documented that the following 7 initiatives have had a major impact on the large reduction in defs/DMFS in the period 1972/73 and up to the turn of the millennium.

Establishment of Oral Health Care for School Children in 1972 with subsequent dentistry for 0-6-yr-olds and expansion with 16- and 17yr-olds (Child and Youth Oral Health Care) so that dentistry involved children and adolescents from 0-18 years in 1988.

Continuous focus on brushing twice daily with fluoride-containing toothpaste as well as instruction and training in better plaque removal.

The use of fluoride rinses in schools (primarily 0.2%NaF solution every 14 days)

Local fluoride treatment e.g. with Duraphat varnish (22,800 ppm F) or 2% NaF solutions (9000 ppm F)

Widespread use and subsequent extended indication range for the use of fissure sealing

Changes in the criteria and timing of filling therapy

Working risk related, including viewing the eruption period of the permanent molar teeth as a risk factor

Regarding toothbrush instructions, Kirkegaard [39] conducted a review

of clinical studies back in 1981 and concluded "that brushing may contribute to some extent to a reduction in caries activity, especially on easily accessible tooth surfaces. However, it is difficult to provide completely convincing evidence". Data from SCOR from 1972/73 to 1986/87 showed a gradual improvement

in plaque index among children and adolescents. Later clinical studies also showed that the plaque index has become even very low in child and youth oral health care in Denmark [17], so the resources, which the staff in child and youth oral health care have used and still use in this area, have not been in vain.

Fluoride rinses were phased out in the late 80s, when clinical studies showed that local application of fluoride, such as Duraphat varnish, was as effective as rinsing. However, Duraphat varnish was more expensive to use than fluoride rinses [18] and radiological data from Værløse also showed that fluoride rinses were more effective than Duraphat varnish [20]. The first author of this article therefore opens up for a discussion of whether a cost-effective method such as fluoride rinsing [18,20] should be phased out in general in Child and youth Oral Health Care in Denmark. An alternative could be that oral health care in the individual municipalities should instead have considered continuing with rinsing for children at risk and during risk dental ages, for example from 5-6 years of age to the permanent 1st molar teeth were fully erupted. This is to reduce filling-requiring caries on the most caries-prevalent surfaces in both dentitions, namely approximally between the primary molars and occlusally/bucally/palatinally on the 1st permanent molars [25,30]. In municipalities with a fluoride content below e.g. 0.3 ppm in the water supply, it would be obvious to discuss such an effort even today and be highly relevant to the many refugee children who have a high caries treatment need. The counter-argument (from the 2nd and 3rd authors) is that the children and adolescents who needed to rinse would be exposed to a possible stigma. It is more relevant today to organize local oral health care in accordance with what we know about how caries can be controlled [35,36,37, 40].

Although 2/3 of the observed reduction in defs/DMFS in this article expressed in 7- and 15-yr-olds occurred before the turn of the millennium, caries experience continued to decline until 2022 (Figure 2,3).

Possibly prompted by Bratthall and colleagues from Malmö and their work with the Cariogram [41], a computer-based caries risk programme, caries risk assessment became a popular tool in the 1990s and onwards in Child and Youth Oral Health Care Scheme. The risk assessment of caries was considered as the basis for decisions on preventive and conservation treatment, as well as for determining an appropriate call interval. The Nexoe method (Table 6B) and the Odder model used caries risk assessment on children and adolescents, and this measure helped to achieve the results described above. As far as is known, the Nexoe method and the Odder model are the only two programmes with data over a 10 year period or longer, which are described in detail both nationally and internationally [35,36,37]. In all the years, there has also been an extensive national as well as international course activity around the two programs.

SEAL treatment, sealing occlusal caries with or without clinical cavity and radiologically identified dentin caries limited to the outermost 1/2 part of the distance to the pulp introduced by the Qvist group [29] should also have been an initiative that reduced DMFS. But the Qvist group has proposed that the SEAL treatment be registered with a “4“ on the formular (Figure 1), just like a filling, which is why SEAL-treated teeth cannot be directly read in SCOR. SEAL treatments are convincing evidence that the indications for filling therapy have changed over the 50 years of Child and Youth Oral Health Care in Denmark.

It was mentioned that plaque was a necessary factor for caries to develop [15]. Another necessary factor is fermentable carbohydrates, specifically sucrose [15]. Therefore, one would have imagined that there has been a reduction in sugar consumption in Denmark over the last 40-50 years. According to a report on food supply covering the period 1955-1999 [42], consumption per inhabitant in Denmark was just under 50 kg from 1955 to the mid-70s, after which it fell to around 40 kg per inhabitant until 1999. According to Nyvad [43] and Mølgaard and colleagues [44], it remained around 40 kg/individual until 2004. According to the above-mentioned Supply Report, the intake of soft drinks increased from about 50 l per capita in the 1960s to about 90 l in the 90s. A high intake of soft drinks has continued into the new century, but with a slightly decreasing trend and approximately 35% of soft drinks in 2019 were light products [45]. So even though these figures are far from related to only children and adolescents' consumption of sugar, it is difficult to see that sugar consumption, including sugary soft drinks, could in any way explain the large reduction in caries experience experienced from the 1970s to 2022 among children and adolescents in Denmark.

The authors would like to emphasize that there have been many initiatives locally that have presumably also had an impact on the reduction in caries, but it has not been possible to document the efforts through clinical studies. From the authors' point of view, the following 3 areas could also have had an impact:

The strong focus on health promotion and active prevention programmes in the form of training of key personnel such as health visitors, pre-school teachers and teachers as well as activities in kindergartens and schools, see reference 46 for a description.

As a large number of the authors in the referenced literature have been/are course holders, affiliated with the dental schools and the schools for dental assistants and hygienists and the Danish Health Authority, they have helped to

undertake post-graduate coursework and

modernize the teaching of Cariology in educational establishments

Conclusion

The above-mentioned factors have without doubt likely contributed to reducing caries experience among children and adolescents in Denmark from being extremely high to extremely low over 50 years.

Epilogue

The 7 factors mentioned above in this article (in italics) have most likely contributed to reducing the caries experience among children and adolescents in Denmark from being extremely high to extremely low over 50 years. It is important for the authors to point out that the results have not come from nothing, but through hard work in daily life. The approx. 70% of the 15-yr-olds who have a DMFS=0 in 2022 have been to examinations, checks and preventive caries treatment within the oral health care, from the age of 1-3 years until they are now 15 years old. If it wasn't, many of them would probably have had a DMFS>0. In addition, 20-25% have received expensive orthodontic treatment. It would be bad business for society and for the individual if politicians and decision-makers continue to starve the scheme. What is needed is a professional debate,

centrally and locally, about where the oral health care system should be modernized, for example the SCOR system and by introducing tele dentistry just to name a few areas, in order to maintain the fantastic result that has been achieved also over the next 50 years.

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