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Inequalities in dental caries experience among 6-year-old German children after the caries decline

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Abstract

Objective. As in many other countries, caries decline in Germany has left pockets of persisting caries prevalence. This study aims to assess the benefit of a 10-year community-based prophylaxis program, focused on regular toothbrushing with fluoridated toothpastes or gels and involving institutions noted as having the highest caries levels. ***Materials and methods.*** The caries data ($d_3$mft/D_3MFT) was extracted from the results of the compulsory school entry examinations in Greifswald/Germany (2003/2004–2012/2013) involving ~ 280 6–7-year-olds each year. Data from schools that include children with the highest caries levels and coming from low-SES families were analyzed independently and used for comparisons. Additionally, caries trends from Greifswald were compared to data from representative national surveys (2004–2009). ***Results.*** Data from 2871 children were available for analysis. The baseline $d_3$mft value (2003/2004) was 3.2 ± 3.8; the d_3-component corresponded to 70% of the index. The latest caries data (2012/2013) showed a strong reduction (43.8%) in caries prevalence ($d_3$mft = 1.8 ± 2.5). Similarly, the SiC-Index declined significantly from 2003/2004 (7.9 ± 2.3) to 2012/2013 (4.8 ± 2.3; $p < 0.001$). Nevertheless, in all analyzed years the $d_3$mft values and the SiC-Index were significantly higher in the institutions that included children coming from lower-SES families ($p < 0.05$). The amount of caries reduction between 2004 and 2009 corresponded to 38% in Greifswald as compared to 13% in Germany. ***Conclusions.*** This strategy involving a combination of regular toothbrushing and fluoride application has achieved an overall substantial caries reduction, thereby indicating that caries-control strategies for heterogeneous risk groups can be highly successful as setting approach. However, activities targeting high risk groups still need to be strengthened.

Key Words: *caries decline, caries prevalence, dmft, significant caries index*

Introduction

During the last few decades, the oral health status of children and adolescents has undoubtedly improved worldwide, this however being primarily evident in developed countries [1]. Following the international trend, a substantial decline in caries experience has also been observed in Germany. Data from the last national survey [2] showed an important reduction in the $d_3$mft values in 6–7-year-olds of ~37% from 1994 to 2009, with a significant increase in caries-free children of ~30%.

Caries decline has been generally accompanied by a strong polarization of the disease [3]. Different studies have reported a significant positive correlation between high caries levels and the socioeconomic status of the population. Borges et al. [4] reported that caries is significantly more prevalent in children coming from families with low educational level and incomes. These findings have been supported from many other studies, which have analyzed caries levels and socioeconomic factors of children and families belonging to ethnic minority populations, immigrants and in general those people who belong to less privileged groups [1,5–7].

In Germany, this situation is also familiar, with small population groups demonstrating persistently higher caries rates, a fact that appears to be a major issue [8,9]. Although caries levels in Germany are not very high as compared to other countries in the world, a more detailed analysis of caries prevalence in children has shown a skewed distribution of the disease: a

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small group of children show the highest caries levels, while the majority are completely caries free [10–12]. In this case, the generally used mean D_3MFT value, which describes the population caries status results less as significant and may lead to the false assumption that caries is no longer a problem [13]. In 2000, the Significant Caries Index (SiC) was presented in order to facilitate the recognition of those individuals with the highest caries values in a population [13].

Both the financial as well as the manpower resources intended for caries control are limited; therefore, in view of this problem, population groups having the higher caries risk levels should ideally be identified and targeted primarily by oral healthcare strategies and services [14,15]. A community-based prophylaxis program has been implemented since 2001 in Greifswald, a city which had traditionally had one of the highest caries prevalence levels in children and adolescents in Germany, along with the individualized caries control strategies provided within the framework of the German National Health System. In 2003, this program was amplified by an additional risk-specific component for pre-school and school children. This program concentrated on regular brushing with fluoridated toothpastes or gels in the institutions with the highest baseline caries levels observed. The aim of this study was to assess the long-term benefits of this program for the oral health status of 6–7-year-old children in Greifswald and to compare these data to representative national surveys conducted in similar age groups in Germany in order to analyze the remaining pockets and problems of the persisting caries prevalence.

Materials and methods

Ethical aspects

This research was approved by the Research Ethics Committee of the University of Greifswald (Reg.-Nr.: BB 48/10) and conducted in accordance with the principles for medical research involving human subjects described by the Helsinki Declaration.

Study population

The data for this study were based on recorded figures from the results of the school entry examinations in Greifswald involving ~280 (mean = 287.1; SD = 44.2) 6–7-year old children each year (>80% of the 6–7-year olds population). Greifswald is located in the German state of Mecklenburg-Western Pomerania (MWP) and the city count with ~55 000 inhabitants. Annually, a compulsory entry school examination takes place in all primary schools in Greifswald ($n = 8$) as part of an oral health preventive program and a national epidemiological survey [2]. Three out of the eight primary schools in Greifswald have been described as 'including children of lower socioeconomic status families' (SES; defined as a combination of education and income) and showing the highest caries levels.

Oral health program

Since 2001, the preventive oral health program conducted in Greifswald has been co-ordinated by the community dental service. This program comprises an age-related preventive approach including different oral health activities that take place in nurseries and schools. Caregivers and teachers as well as children and their parents have received education on caries etiology, oral health prevention and nutrition counseling. Additionally, children brush their teeth with fluoridated toothpastes (500 ppm F) in most nurseries. To complement these actions, in 2003 the German state of MWP started an intensive preventive approach involving dental hygienists who have concentrated their activities on the nurseries (0–3/3–6-years of age) and schools (6+) with the highest mean caries values. The awareness of the staff and the parents was raised with the aim of finding a common approach to accomplish the decrease of caries levels in their institutions. This included providing education for the school teachers in order to implement weekly supervised brushing with fluoride gels (Elmex Gel®, GABA, Lörrach, Germany; 12 500 ppm F). In nurseries, the daily brushing with fluoridated toothpastes was stressed out and educators were instructed to provide special assistance to children presenting with high caries and gingivitis levels. Parents of small children (0–2 years of age) were contacted when bringing or taking their child home in order for an individualized instruction on the child's plaque, gingivitis and caries levels to take place followed by practical brushing exercises and recommendations on oral home care, fluoride use and feeding habits focusing on the use of nursing bottles and drinks. Institutions presenting with the highest caries levels received more frequent visits. These activities have been complemented with regular oral health examinations carried out by dentists to determine the children's oral health status and to refer children to dental treatment if necessary.

Study design

This is a retrospective longitudinal study based on caries data obtained from the yearly examinations in 2003–2004 to 2012–2013. The outcomes are based on the d_3mft/D_3MFT values. The data collection was performed following the WHO recommendations and guidelines [16]. All 6–7-year old children from all primary schools in Greifswald and their parents were invited to participate in the study. Exclusion criteria were as follows: children with a systemic disease

requiring special considerations during their dental examinations; and parents/children who declined to participate in the study. Overall childrens'/parents' participation rates remained consistent between 85–96% from 2003 to 2013. Each year two-to-three calibrated dentists (>85% inter-examiner agreement) [2] examined the children in their respective institutions using non-magnifying mirrors and dental probes under daylight or, where necessary, using an artificial light source. The dentists' calibration took place as part of the regular calibration practical exercises for the German National Survey in schools. In total, six examiners have been involved in the examinations between 2003 and 2013.

The German national survey takes place every 3–5 years and examines nationally representative samples of caries prevalence in the German states among different age groups (6–7-, 9-, 12-, 15-year-olds). For the purpose of the present study, national (Germany) as well as regional (MWP) data concerning 6–7-year old children taking part in the last German surveys (2004 and 2009) [2] were compared to data referring to the same age group assembled during the corresponding years from Greifswald.

Data analysis

The mean number of decayed, missing and filled primary ($d_3$mft) and permanent teeth (D_3MFT) and the percentage of caries-free children (D_3MFT/$d_3$mft = 0) were calculated. Furthermore, for primary teeth the Significant Caries Index (SiC) as the mean $d_3$mft value of the one-third of children with the highest caries levels [13] and the Care Index (CI) representing the proportion of teeth with caries experience which have been filled were calculated for each survey year. The Chi-square test (categorical data) and the *t*-test (continuous variables) were used for the data analysis. Logistic regression was used in order to identify if SES (independent variable) is a significant risk factor for a higher $d_3$mft (dependent variable). Data analyses were performed using the SPSS software for Windows (version 17.0. SPSS Inc., Chicago, IL). The level of significance was defined as $p < 0.05$.

Results

Sample distribution

Data from 2871 6–7-year old children were used for this analysis; 1493 (52%) children were boys and 1378 (48%) were girls, without significant differences between the groups ($p > 0.05$).

Prevalence data

The overall baseline caries data (2003–2004) showed a $d_3$mft value of 3.2 ± 3.8, the d_3-component corresponded to 70% of the index. The D_3MFT value was 0.2 ± 0.7, with 88.1% of caries-free children in the permanent dentition. The caries prevalence and D_3MFT/$d_3$mft indexes were similar in boys and girls (χ^2-test, $p > 0.05$). Children coming from lower-SES families showed higher $d_3$mft levels (4.3 ± 4.2) than children from the other schools (2.6 ± 3.6), with significant differences between the two groups ($p < 0.000$).

In 2012/2013, the overall $d_3$mft value was 1.8 ± 2.5; the d_3-component corresponded to 63% of the index. Children from lower-SES families showed higher $d_3$mft levels (2.5 ± 2.7) than children from the other schools (1.4 ± 2.3; $p < 0.000$). Caries reduction between 2003 and 2013 corresponded to 43.8%, the highest caries reduction was reached in 2010 ($d_3$mft = 1.51, 52.8% compared to 2003/2004). Overall caries values from 2003 to 2013 are shown in Table I.

Comparisons with national and regional caries data from Germany

In 2004, the $d_3$mft values among 6–7-year-olds in Germany and MWP corresponded to 2.16 and 2.58, respectively, compared to 3.2 in Greifswald. In 2009, an overall caries decline in the $d_3$mft values in Germany (1.87), MWP (2.26) and Greifswald (1.93) was observed as compared to the earlier survey. Caries reductions between 2004 and 2009 were calculated to be 13% in Germany, 12% in MWP and 38% in Greifswald. Comparisons between Germany, MWP and Greifswald at the $d_3$mft level are shown in Figure 1.

Significant Caries Index (SiC) and Care index

In 2003–2004 the SiC $d_3$mft value (cut-off 4+ $d_3$mft) of the whole sample was 7.9 ± 2.3 and the Care Index corresponded to 70.9%. The SiC group contributed 74% to the total caries load. Data from schools including lower-SES families showed a SiC-value-= 9.5 ± 2.7 as compared to 7.6 ± 2.6 from the other schools ($p < 0.0001$, CI = 1.27–2.62). Children from lower-SES families were 2.08-times more likely to have $d_3$mft 4+ than children from the other schools ($p = 0.003$, CI = 1.27–3.38) and their mean caries values were 3-times the mean value of the whole sample.

The overall SiC-Index $d_3$mft declined from the baseline year (2003–2004) until 2012–2013 (cut-off 2+ $d_3$mft) (4.8 ± 2.3; $p < 0.001$, CI = 2.46–3.83). Nevertheless, in 2012–2013 it was still significantly higher in the institutions that included children coming from lower-SES families (5.6 ± 2.2) as compared to the other schools (4.0 ± 0.4) ($p < 0.0001$, CI = 1.29–1.92) and their caries values were still 3-times the mean value of the whole sample. Children from

Table I. Caries trends in primary and permanent teeth among 6–7-year-old children in Greifswald between 2003 and 2013 ($n = 2871$ children).

	Mean values by year									
	2003/2004 ($n = 302$)	2004/2005 ($n = 285$)	2005/2006 ($n = 314$)	2006/2007 ($n = 304$)	2007/2008 ($n = 333$)	2008/2009 ($n = 287$)	2009/2010 ($n = 217$)	2010/2011 ($n = 204$)	2011/2012 ($n = 289$)	2012/2013 ($n = 336$)
Caries-free children (%)	42.1	37.9	31.5	40.8	38.7	46.7	52.5	58.8	54.0	48.8
$d_3$mft ± SD	3.2 ± 3.9	3.2 ± 3.5	3.4 ± 3.5	3.0 ± 3.6	2.7 ± 3.2	2.2 ± 3.1	1.9 ± 2.9	1.5 ± 2.6	1.6 ± 2.5	1.8 ± 2.5
d_3t ± SD	1.7 ± 2.7	1.8 ± 2.6	1.9 ± 2.8	1.6 ± 2.6	1.4 ± 2.3	1.0 ± 2.1	0.8 ± 1.8	0.7 ± 1.6	0.9 ± 1,8	0.8 ± 1.4
m_3t ± SD	0.3 ± 1.2	0.2 ± 0.7	0.2 ± 0.6	0.2 ± 0.7	0.2 ± 0.7	0.1 ± 0.6	0.2 ± 0.7	0.2 ± 0.8	0.2 ± 0.8	0.2 ± 0.9
f_3t ± SD	1.2 ± 1.9	1.2 ± 1.9	1.3 ± 1.9	1.2 ± 1.9	1.1 ± 1.8	1.1 ± 1.9	0.9 ± 1.7	0.6 ± 1.3	0.5 ± 1.6	0.8 ± 1.5
D_3MFT ± SD	0.2 ± 0.7	0.1 ± 0.5	0.1 ± 0.5	0.1 ± 0.3	0.1 ± 0.4	0.02 ± 0.2	0.02 ± 0.2	0.0 ± 0.0	0.01 ± 0.3	0.02 ± 0.2
SiC ($d_3$mft)	7.9	7.6	7.7	7.3	6.6	5.9	5.3	4.3	4.5	4.8
SiC ($d_3$mft) lesion in total caries load (%)	74	71	68	70	73	80	84	86	84	80
Care Index%	70.9	80.1	72.1	70.8	71.5	65.6	63.1	58.3	74.1	64

Number of decayed, missing and filled primary and permanent teeth (mean $d_3$mft/D_3MFT and standard deviation [SD]).
SiC, Significant Caries Index.

lower-SES families were 1.93-times more likely to have $d_3$mft 2+ than children from the other schools ($p = 0.015$, CI = 1.13–3.29). The SiC group contributed 80% to the total caries load. In the last year of study, the Care Index corresponded to 63.1%. SiC and Care Index trends over time are shown in Table I.

Discussion

This paper was based on a comprehensive dataset ($n = 2871$) containing 10-years-longitudinal data corresponding to the compulsory entry school examinations from 6–7-year-olds in Greifswald. This study documented the positive trends in the level of dental disease among the examined children; these results were confirmed in a benchmarking with the data from Greifswald and the German national surveys of children's dental health [2].

The positive caries reduction in Greifswald (43.8%) coincides with the preventive oral health program implemented since 2001 and reinforced in 2003 in nurseries and schools, which, among other things, focused on a decisive activity for caries control such as supervised toothbrushing with fluoridated toothpastes. Additionally, one of the main focuses of this strategy was the institutions presenting with the highest caries levels. Results from the SiC-index showed overall substantial improvement in the SiC-values between the baseline data (SiC = 7.9) and 2012–2013 (SiC = 4.8). However, when the SiC was adjusted by SES, the institutions including children from lower-SES families showed significantly higher values as compared to the other schools in all analyzed years. A recent longitudinal study in 5 year-olds in Scotland showed a similar trend when the overall SiC (5.43) and the SiC of poorest were compared (9.27) [17].

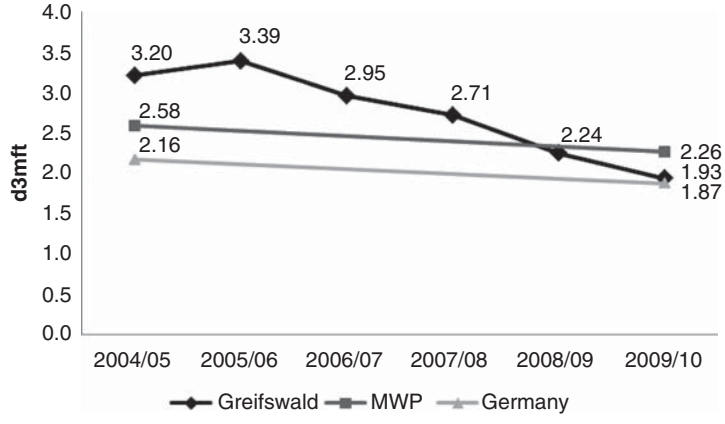

Figure 1. Comparison over time in the number of decayed, missing and filled primary teeth (mean $d_3$mft) between Greifswald, MWP and Germany in 6–7-year-olds from 2004 to 2009. MWP, Mecklenburg-Western Pomerania.

In our study the magnitude of the caries experience in the high caries group decreased clearly, but about to the same extent as for the total group of children. Thus, the gap to the mean values could be closed in absolute numbers, but not proportionally and, therefore, the highest caries levels can be still identified in the institutions that include children belonging to less privileged families. Thereby, children showing the higher caries levels identified with the SiC-index, represented at baseline (SiC in total caries load = 74%) and still represents (80%; 2012/2013) the most significant burden of caries experience.

The current mean $d_3$mft (1.82) and the SiC (4.8) values from Greifswald were comparable to results from regional/national studies conducted in similar age groups in different European countries: Italy ($d_3$mft = 1.45, SiC = 4.31) [18]; Greece ($d_3$mft = 1.77, SiC = 5.01) [19]; Scotland ($d_3$mft = 1.9, SiC = 5.43) [17]. In addition, caries reductions in Greifswald have followed the trends observed in the last years at the national level [2]. A very interesting and encouraging finding from our study was that caries reductions in Greifswald between 2004 and 2009 were 3-fold higher (38%) than reductions from the whole state of MWP (12%) and Germany (13%). Similar trends were observed when caries data from Greifswald were compared to other similar cities (in terms of children population distribution) in the region, e.g. Schwerin (16%), Neubrandenburg (18%), Stralsund (21%) [20]. A potential reason is the lack of stressing caries control activities at schools and use of fluorides in these cities. Thus, in Greifswald the implemented oral health program seems to have shifted the caries levels from above average (baseline data) to a below average position.

Oral disease prevention and health promotion strategies have been traditionally used for caries control. At the community level, preventive measures include activities ranging from water fluoridation and dental health education to the application of topical fluorides and fissure sealants, etc. One of the main limitations of these interventions has been the long-term sustainability of the oral health improvements (clinical outcomes) [15]. Encouragingly, the results of the present study have shown an important improvement in the clinical outcomes during the 10 years follow-up presenting with a constant reduction in the caries levels. Main contributors to caries decline in this population have been the focus on behavior change through parents' and caregivers' involvement (as the main people responsible for children's caries control), as well as the regular visits of the dental hygienists aiming to reinforce the daily brushing activities with fluoridated toothpastes. Special attention was given to children presenting with high caries and gingivitis levels. Additionally, this program took place in nurseries and schools, which are considered as potential settings for the implementation of behavior changing interventions and healthy behaviors development [21]. In line with the latter, a perfect illustration of a successfully implemented preventive caries control strategy is the Nexö Program (http://www.nexodent.com) [22]. This program is an individualized strategy implemented at the community level based on oral health education aiming to 'the understanding of caries as a localized disease, bacterial plaque control through efficient toothbrushing and early non-operative intervention'. Parental co-operation here is not just required, but essential for successful caries control as they are responsible for toothbrushing with fluoride toothpastes. With this strategy among other things, caries reduction of 75.5% was observed in 5-year-old children from 1987 (program implementation) to 2000. Similarly, but not to the same extent, the most encouraging finding from our data was the substantial caries decline observed between 2003 and 2013 (43.8%).

It is well known that the financial burden of the dental treatment due to caries is particularly high, this disease being in the top five of the most expensive conditions to treat in many countries [23]. Nevertheless, at the same time there is supportive evidence showing that oral health programs involving biofilm control and fluorides application are effective approaches for caries control [22,24–26]. Additionally, it is nowadays clear that the activity and progression of carious lesions can be controlled by influencing the cariogenic biofilm development. In the case of initial carious lesions with intact surface layers, plaque control leads to re-mineralization and lesion's arrestment [27]. Even in cases of cavitated carious lesions, there is growing evidence showing that through biofilm disturbance on the lesion's surface it is possible to control the disease progression [28,29]. In line with these concepts, biofilm control and the use of fluorides should be fundamental for all caries control strategies at individual as well as community level.

An unexpected finding from the present study was that, since 2010–2011, there has been a trend towards an increased $d_3$mft value, with less caries-free children (Table I). However, when data from 2012–2013 were compared to the two previous years, an increase in the number of filled teeth was observed; although the mean of missed teeth has apparently not changed. Different studies have reported a rise in caries prevalence in children during the past years [30,31]. This situation has been increasingly observed in various countries worldwide. The influence of immigration has been suggested as a contributor to this phenomenon [1,30]. This aspect could not be analyzed independently in our study.

One of the main questions of this study is the generalizability of the obtained results. Various aspects in favor of the latter should be taken into

account: First, data collection for the present study was performed by calibrated dentists, who have taken part in the German National Surveys. Additionally, the obtained epidemiological data clearly followed caries national trends in terms of caries experience and the level of restorative care [2]. This homogeneity has been probably related to the widespread healthcare system in the whole country. Promotion and prevention activities, as well as healthcare services in Germany, cover more than 98% of the population through the law-enforced National Health System (NHS) [32]. In terms of children's oral health, the NHS ensures that all children are covered by preventive and curative care without any distinction. The uniformed distribution and coverage of oral health activities assure not only that the whole population benefits from the programs, but also that the data obtained from regional studies can be interpreted and generalized for larger populations.

In conclusion, this oral health strategy, which targeted institutions with initially very high caries levels, has achieved with a combination of regular toothbrushing and fluoride application in general substantial caries reductions. However, children belonging to less privileged families continue experiencing higher caries levels. This community-centered caries control approach needs still to be strengthened with special attention to the high caries risk groups.

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