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ORIGINAL ARTICLE

Demographic factors and dental health of Swedish children and adolescents

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Abstract

Objective. To investigate the dental health of Swedish children and adolescents with reference to age, gender and residence. ***Material and methods.*** Electronic dental records from 300,988 3–19-year-olds in one Swedish region were derived in a cross-sectional study in years 2007–2009. The DMFT system was used. Age was categorized into 3–6/7–9/10–12/13–15/16–17/18–19-year-olds and residence into '*metropolitan*', '*urban*' and '*rural*' areas. ANOVA, generalized linear regression models and Fisher's exact test were used. ***Results.*** Among 7–9-year-old children, nine out of 10 were free from fillings and manifest caries, while for 18–19-year-olds; this proportion was one third. Girls (18–19-year-olds) had a significantly lower risk of caries compared to boys of the same age, RR for the DT index = 0.83 (95% CI = 0.81–0.85). This pattern was reversed in 7–12-year-old children. Children and adolescents in metropolitan and urban areas had significantly more caries than subjects in rural areas, for instance the RR for the DT index in metropolitan 7–9-year-olds was 2.26 (95% CI = 2.11–2.42) compared to their rural counterparts. ***Conclusions.*** In the permanent dentition, the overall pattern revealed that girls ≤ 12 years had a higher risk of caries, while adolescent girls had a lower risk of caries, both compared with boys of corresponding ages. Living in an urban or metropolitan area entailed a higher risk of caries than living in a rural area. A greater occurrence of dental caries in adolescents than in children was confirmed. The findings should have implications for planning and evaluation of oral health promotion and disease prevention activities.

Key Words: *Age distribution, dental caries, epidemiology, residence characteristics, sex*

Introduction

Dental health in Swedish children and adolescents has improved continuously and considerably over the past decades, according to both official statistics and to scientific studies [1–3]. Dental care in Sweden is free of charge for all individuals until the age of 19, both in the Public Dental Service (PDS) and in private dental care. Prevention programs in school settings are conducted. Despite the reduction in the caries disease, studies in sub-samples show that dental caries is a considerable health problem among children and adolescents [4]. This applies, for instance, to socio-economically weak groups [5]. Furthermore, the dental caries goals determined by the World Health Organization have not all been attained in Sweden; for instance, not for 6-year-olds [5]. Moreover, there are indications of an increase in the caries disease among those with the poorest dental health [5]. A similar trend has been noted in other Western countries [6,7]. Demographic characteristics have been considered to explain the differences in caries occurrence. Age is one such factor and higher caries prevalence with increasing age has been demonstrated [1,8]. In addition, children with caries disease at an early age were likely to develop new lesions later [4,9].

Possible gender differences in dental caries occurrence have been discussed. Findings in the US indicated that girls had more restored teeth due to dental caries than boys, while a Swedish study found the opposite [10,11]. A recent review reported lack of evidence for gender differences in dental caries

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for both children and adults [12]. In official epidemiological registers at national level in Sweden, possible gender differences in caries prevalence or incidence have not been analyzed [5].

Demography includes residence characteristics. The impact of residence on dental health has been studied sparsely and with inconsistent results. Scottish children in remote and rural areas had better dental health than urban children [13], concordant with findings in US children in New England [14]. However, a US nationwide study showed no difference in the number of decayed teeth between children in urban and rural areas [15]. Rodakowska et al. [16] found a high caries prevalence among Polish 12-year-olds, both in rural and urban areas. In Sweden, such studies are scarce. Källestål [17] found a higher prevalence of dental caries in urban than in rural adolescents in the 1990s, while earlier Swedish studies in the 1970s found the opposite [18,19]. A few years later, urban children in southern Sweden displayed poorer dental health than rural children in northern Sweden [20].

Based on the contradictory findings described above, the influence of demographic factors for dental caries occurrence need to be better explored. Therefore, the aim of this study was to investigate the dental caries occurrence among Swedish children and adolescents, with special reference to age, gender and residence.

Materials and methods

Subjects

Electronic dental records from 3–19-year-olds examined in all 117 dental clinics in the PDS and from private dental clinics in the largest Swedish region, Region Västra Götaland (VGR, 1.6 million inhabitants out of 9 million in the whole of Sweden) constituted the study base. Children and adolescents examined in 2009 (n = 163,036, 54% of the study subjects) were supplemented with subjects examined in 2008 (n = 96,262, 32%) and in 2007 (n = 41,690, 14%), to reach a final coverage of 97.3% (n = 300,988) of the total population in the studied ages in VGR (based on year 2009). The supplement was made due to that the interval for dental examinations was a maximum of 24 months. Each subject had a unique registration in the database during the period 2007–2009. When there was more than one recorded examination during the time period, the most recent one was used. The study was approved by the Regional Ethical Review Board in Gothenburg (No. 507-10, 2010-09-22).

Variables

The dental caries variables used were caries indices according to the DMFT system (Decayed, Missing, Filled Teeth) [21]. Manifest lesions that clearly extended into the dentine were recorded [22]. The indices were: deft (decayed, extracted, filled teeth) for the primary dentition (3–12 years) and DT (Decayed Teeth), DFT (Decayed, Filled Teeth), DSa (Decayed Surfaces, approximally) and DFSa (Decayed, Filled, Surfaces approximally) for the permanent dentition (7–19 years). In Sweden the M component is left out in official records, because of very few teeth lost due to caries. Background information included age, categorized for the analyses into six groups (3–6/7–9/10–12/13–15/16–17/18–19-year-olds) and gender (boys/girls). Statistics Sweden provided information on residential community for the study subjects in accordance with a conventional system used by the Swedish Association of Local Authorities and Regions [23]. The communities are classified on the basis of structural parameters (population, industry, agriculture, commuting patterns, manufacturing and tourism) as '*metropolitan*', '*urban*' and '*rural*'. '*Metropolitan*' was defined as a municipality with a population > 200,000 (one municipality out of 49; comprising 27.6% of the subjects). '*Urban*' was defined as municipalities with 50,000 up to 200,000 inhabitants and with a population density in excess of 70% (four municipalities; comprising 16.6% of the subjects). All other municipalities (< 50,000 inhabitants) were defined as '*rural*', including municipalities with up to 50% of residents commuting to work in another municipality and/or being dependent on manufacturing industries/tourism (44 municipalities; comprising 55.8% of the subjects) (Table I).

Data collection

The children and adolescents had undergone a dental examination by a dentist or a dental hygienist at dental clinics in VGR, as a part of planned regular dental examinations. The clinics had to follow the same routines regarding examinations both in the PDS and in private dental care, for patients classified with low risk to dental caries (no manifest or active caries lesions), a maximum of 24 months interval. Patients classified with medium risk (i.e. a single manifest occlusal caries lesion or an initial caries lesion progression) had a maximum of 12 months interval and patients classified with high risk (active manifest caries lesions) had an interval not exceeding 6 months. Radiographs were taken when indicated and possible; that is, when proximal molar surfaces could not be visually inspected and/or based on a previous risk assessment. The diagnoses were based on both clinical and radiographic findings. The data were electronically collected from the dental records in the case record systems of both public and private dental clinics.

Table I. Description of the population in different age groups according to residential location.

	Metropolitan *n* (%)	Urban *n* (%)	Rural *n* (%)
Age group, years			
3–6	18 735 (28.4)	10 763 (16.4)	36 376 (55.2)
7–9	12 390 (29.7)	6 729 (16.1)	22 659 (54.2)
10–12	12 492 (27.9)	7 279 (16.2)	25 025 (55.9)
13–15	13 534 (28.5)	8 000 (16.8)	25 981 (54.7)
16–17	9 667 (23.5)	6 876 (16.7)	24 607 (59.8)
18–19	16 203 (27.1)	10 172 (17.0)	33 500 (55.9)

Data analysis

Analyses were performed using the SPSS (Statistical Package Social Sciences), version 22 (SPSS, Inc. Chicago IL). Absolute and relative frequencies together with mean values and confidence intervals (95% CI) were calculated. Initially, ANOVA tests were used to explore overall differences. For the analyses of differences in caries occurrence (rate ratio, RR) between sub-groups (gender, age group and residential community) in full models, generalized linear regression models including Poisson distribution stratified by age group were used. For logistic regression analyses, dental caries was dichotomized into no caries (0) or caries (1). Alternative dichotomizations allowing for 0–2 carious lesions (= 0) vs more (= 1) were also used. Fisher's exact test was used for dichotomous variables. For analysis in the mixed dentition the sum of deft and DFT indices were also used. When the null hypothesis was rejected, post-hoc analyses and Bonferroni adjustments were used. The level of statistical significance was set to 5%.

Results

The subjects are presented in Table I, by age group and residential location. There was no statistical significant difference in gender distribution. The largest proportion of children and adolescents were residing in rural areas.

Distribution of dental caries by age and gender

Mean values with 95% confidence intervals (CI) of caries occurrence in different age groups are shown in Figure 1 (DT and DSa) and Figure 2 (DFT and DFSa) for the total group (plain bars) and for the group with caries (striped bars). The pattern was similar for different indices and ages in both groups. The higher mean values by age group was consistently statistically significant for DFT and DFSa; however, this pattern was less consistent for DT and DSa. For the WHO indicator age 12 years, the mean DFT value was 0.70 in the total group; however, for those with DFT ≥ 1, the mean value was 2.05 (not in figure).

In Figure 3, proportions of children free from manifest caries and/or fillings by gender and age group are presented. For the permanent dentition, almost nine out of 10 (girls 88%, boys 90%) 7–9-year-olds had no manifest caries or fillings measured with the DFT index. The proportion of children and adolescents free from manifest caries and fillings was steadily lower by age and only one third (32%) of all 18–19-year-olds had neither carious lesions nor

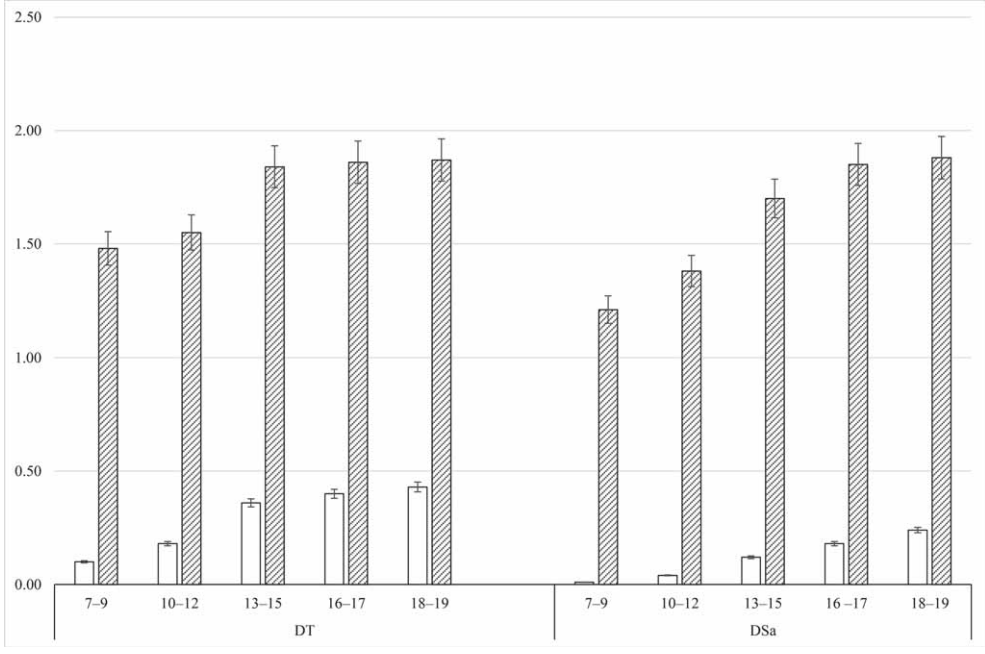

Figure 1. Mean values and 95% confidence intervals for indices DT and DSa in age groups, in the total group (plain bars) and in the group with caries (striped bars).

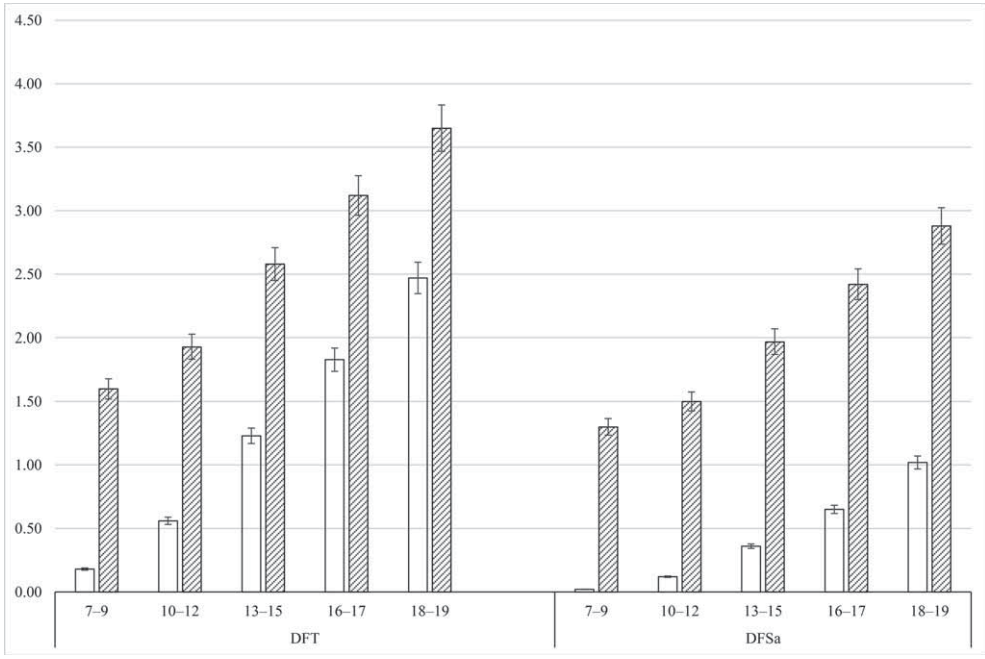

Figure 2. Mean values and 95% confidence intervals for indices DFT and DFSa in age groups, in the total group (plain bars) and in the group with caries (striped bars).

fillings in their teeth (DFT index). Seven per cent of 7–9 year-olds (girls 7%, boys 6%) and 23% of 18–19 year-olds (girls 22%, boys 24%) were diagnosed with caries lesions (DT index). The proportion of children without manifest approximal lesions and/or fillings (DFSa) dropped from nearly 99% of the youngest to two thirds (girls 66%, boys 64%) of the 18–19-year-olds (Figure 3).

In the primary dentition, 85% of the 3–6-year-olds had neither carious lesions nor fillings (deft), while this proportion among the 7–9-year-olds was 48%. The mean deft value for 3–6-year-olds in the total group was 0.49 (95% CI = 0.48–0.51) and in the caries group 3.09 (95% CI = 3.04–3.14). Corresponding values for the 7–9-year-olds was 1.73 (95% CI = 1.71–1.75) in the total group and 3.32 (95% CI = 3.29–3.35) in the caries group (not in figure). In the mixed dentition (the sum of deft and DFT indices), the proportion with neither carious lesions nor fillings among 7–9 year-olds was 45.2%. The mean

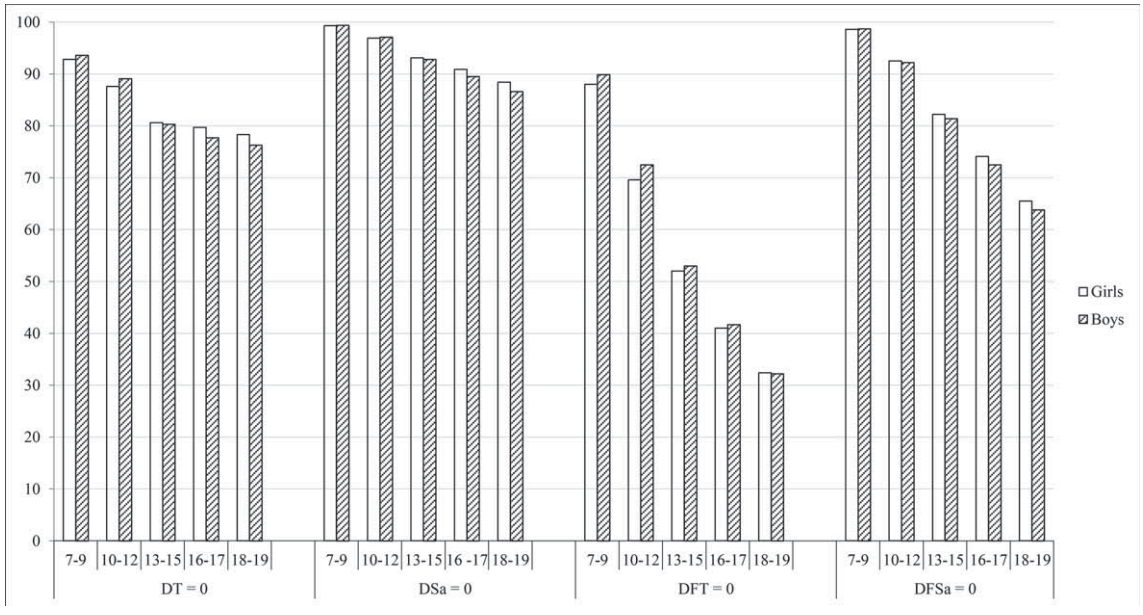

Figure 3. Proportions of children in percentages (%) free from manifest caries and/or fillings by gender and age group (7–9, 10–12, 13–15, 16–17, 18–19 years) for the indices DT, DSa, DFT and DFSa.

Table II. Rate ratios (RR) with confidence intervals (95% CI) of caries indices (DT, DSa) between genders (ref boys) and residential areas (ref rural), separately by age group by means of generalized linear modeling in full models. Dependent variables: continuous caries indices for decayed teeth/approximal surfaces.

	Gender		Residence			
	Girls		Urban		Metropolitan	
	RR	CI	RR	CI	RR	CI
DT						
7–9 years	1.10	1.03–1.17	1.45	1.32–1.59	2.26	2.11–2.42
10–12 years	1.12	1.07–1.17	1.65	1.55–1.76	2.13	2.03–2.24
13–15 years	0.94	0.90–0.97	1.46	1.40–1.52	1.86	1.79–1.92
16–17 years	0.84	0.81–0.87	1.42	1.36–1.48	1.78	1.71–1.84
18–19 years	0.83	0.81–0.85	1.23	1.18–1.27	1.49	1.45–1.53
DSa						
7–9 years	1.01	0.81–1.25	1.54	1.13–2.07	1.91	1.50–2.42
10–12 years	1.07	0.97–1.17	1.96	1.72–2.23	2.52	2.27–2.80
13–15 years	0.94	0.88–0.99	1.70	1.58–1.83	2.13	2.00–2.25
16–17 years	0.80	0.76–0.84	1.71	1.60–1.82	2.12	2.01–2.24
18–19 years	0.78	0.75–0.80	1.33	1.27–1.40	1.62	1.56–1.68

DT, decayed teeth; DSa, decayed surfaces approximally.

value in the mixed dentition was 1.91 (95% CI = 1.88–1.93) in the total group and 3.48 (95% CI = 3.44–3.51) in the caries group (not in figure).

Dental caries: Associations with gender and residence

The influence of gender and residential characteristics on caries occurrence was analyzed in full models including both these variables. The results are presented in Tables II and III.

Girls, 7–12-year-olds, showed a statistically significantly higher risk of dental caries than boys of the same age, with regard both to the DT and the DFT caries indices. For 7–9-year-old girls, compared with boys of the same age, the RR for DT was 1.10 (95% CI = 1.03–1.17) (Table II) and the RR for DFT was

Table III. Rate ratios (RR) with confidence intervals (95% CI) of caries indices (DFT, DFSa) between genders (ref boys) and residential areas (ref rural), separately by age group by means of generalized linear modeling in full models. Dependent variables: continuous caries indices for accumulated decayed teeth/approximal surfaces.

	Gender		Residence			
	Girls		Urban		Metropolitan	
	RR	CI	RR	CI	RR	CI
DFT						
7–9 years	1.19	1.13–1.25	1.36	1.27–1.46	1.79	1.70–1.89
10–12 years	1.12	1.09–1.15	1.28	1.24–1.33	1.62	1.57–1.67
13–15 years	1.05	1.02–1.07	1.22	1.19–1.25	1.52	1.49–1.55
16–17 years	1.01	0.99–1.03	1.20	1.17–1.23	1.45	1.42–1.47
18–19 years	0.98	0.97–0.99	1.07	1.05–1.09	1.30	1.28–1.32
DFSa						
7–9 years	0.97	0.83–1.13	1.20	0.98–1.47	1.22	1.03–1.44
10–12 years	0.96	0.91–1.02	1.35	1.25–1.46	1.57	1.47–1.67
13–15 years	0.98	0.95–1.01	1.34	1.28–1.40	1.59	1.53–1.64
16–17 years	0.93	0.90–0.95	1.37	1.32–1.42	1.64	1.59–1.68
18–19 years	0.90	0.88–0.91	1.13	1.10–1.15	1.39	1.36–1.41

DFT, decayed filled teeth; DFSa, decayed filled surfaces approximally.

1.19 (95% CI = 1.13–1.25) (Table III). The indices at surface level (DSa and DFSa) revealed no gender differences in the younger age groups (7–12 years). In contrast, in the older age groups (16–19 years), girls had a lower risk of caries than boys with regard to all indices used (except the DFT index). The associations were stronger for DT and DSa than for DFT and DFSa (Tables II and III). For instance, 18–19-year-old girls, compared with boys of the same age, had an RR of 0.78 (95% CI = 0.75–0.80) of having approximal carious lesions (DSa, Table II), while the RR was 0.90 (95% CI = 0.88–0.91) for the DFSa index (Table III).

In the primary dentition, girls had a significantly lower risk than boys of having decayed teeth, with a RR of 0.93 (95% CI = 0.90–0.95) for the deft index in 3–6-year-olds. Similar results were seen among 7–9- and 10–12-year-olds (not in table). The picture was the same in the mixed dentition (the sum of deft and DFT indices), 7–9 year-old girls had a significantly lower risk than boys for caries occurrence, with a RR of 0.96 (95% CI = 0.95–0.97) (not in table).

The associations between residential characteristics and caries occurrence in the permanent dentition are presented in Tables II and III. Children and adolescents in the metropolitan and urban areas had a statistically significantly higher risk than subjects in rural areas of having manifest caries with only one exception (DSa in 7–9-year-olds). The greatest risk of having decayed teeth (DT) was in the metropolitan area among children in age group 7–9 years, with a RR of 2.26 (95% CI = 2.11–2.42), using rural children as reference (Table II). They also had the highest risk when the accumulated index of decayed and filled teeth, DFT, was used (RR = 1.79, 95% CI = 1.70–1.89) (Table III). Children and adolescents of all ages in the metropolitan area also had the highest risk of accumulated caries (DFT), compared with their rural counterparts; however, the associations were somewhat weaker for 13–19-year-olds than for 7–12-year-olds (Table III). The risk for having approximal caries lesions (DSa) was approximately 2-fold in children and adolescents in the metropolitan area compared with subjects in rural areas (Table II).

In the primary dentition (not in table), children in both metropolitan and urban areas had a statistically significantly higher risk of having decayed teeth compared with children in rural areas. Thus, for 3–6 year-olds, the RR (deft index) was 1.45 (95% CI = 1.40–1.50) in urban and 1.67 (95% CI = 1.62–1.71) in metropolitan areas, using rural children as reference. The picture was similar for 7–9-year-olds and in the mixed dentition.

Logistic regression analyses, using dichotomized caries indices as the outcome, confirmed the same overall pattern in caries disease with respect to age, gender and residence.

Discussion

On the whole, the children and adolescents in this study had good dental health with regard to caries. However, in the minor group suffering from dental caries, the disease burden was substantial. Caries occurrence was most prominent during adolescence. There were gender differences in caries occurrence in both the primary and the permanent dentition. Children and adolescents in metropolitan and urban areas had significantly more decayed teeth and more dental fillings than subjects in rural areas.

The coverage; that is, the percentage of all children and adolescents surveyed in the current population, was high in the study and this supports the validity of the conclusions in the study. A contributing factor may be that dental care has been free of charge for all children and young people in Sweden for more than half a century, making regular dental examinations a well-established routine, irrespective of attending the PDS or private dental care [24]. In recent years—after the data collection in the current study—dental care free of charge for the individual has been extended in Region Västra Götaland (up to age 24 years). This benefit is also planned in other Swedish regions. Another contributing factor to the high coverage may be that the dental records were collected from regular, scheduled examinations; that is, no extra visits were needed. Also, reporting epidemiological outcomes are mandatory for all caregivers in order to be subsidized by the remuneration systems. The recall periods were based on risk assessments performed by the dentist or the dental hygienist and, consequently, may have differed between individuals. The age group of 18–19-year-olds included comparatively more subjects than other age groups and this can be explained by dental caregivers being keen on making examinations before the free dental care expires. Thus, the result was an accumulation of individuals in the oldest group. When this study was conducted the allowed recall period was up to 24 months for low risk patients. This was compensated for in the study by supplementing the database with records over a 3-year period. The most likely reason for dropping out is migration during the study period or, possibly, that the clinics were delayed with the examinations. However, other possible explanations for not attending dental visits could be negligence or dental anxiety [25].

Region Västra Götaland comprises almost one fifth of the country's inhabitants in both larger cities and rural areas. This enhances the generalization possibilities of the findings. Also, the gender distribution corresponded to figures at national level. By using the classification of municipalities by the Swedish Association of Local Authorities and Regions, later comparative and follow-up studies were made possible.

The dental records were electronically collected from many clinics involving a large number of examiners (dentists and dental hygienists). Thus, no calibration program was undertaken. Findings by Hausen et al. [26] indicated that, in large settings, data from public health records compensate for under- and over-estimates in caries registrations. However, a limitation of the study was that the available data only included manifest caries. Initial caries (restricted to the dental enamel) represents a significant proportion of caries lesions in young people [27,28]. Today, there are other registration systems for dental caries with more elaborate scales, which should be considered for further studies [29].

In an international perspective, most children and adolescents in the region had good dental health with regard to caries [30]. For instance, in the latest compilations by the WHO, 12-year-olds in the US and Poland displayed DMFT mean values of 1.19 and 3.2, respectively, to be compared with 0.7 in our study. The mean value at national Swedish level was 0.8 at the time, while neighboring Nordic countries reported somewhat lower values (Denmark = 0.6 and Finland = 0.7) [31]. The consistent pattern with higher caries occurrence with increasing age corresponds to other studies [8,32]. It is notable that the caries disease, according to all the caries indices used, increased with age. Dental caregivers should be aware of the risk of new caries lesions at all ages and of the need to explore possible risk factors, such as socioeconomic level [33]. The findings call for health promotion and disease prevention activities targeting all children and adolescents. Official statistics, both at national and international level, should also include indices with and without the 'F' component. This should make it possible to clarify the occurrence of new caries lesions, which can be said to correspond to the incidence. This would allow reflection on the caries occurrence, especially in many developing countries, where risk factors like growing consumption of sugars and inadequate exposure to fluorides are common [31].

The younger girls (7–12-year-olds) in the study showed a greater risk of caries in the permanent dentition (indices DFT and DT). Already in the 1950s, Mansbridge [34] in the UK discussed a gender difference in caries prevalence to the disadvantage of girls, which some Scandinavian studies confirmed [4,7]. In contrast, girls with a primary or a mixed dentition (≤ 12 years) and girls in their upper teens had a significantly lower risk of dental caries than boys of the same ages in our study. The sociocultural expectations of girls may be greater, which may facilitate easier examination and treatment at younger ages [35]. During adolescence, the gender differences may be explained by the greater fulfillment of role expectations among girls, which involves adherence to healthy habits [35]. In line with this, recent findings in Swedish 19-year-olds showed that boys, more often than girls, had poor oral health habits with more plaque and gingivitis [30]. Biological causes have been suggested and, according to a study in Danish children, the permanent teeth erupt somewhat earlier in girls than in boys, leading to earlier exposure to risk factors for oral disease [36]. Another proposed reason is hormonal differences affecting the saliva in girls during puberty and pregnancy [37]. Taken together, some authors conclude that sociocultural differences are more important than biological differences [37,38]. No substantial evidence has been found to explain the gender differences with regard to dental caries and this needs to be further investigated and considered in dentistry as a whole.

The dental health was significantly poorer in children and adolescents living in metropolitan and urban areas compared with those living in rural areas, which corresponds to several studies in other contexts, for instance, in northern Sweden, New England and Scotland [13,14,17]. This might be related to urbanization with a resulting cariogenic diet [4,39,40].

In rural areas, access to shops, kiosks and fast food restaurants is more limited, due to long distances. This may contribute to a lower intake of sugar and less between-meal snacking. However, within a specific area, for instance, a community, the dental health status may differ between sub-groups. Further analyses on lower levels are necessary to explore caries outcomes in relation to sociodemographic characteristics.

In conclusion, this study revealed an overall pattern that, in the permanent dentition girls ≤ 12 year had a higher risk of caries, while adolescent girls had a lower risk of caries, both compared with boys of corresponding ages. Living in an urban or metropolitan area entailed a higher risk of caries than living in a rural area. A greater occurrence of dental caries in adolescents than in children was confirmed (all indices measured). The findings should have implications for the planning and evaluation of oral health promotion and disease prevention activities.

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