

A time-series analysis of caries status among adolescents in relation to socioeconomic variables in Göteborg, Sweden

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Swedberg Y, Norén JG. A time-series analysis of caries status among adolescents in relation to socioeconomic variables in Göteborg, Sweden. *Acta Odontol Scand* 1999;57:28–34. Oslo. ISSN 0001-6357.

The aim of this study was to detect, using time-series analysis methods, whether measurable socioeconomic adjustments for the time period 1986–96, as presented by caries index values, could be related to a new trend in caries status development for specific age groups leaving the free state-organized dental care system. In the study, Göteborg was divided into four districts. The study showed a favorable development in dental health for the 15–19 age group. However, the caries incidence index DSA (decayed approximal surfaces) values showed no or only negligible signs of lower mean values. During the study period, the study showed an unfavorable trend concerning the socioeconomic variables related to health care. However, the incongruity for the different districts between the trend results of the caries index values and the contemporaneous socioeconomic variable development indicated few signs of relationship. In relation to general discussions of environmental questions, the idea of *sustainable development* was discussed when applied to the field of dental care. The results of this study indicate that dental health, in times of major economic adjustments and lack of resources for health care for the 15–19 age group in Göteborg—as interpreted by the caries indices used—is an example of sustainable dental health development. □ *Caries; dental health surveys; epidemiology; public health dentistry; socioeconomy; trend analysis*

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When searching for caries predictors, socioeconomic status has been associated with caries in numerous cross-sectional studies (1). In a survey paper in 1990, Winter summarized that socioeconomic factors are important for determining the proportion of high-risk children in industrialized societies (2). As resources for health care have been cut since 1990, the question arises as to how this may have affected the dental health of different age groups. With regard to caries development in Swedish children and adolescents during the time period 1985–95, the Swedish National Board of Health and Welfare reported (3) low correlation between dental health and socioeconomic variables. However, the report findings verified a covariation relationship in certain groups of the population with regard to dental health and the family income situation, as well as to the proportion of individuals with foreign citizenship.

The caries situation for the age-specific year classes leaving free state-organized dental care in Göteborg, Sweden, during the period 1986–91 has been studied by Swedberg et al. (4). They found high stability in the caries-free prevalence and incidence index groups. In the 15-year-old patient groups with the 10% highest frequency of carious lesions, the DSA (decayed approximal surfaces) index mean values were as little as half the size when the 15-year cohorts reached 19 years of age. However, the groups with 20% of the highest DFSa (decayed and filled approximal surfaces) index values were registered for about 80% of all approximal lesions. The indications of stable caries development for the caries extreme patient

groups studied during the time period 1986–91 raises the question as to whether the ensuing years of increased economic adjustments would alter this stability.

Thus, the aim of this study was to detect whether measurable socioeconomic adjustments for the time period 1986–96 could be related to a new trend in caries status development for patients leaving organized dental care, as presented by a time series analysis of caries index values.

Materials and methods

Population

The study included the caries epidemiological records of all patients of 15–19 years of age who had received dental care at the Public Dental Service of Göteborg (PDSG) during the time period 1986–96 and had been registered in the caries epidemiological data base. The total number of individuals of 15–19 years of age living in the City of Göteborg varied from ~4,500 to ~3,800 (for year class 15), and from ~5,600 to ~4,800 (year class 19). The highest number of registered individuals was during the period 1986–87. The percentile values of caries epidemiological registered patients for both year classes varied around 70%. Only for 1992 were the values around 50%. Table 1 gives the numbers of registered individuals and the corresponding percentile values of the 15 and 19 year classes for 1986 and 1996, respectively.

In the study, the City of Göteborg has been divided into

Table 1. Caries status for 15- and 19-year age groups, for the time period 1986–96 in Districts I–IV, and in Göteborg as a whole

DMFT	15 years					19 years				
	<i>n</i>	DMFT = 0 (%)	DMFT 20% (Mean)	DMFT > 0 (Mean)	DMFT total (Mean)	<i>n</i>	DMFT = 0 (%)	DMFT 20% (Mean)	DMFT > 0 (Mean)	DMFT total (Mean)
District I										
1986	687	4.22	12.34	7.04	6.74	780	0.64	16.74	10.25	10.19
1996	752	16.09	11.24	5.67	4.76	723	9.54	13.55	7.08	6.40
District II										
1986	482	10.58	11.49	6.30	5.63	836	2.39	14.77	8.67	8.47
1996	500	28.20	7.68	3.06	2.84	652	17.79	10.80	5.60	4.61
District III										
1986	1058	8.22	10.37	5.97	5.48	1328	2.11	15.58	9.44	9.24
1996	873	20.85	8.58	4.48	3.55	979	12.46	12.23	6.49	5.68
District IV										
1986	1128	7.00	11.14	6.26	5.82	1369	1.39	15.81	9.60	9.47
1996	753	18.59	8.84	4.48	3.64	999	11.11	12.43	6.59	5.86
Göteborg										
1986	3354	7.33	11.24	6.34	5.87	4313	1.67	15.77	9.49	9.33
1996	2878	20.29	9.37	4.73	3.77	3353	12.47	12.38	6.49	5.68

DFSa	<i>n</i>	DFSa = 0 (%)	DFSa 20% (Mean)	DFSa > 0 (Mean)	DFSa total (Mean)	<i>n</i>	DFSa = 0 (%)	DFSa 20% (Mean)	DFSa > 0 (Mean)	DFSa total (Mean)
District I										
1986	687	48.91	6.69	3.59	1.83	780	25.13	14.18	6.47	4.84
1996	752	56.61	6.03	3.56	1.54	720	43.75	9.81	4.97	2.80
District II										
1986	482	63.07	5.84	3.69	1.36	836	40.55	10.69	5.28	3.14
1996	500	74.55	3.04	2.61	0.66	654	59.48	6.57	4.01	1.62
District III										
1986	1058	58.13	4.65	2.90	1.21	1328	29.29	13.08	6.10	4.31
1996	873	65.10	3.58	2.48	0.87	979	45.97	8.69	4.43	2.40
District IV										
1986	1128	54.79	5.88	3.38	1.53	1369	28.49	13.88	6.36	4.55
1996	753	63.38	4.10	2.75	1.01	996	47.59	8.98	4.72	2.47
Göteborg										
1986	3354	55.81	5.69	3.32	1.47	4313	30.47	13.16	6.12	4.26
1996	2878	64.08	4.32	2.91	1.04	3349	48.61	8.66	4.58	2.35

DSa	<i>n</i>	DSa = 0 (%)	DSa 20% (Mean)	DSa > 0 (Mean)	DSa total (Mean)	<i>n</i>	DSa = 0 (%)	DSa 20% (Mean)	DSa > 0 (Mean)	DSa total (Mean)
District I										
1986	687	74.53	2.27	1.99	0.51	780	64.62	3.07	2.17	0.77
1996	751	74.03	2.48	2.14	0.56	723	69.85	3.66	2.77	0.84
District II										
1986	482	81.74	1.82	1.97	0.36	836	75.00	2.46	2.16	0.54
1996	500	87.00	1.25	1.92	0.25	653	79.79	2.25	2.23	0.45
District III										
1986	1058	79.11	1.97	1.93	0.40	1328	67.39	2.55	1.95	0.64
1996	874	83.64	1.49	1.82	0.30	979	67.01	2.77	2.07	0.68
District IV										
1986	1128	79.43	1.97	1.94	0.40	1369	68.59	2.59	2.01	0.63
1996	751	82.16	1.65	1.84	0.33	998	73.25	2.46	2.09	0.56
Göteborg										
1986	3354	78.65	2.02	1.95	0.42	4313	68.75	2.64	2.05	0.64
1996	2876	81.33	1.82	1.95	0.36	3353	71.97	2.77	2.26	0.63

n, number of registered patients. The remaining columns show mean/percentile values for caries index groups and subgroups DMFT, DFSa, and DSa.

DMFT/DFSa/DSa = 0, individuals with no caries records; DMFT/DFSa/DSa 20%, patients with the highest index values; DMFT/DFSa/DSa > 0, all patients with caries records; DMFT/DFSa/DSa total, all patients.

DMFT, decayed missing, and filled permanent teeth; DFSa, decayed and filled approximal surfaces in permanent teeth, DSa, decayed approximal surfaces in permanent teeth.

Table 2. Socioeconomic variables for Districts I–IV and for the entire city of Göteborg for the time period 1986/7–96/5

District	Year	Individuals seeking employment (%)	Individuals without Swedish citizenship (%)	Year	Mean yearly income (SEK)	Households receiving social allowance (%)
District I	1986	3.6	19.9	1987	91 650	15.2
	1996	8.5	24.6	1995	122 052	28.3
District II	1986	3.2	4.6	1987	108 889	7.1
	1996	7.8	5.9	1995	155 210	10.2
District III	1986	2.4	3.7	1987	119 128	4.7
	1996	5.3	5.0	1995	183 810	8.8
District IV	1986	2.4	10.4	1987	104 881	7.3
	1996	6.9	11.4	1995	157 221	14.7
Göteborg	1986	2.9	8.6	1987	106 655	8.3
	1996	7.2	9.0	1995	155 566	14.2

Data refer to individuals/householders 20–64 years of age. Percentage values for individuals seeking employment, those without Swedish citizenship, and households receiving social allowance are expressed as part of a corresponding group of all individuals/households.

four districts. District I (north-east) constitutes a suburban region, District II (south-east) and III (south-west) represent the residential districts, while the industrial areas are mainly situated in District IV (north-west). The districts are based on 21 official city sector divisions. Their borders are based on geographical and administrative–technical factors. The PDSG has used the same factors to group its clinics in these four districts from time to time.

Epidemiological caries indices and socioeconomic variables used

An epidemiological caries recording program using an identical collection and data compilation system for the 3–19-year-old patient groups was introduced at the PDSG in 1984 and used until 1991. From 1992 onwards, a similar new compilation system was used. In both systems, all individuals were recorded at each recall examination, and it was possible to individually identify all caries index data in the epidemiological data base. The definitions of the caries indices used in this study were as follows:

Caries prevalence indices. (i) DMFT: decayed, missing, and filled permanent teeth. Caries-free = no caries in the dentine and no fillings in the permanent dentition. (ii) DFSa: decayed and filled approximal surfaces with dentine carious lesions in permanent teeth.

Caries incidence index. (i) DSa: decayed approximal surfaces in permanent teeth with dentine carious lesions formed since the previous examination. Four subgroups for each caries index were identified: (a) individuals with no caries records; (b) patients with 20% of the highest index values; (c) all patients with caries records, and (d) the total registered patient material.

The socioeconomic material was collected as official information from the City Council's central data base at the City Council of Göteborg. The selection of variables was principally based on the ability to obtain continuous

time-series data for the time periods in question. It was possible to establish two time series of 11 years, and two of 9 years. The socioeconomic variables were as follows:

Time series 1986–96. (i) Number of individuals 20–64 years of age looking for employment as a percentage of a corresponding group of all inhabitants, and (ii) number of individuals 20–64 years of age without Swedish citizenship as a percentage of a corresponding group of all inhabitants.

Time series 1987–95. (i) Mean yearly income in Swedish currency (SEK) in households 20–64 years of age, and (ii) householders 20–64 years of age receiving social allowance, as a percentage of a corresponding group of all households.

Data analysis procedures

The epidemiological data base was first divided up according to year classes, districts, caries index groups, and subgroups. Next, the material was put together in time series of mean values for 1986–96, and presented as 5th degree polynomial trend curves, with the value for 1986 as a base quotient = 1.

The socioeconomic material was first sorted out according to districts, and put together in time series of percentile values in relation to all individuals/householders in the 20–64 age group (mean yearly income) for 1986–96 (1987–95), and presented as 5th degree polynomial trend curves with the value for both 1986 and 1987 as a base quotient = 1.

Results

The caries status for the 15 and 19 year age classes is presented in Table 1 as mean values for the different caries index groups and subgroups of DMFT, DFSa and DSa for

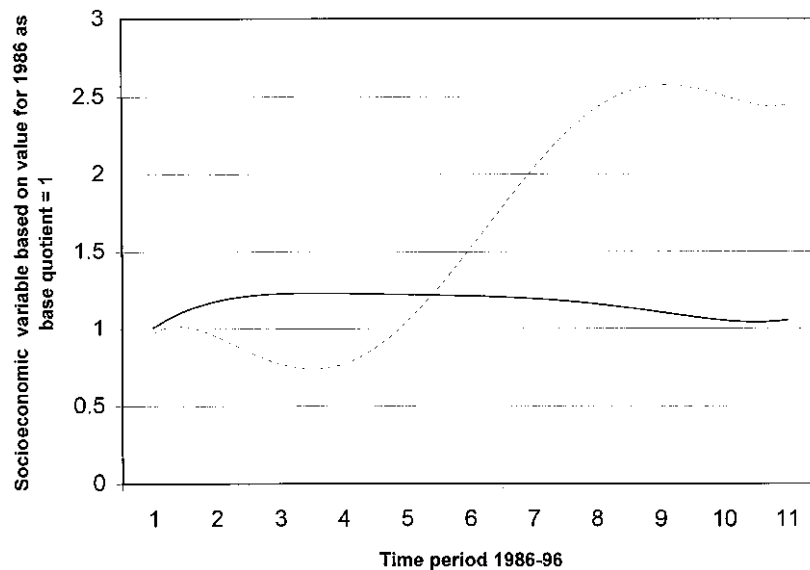


Fig. 1. Development trends presented as 5th degree polynomial trend curves for socioeconomic variables for the entire city of Göteborg for the time period 1986–96, based on the value for 1986 as a base quotient = 1. Curve 1 represents individuals 20–64 years old seeking employment as a percentage of all individuals in Göteborg. Curve 2 shows individuals 20–64 years old without Swedish citizenship as a percentage of all individuals in Göteborg (curve 1 - - -; curve 2 —).

1986, and 1996 in Districts I–IV, and for the entire city of Göteborg.

There were striking differences between the mean values for the different districts. Districts I and II showed the greatest variation, with District I presenting as the worst dental health district and District II the best. The remaining areas, districts III and IV, gave mean values which largely corresponded to the total mean values for the whole of Göteborg.

In Table 2, the socioeconomic variable values for each district showed a slightly different pattern than that for the caries index values. District I showed the highest values for effects related to economic adjustments during the study period. District III had the lowest value levels. Districts II and IV showed values as for Göteborg in total.

Due to the large amount of data, Tables 1 and 2 indicate the edited results obtained from the total data bases for the caries index values for all year classes and the socioeconomic variables, and Figs 1–3 exemplify in trend curves the results of the final steps of the data analysis procedure. The entire table and trend curve material, if required, is available on request from the corresponding author.

Using the information provided by the trend analysis curves, the results concerning the socioeconomic variables were as follows. After a decrease around 1989—and to a lower extent around 1995—there was an increase in the percentage of individuals seeking employment. District IV showed the highest levels. Furthermore, both the percentage of individuals without Swedish citizenship and the mean yearly household income values showed a vague, but

decreasing tendency for the same time periods. After a decrease around 1990, there was a marked increase until 1994 in the percentage of all households receiving social allowance. After 1994, a general decline occurred, which was most obvious in District II.

The information in Tables 1 and 2 and in Figs 1, 2 and 3, gave the following comprehensive survey. District I showed the worst dental health values, however, the trends were homogeneous and favorable. A trend break in 1995 indicated a conversion to a new, lower dental health level. This district showed the highest values of effects related to economic adjustments.

District II presented the best dental health values. The tendency towards a new dental health level in 1995 was as obvious as in District I. In this case, however, the change was toward a new and better health level. Concerning the percentage of all households receiving social allowance, a marked drop occurred at the end of the study period.

District III showed a tendency towards less favorable dental health levels in 1995 for the 15–17 year classes, and it had the lowest values of effects related to economic adjustments. District IV had a tendency towards less favorable health levels in 1995 for the 15–17 year classes. The district showed the highest percentage values of individuals seeking employment.

Generally, the caries index values and trend curves continuously point toward a better dental health level. After a minor drop in 1987–90, the mean values for all socioeconomic variables show an increase. Two of the variables have increased markedly, i.e. the percentage of individuals seeking employment, and of households

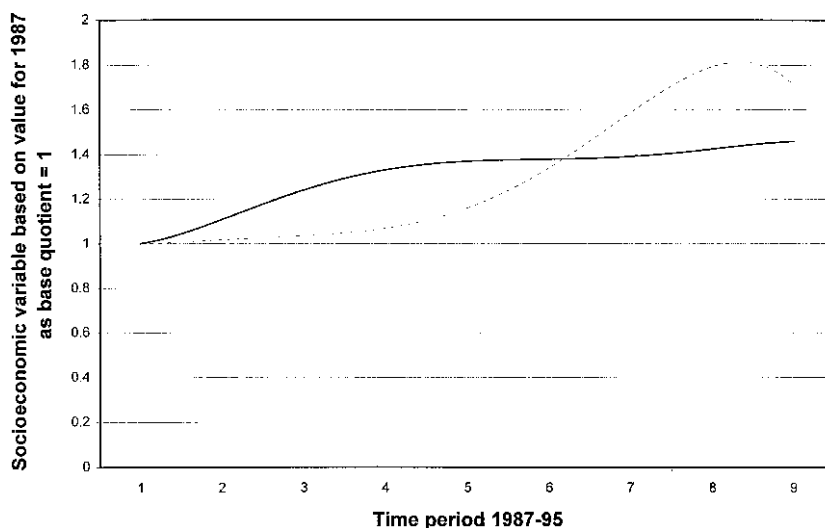


Fig. 2. Development trends presented as 5th degree polynomial trend curves for socioeconomic variables for the entire city of Göteborg for the time period 1987–95, based on the value for 1987 as a base quotient = 1. Curve 1 represents mean yearly income in Swedish currency (SEK) per household in Göteborg. Curve 2 shows households receiving social allowance as a percentage of all households in Göteborg (curve 1 - - - ; curve 2 —).

receiving social allowance. Thus, Göteborg in total shows a good and stable dental health development. However, there was a tendency toward a lower level in 1995, especially related to the DFSa and DSa indices, and

concerning the younger age classes. After 1994, a general decline was observed concerning the percentage of individuals seeking employment, and an opposite trend in the percentage of households receiving social allowance.

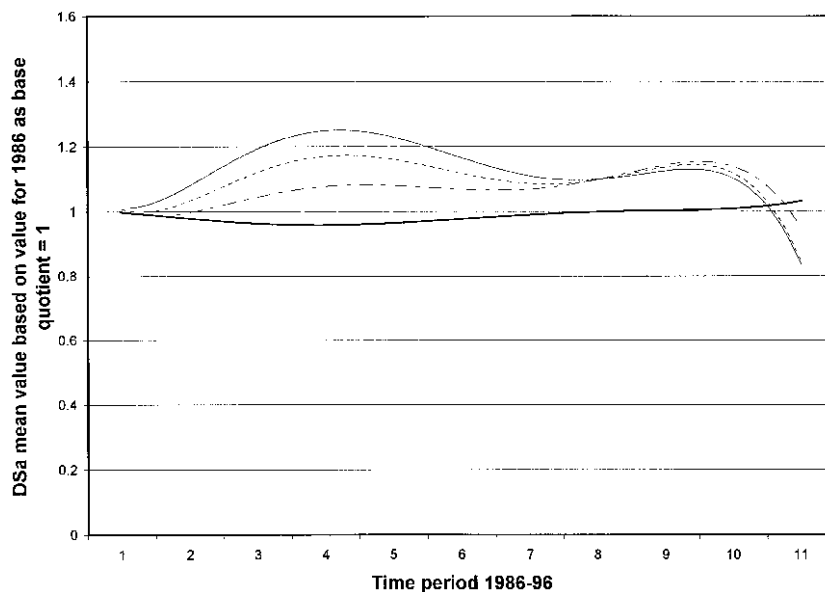


Fig. 3. Development trends presented as 5th degree polynomial trend curves for the 15-year age group in District IV for the time period 1986–96. Data refer to mean index DSa (decayed approximal surfaces) values, based on the value for 1986 as a base quotient = 1. Curves 1 represents individuals with no caries records. Curve 2 represents mean values of patients with 20% of the highest index values. Curve 3 represents all patients with caries records. Curve 4 represents all registered patients (curve 1 —; curve 2 - - - ; curve 3 — — — ; curve 4 — — —).

Discussion

This study has shown favorable dental health development for the 15–19 year classes during the time period 1986–96, despite the fact that the period has been a time of major economic adjustments and reduced resources for health care.

In relation to general discussions of environmental questions, the idea of *sustainable development* has arisen, and will require considerable changes in almost all major policy areas in which the community is involved. A European Community program of policy and action in relation to the environment and sustainable development (5) depicts the interdependence of these various policy areas, resources, and sectors. Precisely parallel arguments to those made about the environment can also be made about the importance of integrating health issues into national economic planning. A World Health Organization (WHO) publication (6) states that there is a need for nationally accepted criteria and norms regarding the allocation of resources for health, reflecting the national commitment to health improvement. Also, in times of major economic adjustments, these criteria would have to guide macroeconomic policies to ensure that the essential health needs of the population are met. The WHO Commission on Health and Environment (7) has confirmed that the global number one objective is to achieve a sustainable basis of health for all. Further, the Commission states that all governments and international agencies should give higher priority to developing a sustainable basis for the health of their people and countries, including identifying and acting on health risks at all levels, e.g. from macroeconomic policies and pricing structures to decisions concerning particular projects. In 1995, Warford (8) pointed out that the fundamental importance of human health as a determinant, as well as an objective, of economic development warrants its inclusion in any list of explicit objectives of macroeconomic policy.

Applied to the field of dental care, the idea of *sustainable development* leads to questions of what is essential for a sustainable basis for good dental health. From a national-economic point of view, it is essential to be able to follow the dental health situation of different patient groups, and to create a functional reporting system, analyzable for the dental resources used. An important subject of research would be the exploration of relationships between socioeconomic factors and other health-dependent indicators, to quantify favorable links and detect possible adverse effects. In most circumstances the relationships are likely to be indirect and linked through interdependent intermediaries. Concerning the 15–19 year classes in Göteborg—as interpreted by the different caries indices used—the present study showed only negligible indications of new dental health trends during the study period. During the study period, changes in diagnostic criteria and treatment of carious lesions may have occurred, as well as changes in ways of reporting socioeconomic data variables. However, it is likely that these factors have little effect on the trends

in data values. Thus, dental health development—as interpreted by the caries indices used—in times of major economic adjustments and lack of resources for health care was of a sustainable development character.

When choosing Göteborg for this study, it was of special interest that, divided into districts, each district has its own characteristic with regard to the different caries index variables, representing different types of dental health regions. Thus, the mean values for District II showed standards comparable with the total mean values for all Swedish county councils; the values for District I were comparable with some county councils with the worst dental health index values; and the total mean values for Göteborg were similar to the corresponding values of Malmö, a Swedish city next in size to Göteborg (9, 10).

The percentile values of registered patients in relation to the total number of individuals living in the city of Göteborg varied around 70%, and only for 1992 did the values drop to around 50%. The general causes of a decline in the number of individuals registered at each recall examination in Göteborg have been discussed by Swedberg et al. (11). Furthermore, it is obvious that the low 1992 percentile registration values were related to the change in the data compilation system that year.

The previous study of caries development in Göteborg 1986–91 (4) was a longitudinal caries presentation of data from stationary resident patient groups. Most presentations of longitudinal epidemiological caries data are based on cross-sectional index series, as from the Swedish National Board of Health and Welfare (9, 10, 12). The comparative study by Swedberg et al. (11), comparing cohort and cross-sectional data, showed statistically minor differences when reporting mean value results. The present study has additionally showed that the results mentioned above are similar to the values of an ordinary cross-sectional study.

The literature on inequalities in health concerning general and dental health in relation to socioeconomic factors is extensive. Socioeconomic status has been measured in terms of occupation, income, or education. However, the socioeconomic characteristics of neighborhoods are better predictors than characteristics of individuals or households (13). The selection of socioeconomic variables in the present study was principally based on the ability to obtain continuous time series for the study period in question. Two of the variables showed considerable changes during the time period studied: the number of individuals seeking employment, and households receiving social allowance. The other two, concerning individuals without Swedish citizenship and yearly income, showed only minor changes. Thus, the selection of variables proved to be examples of different socioeconomic standards.

The selection of caries index groups and subgroups provided several opportunities of assessing dental health development. The selection of both prevalence and incidence index variables, as well as the subgroups of representative extreme caries group mean values, gives a

vast panorama of dental health information. The increasing mean values for caries-free individuals from the prevalence index DMFT—and also DFSa—mainly depend on the result of preventive dental care from the decade before the study period. However, the other mean index and subgroup value changes in the prevalence indices, and all of the incidence index DSa, could be interpreted as being related to circumstances arising during the study period. Needless to say, the DSa index values present the most 'trend-sensitive' results, as they continuously measure the caries situation since the previous examination.

The four official city district and sector divisions of the city of Göteborg (I–IV) provided examples of differing socioeconomic and dental health status. It ought to be possible to compare these district values with comparable values from other regions and districts in Sweden.

The results call for different interpretations. Of special interest is the tendency of a trend break in the two extreme dental health districts. In both districts, a trend break occurred in 1995, but the new trend for District I was worse, and that in District II became better. With regard to the trend for Göteborg in total, the trend indications from the extreme districts cancel each other out. Thus, when all the districts are assessed together, the trend signs were toward a less favorable dental health level. If the socioeconomic trends are related to the dental health situation, and keeping in mind that the socioeconomic trend curves reached their highest levels around 1994, the formula seems to be: in times of increased economical adjustments and lack of resources for health care, the worst dental health district grows worse, and the best becomes better. However, the incongruity between the trend results of the caries index values and the contemporaneous socioeconomic variable development indicates few signs of such a relationship.

Another finding was the general trend of continuously better dental health levels based on the DMFT index values. According to the study analysis, it is obvious that the DMFT caries index should not be used separately to describe the dental health situation of a Swedish county council district.

Conclusions

This study showed favorable dental health development for the 15–19 year classes during the study period. However, the values for the caries incidence index DSa showed none or only negligible signs of lower mean values. Thus, the Swedish system for organized dental care seems to be successful in achieving sustainable dental health for

those patient groups leaving organized dental care, but not fundamentally capable of reducing the share of individuals in the patient groups with new approximal carious lesions.

During the study period, the socioeconomic variables showed a marked unfavorable trend. The incongruity between the trend results of the caries index values and the contemporaneous socioeconomic variable development indicates few signs of relationship.

In relation to general discussions of environmental questions, applied to the field of dental care, the idea of *sustainable development* was discussed. The study results indicate that dental health, in times of major economic adjustments and lack of resources for health care for the 15–19 year classes in Göteborg—as interpreted by the caries indices used—is an example of sustainable dental health development.

References

1. Demers M, Brodeur J-M, Simard PL, Mouton C, Vielleux G, Fréchette S. Caries predictors suitable for mass-screenings in children: a literature review. *Community Dent Health* 1990;7: 11–21.
2. Winter GB. Epidemiology of dental caries. *Arch Oral Biol* 1990;35 Suppl:1S–7S.
3. National Board of Health and Welfare. Analys av kariesutvecklingen hos barn och ungdomar under perioden 1985–1995. Socialstyrelsen. Rapport mars 1998. In Swedish. Stockholm 1998.
4. Swedberg Y, Fredén H, Norén JG. Caries extreme groups among adolescents, leaving organised dental care in Göteborg, Sweden. *Swed Dent J* 1997;21:221–6.
5. Towards sustainability. A European Community programme of policy and action in relation to the environment and sustainable development. Brussels, Belgium: ECSC–EEC–EAEC; 1993.
6. Intersectoral action for health. The role of intersectoral cooperation in national strategies for Health for All. Geneva, World Health Organization, 1986.
7. Our planet, our health. Report of the WHO Commission on Health and the Environment. Geneva: World Health Organization; 1992.
8. Warford J.J. Environment, health, and sustainable development: the role of economic instruments and policies. *Bull World Health Organization* 1995;73:387–95.
9. SoS-rapport 1990: 40. Tandhälsan hos barn och ungdom 1985–1989. Socialstyrelsen. In Swedish. Stockholm; 1990.
10. Meddelandebblad Nr 13/97. Socialstyrelsen. In Swedish. Stockholm; 1997.
11. Swedberg Y, Fredén H, Norén JG, Johnsson T. On longitudinal caries index data. A comparison study between cohort and cross-sectional attempts. *Swed Dent J* 1997;21:205–11.
12. National Board of Health and Welfare Oral health and dental care in Sweden. Socialstyrelsen. Stockholm; 1991.
13. Locker D. Measuring social inequality in dental health services research: individual, household and area-based measures. *Community Dent Health* 1993;10:139–50.