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Correlation between perceived experience of caries disease and recorded caries activity among adult patients at a Swedish Public Dental Clinic: A longitudinal study

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Abstract

Objective. To compare patients' perceived experiences of caries activity with recorded longitudinal caries prevalence, consequences of caries and length of recall intervals. ***Materials and methods.*** A questionnaire was mailed to 134 caries active (CA) and 40 caries inactive (CI) adult patients at a Swedish Public Dental Clinic. The overall response rate was 69%. The questionnaire included items regarding perceived caries activity, general health, dietary and oral hygiene habits, level of education and socioeconomic status. Questionnaire responses were studied for their association to clinical data extracted from patient dental records. ***Results.*** There was a correlation between patient-perceived and documented caries activity for all respondents (rho = 0.65; $p < 0.001$). CA patients had significantly more perceived caries activity ($p < 0.001$), decayed teeth ($p < 0.001$), root fillings ($p = 0.001$) and extractions ($p < 0.001$) than CI patients. The mean recall interval was 1.5 years for CA and 2.1 years for CI ($p < 0.001$). In multiple logistic regression analysis, CA patients were at increased risk for xerostomia (OR = 22.66, $p = 0.003$), sleep disturbances (OR = 4.36, $p = 0.04$) and more frequent use of daily extra fluoride (OR = 3.58, $p = 0.03$). ***Conclusions.*** Patient-perceived experience of caries correlated well with recorded caries activity in this group of middle-aged Swedish adults. Individuals with active caries were aware of their disease and made more frequent attempts to reduce caries activity by use of daily extra fluoride. Individual risk-based recall intervals did not seem to eliminate consequences of disease activity such as root fillings and extractions during the follow-up period.

Key Words: *caries inactivity, extractions, recall interval, sleep disturbances, xerostomia*

Introduction

Evidence-based reports indicate that previous caries experience is the most reliable indicator of developing new caries [1–4]. This supports the proposal that dental caries develop in the same individuals repeatedly and indicates that caries should be regarded as a chronic disease [5,6]. However, it is not possible to tell how severe and how long the caries active periods might be due to the lack of longitudinal studies, especially among adults [4]. Furthermore, little is known about experiences of caries activity among caries active individuals, even if related problems have been described [7,8].

The decline of caries prevalence during the last 50 years has been tremendous in the industrialized world [9]. Despite this large total caries reduction, ~ 30–40% of the adult population develop new manifest caries cavities every year [10,11]. One way to handle the increased difference in caries risk is to use individual recall intervals for dental check-ups, which have been discussed for more than two decades [12]. This approach suggests longer recall intervals for low risk individuals and shorter intervals for high risk individuals. There are guidelines for implementing risk-based recall intervals [13] and dental practitioners have been asked if they use fixed or individual recall intervals [14]. However, to the best of our

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knowledge, there are no studies of actual outcome of recall intervals among adult dental patients over time.

The current study combined a questionnaire study with a retrospective review of patient journal data. The aims were to investigate and compare perceived experiences of caries activity, recorded prevalence of caries, secondary effects of caries (root fillings and extractions) and differences in recall intervals between caries active and caries inactive individuals over time.

Materials and methods

Setting and participants

The study was performed at the Public Dental Clinic in Sala, Sweden, that treats ~ 11 500 recall patients. A total of 134 caries active (CA) and 40 caries inactive (CI) individuals were recruited. Among these, 40 caries active (CA) and 40 caries inactive (CI) were previously known [15] and an additional 94 caries active (CA) were consecutively recruited during 2007. All individuals were 25–50 years of age. A questionnaire along with written information about the study was mailed to all individuals. Two reminders were sent 3 and 6 weeks later to those not answering the first invitation. All participants answering the questionnaire also returned a signed consent form. The Regional ethical committee at Uppsala, Sweden, approved the study (Dnr: 2006/310).

Drop outs

Out of 54 individuals not returning the questionnaire, 44 were reached by phone. Among these, 39 were willing to answer some questions over the phone. The results from the question: 'Is caries a problem for you today?' (graded from 0–10, where 0 = no problem and 10 = very much) were compared between the non-responding and the responding groups. Among non-respondents, caries active (n = 32) individuals had a mean value of 4.1 (± 2.0) compared to 1.4 (± 2.1) for caries inactive (n = 5) individuals (p = 0.009). The results were similar to the results for the responding group. This suggests that respondents and non-respondents did not differ significantly in their perceptions of caries disease.

Questionnaire

The questionnaire was developed for this study and included questions about subjective experience of caries activity, self-assessed general health, use of medications, sleeping habits, weight and height, dietary and oral hygiene habits, education, socioeconomic status and smoking habits. The questions were constructed as Likert scales with 4- or 5-answer alternatives. On the question 'Is caries a problem for you today?', a numeric rating scale (NRS) scale was used, graded from no problem = 0 to very much = 10.

Dental record

Dental records were read retrospectively to the patient age of 20 years or as far back as possible. Data were collected at every regular examination and compared with bitewing radiographs regarding number of decayed teeth (DT) including secondary caries, root filled and extracted teeth since last examination. Time interval between examinations (recall time), number of examining dentists and decayed, missing and filled tooth surfaces (DMFS) at the start and end of the follow-up period were also registered.

Definitions

- *Caries active group (CA)* at inclusion was defined as individuals who developed manifest dental caries, including secondary caries, in two or more teeth during the last 3 years.
- *Caries inactive group (CI)* was defined as individuals who have been free from manifest dental caries for 3 years or more.
- *Caries active time* was defined as the time between two examinations where the patients showed development of manifest caries.
- *Caries inactive time* was defined as the time between two examinations where no manifest caries were recorded.

Statistical methods

Differences between the two groups were tested by t-test for continuous variables and the chi-square test for categorical variables. Spearman's rank test was used to test the correlation between caries active time and questionnaire responses to the question: 'How often, as an adult, have you experienced that you have had caries at your dental examinations?'

Risk factors for caries active vs caries inactive individuals were studied via logistic regression. Variables related to gender, self-assessed general health, use of medications, sleeping habits, body mass index (BMI), dietary and oral hygiene habits, education, socioeconomic situation and smoking were dichotomized and used as independent variables with stepwise forward inclusion, with caries group as the dependent variable. Nagelkerke R^2 was used to estimate the explained variance of the models. All tests were two-sided and p-values below 0.05 were considered significant. All analyses were conducted using IBM SPSS version 20.0; SPSS (Chicago, IL).

Results

The response rate was 69%, with 120 of the 174 individuals responding. Complete dental records could be obtained for 87 out of 88 in the caries active (CA) group and 30 out of 32 in the caries inactive (CI) group. There were no significant age differences

Table I. Gender, general health, diet, oral hygiene habits and sociodemographic variables of study participants: Caries active vs Caries inactive.

	Caries active (n = 88)		Caries inactive (n = 32)		
Variables	n	%	n	%	p
Gender					
Men	24	27	9	28	0.93
Women	64	73	23	72	
General health					
Self assessed health					0.005
Very good, good	65	74	31	97	
Neither good or bad, poor, very poor	23	26	1	3	
Medications					0.14
No	62	71	27	84	
Yes	25*	29	5	16	
Do you sleep well?					0.001
Thoroughly rested? Yes	52	60	29	91	
No	35*	40	3	9	
BMI (body mass index)					0.17
≤ 25	41	48	20	62	
> 25	44**	52	12	38	
Xerostomia—Have you felt dry mouth?					< 0.001
Never, Hardly ever	44	51	31	97	
Occasionally, Frequently or Very often	43*	49	1	3	
Diets					
How often do you eat sweets?					0.041
Never, Hardly ever, Occasionally	42	48	22	69	
One time per day or more	46	52	10	31	
How often do you drink soft drinks?					0.13
Never, Hardly ever, Occasionally	82	93	32	100	
One time per day or more	6	7	0	0	
Oral hygiene habits					
How often do you brush your teeth?					0.74
One time per day or less	10	11	3	9	
Two times per day or more	77*	89	29	91	
How often do you use dental floss?					0.33
Hardly ever, Never	67	76	27	84	
Once per day or more	21	24	5	16	
How often do you use toothpicks or proximal brushes?					0.08
Hardly ever, Never	71	71	30	94	
Once per day or more	17	19	2	6	
Do you use any kind of extra fluoride?					0.02
(tablets, chewing gum or rinses)	55	62	27	84	
Hardly ever, Never	33	38	5	16	
Once per day or more					
Education					
Your highest level of education					0.02
College, University	20	23	14	44	
Elementary, High school	68	77	18	56	
Socioeconomic status					
Your family yearly income					0.16
300 000 SEK or more	55	65	25	78	
Less than 300 000 SEK	30**	35	7	22	
Smoking habits					
Do you smoke?	73				0.16
Never, have stopped	14*	84	30	94	
Sometimes, daily		16	2	6	

*one missing, **three missing.
SEK, Swedish Krona.

Table II. DMF-S (decayed, missing or filled tooth surfaces) at start, end and total increase of the follow-up period. DT (decayed tooth) at inclusion, total and per year during the follow-up period.* Caries related variables; root fillings, extractions during the follow-up period.

	Caries active group		Caries inactive group		
	n	Mean (SD)	*n*	Mean (SD)	*p*
DMF-S start	86	20.6 (15.5)	30	8.6 (8.2)	< 0.001
DMF-S end	88	33.6 (16.1)	32	10.6 (9.0)	< 0.001
DMF-S increase	86	12.9 (8.3)	30	2.2 (2.5)	< 0.001
DT at inclusion	88	2.2 (1.7)	32	0.0	< 0.001
DT during follow-up	88	15.5 (10.2)	30	1.5 (1.6)	< 0.001
DT per year	87	1.0 (0.6)	30	0.1 (0.1)	< 0.001
Root fillings (*n*)	88	0.7 (1.1)	30	0.0 (0.0)	< 0.01
Tooth extractions (*n*)	88	1.0 (1.4)	30	0.1 (0.3)	< 0.001

*The follow-up period was 16.5 (± 6.8) and 18.3 (± 6.4) years for CA and CI groups, respectively.

between the two groups, the mean age was 39.5 (± 6.2) years for the CA compared to 41.0 (± 6.3) years for the CI group.

Descriptive statistics for questionnaire variables related to gender, general health, diet, oral hygiene habits and sociodemographic characteristics are summarized across CA and CI patients in Table I. There were statistically significant differences between groups with regard to self-assessed health, sleep quality, xerostomia, use of fluoride and education. CA individuals gave significantly lower ratings to their health and sleep quality than CI individuals and they were generally less-well educated. Xerostomia differed significantly between the two groups at different cut-offs. In the CA group, 24% reported that they 'frequently or very often' experienced xerostomia, compared to none in the CI group ($p = 0.002$). If those answering the alternative 'occasionally' were included, the difference was larger ($p < 0.001$, Table I). A greater proportion of the CA group reported that they used extra fluoride daily or more often, compared to the CI group.

The mean follow-up times in dental records were 16.5 (± 6.8) and 18.3 (± 6.4) years for the CA group and the CI group, respectively. During this time the mean number of examinations was 12.3 (± 5.7) for the CA and 10.8 (± 4.2) for the CI group. The examinations had been performed by 5.3 (± 2.5) and 5.1 (± 2.4) different dentists for the CA and CI groups, respectively.

For all caries-related variables obtained from the patient records, the CA group had a significantly higher prevalence of decayed teeth (DT), decayed, missing and filled surfaces (DMFS), root fillings and tooth extractions, compared to the CI group (Table II).

On the question 'Is caries a problem for you today?' (graded from no problem = 0 to very much a problem = 10), responses between the groups differed significantly: 4.7 (± 2.5) and 0.8 (± 0.9) for the CA and CI groups, respectively ($p < 0.001$). The subjective experience of caries activity over time, expressed by responses to the question 'How often, as an adult, have you experienced that you have had caries at your dental examinations?' also differed significantly between groups ($p < 0.001$, Table III).

Caries active and caries inactive time during the follow-up period showed statistically significant differences between the two groups ($p < 0.001$, Table IV). The proportion of the follow-up time classified as caries active (caries active time divided by the follow up time) was 61% (± 22%) for the CA group, compared to 9% (± 11%) of the follow-up time for the CI group ($p = 0.001$).

When combining all participants, there was a statistically significant correlation between caries active time/follow-up time and responses to the question; 'How often, as an adult, have you experienced that you have had caries at your dental examinations?' (rho = 0.65; $p < 0.001$, Figure 1).

The mean recall times were 1.6 (± 0.5) and 2.1 (± 1.3) years for the CA and the CI groups, respectively ($p < 0.001$). In this long-term perspective the shortest recall times were 0.9 (± 0.3) and 1.2 (± 0.4)

Table III. Question: How often, as an adult, have you experienced that you have had caries (at your dental examinations)?

Groups	Very often	Often	Sometimes	Seldom	Never	No answer	Total *n*
Caries active	20 (23)	30 (34)	28 (32)	9 (10)	0 (0)	1 (1)	88 (100)
Caries inactive	0 (0)	0 (0)	1 (3)	23 (72)	8 (25)	0 (0)	32 (100)

Chi^2 test: $p < 0.001$.
Number of responses (%).

Table IV. Caries active time* and caries inactive time** during the follow-up period (16.5 (± 6.8) and 18.3 (± 6.4) years for CA and CI groups, respectively) and the longest caries active and caries inactive periods (uninterrupted) in both groups.

	CA		CI		
	n	Mean years (SD)	*n*	Mean years (SD)	*p*
Caries active time, total	87	9.9 (4.7)	30	1.7 (2.1)	< 0.001
Caries inactive time, total	87	6.6 (4.4)	30	16.5 (6.3)	< 0.001
Longest caries active period	87	6.2 (3.5)	30	1.2 (1.2)	< 0.001
Longest caries inactive period	87	3.5 (2.1)	30	14.3 (6.9)	< 0.001

*The time between two examinations where the patients showed development of manifest caries.
**The time between two examinations where no manifest caries were recorded.

years for the CA and the CI groups, respectively ($p < 0.001$), while the longest recall time for the CA group was 2.6 (± 1.2) and 3.5 (± 2.5) years for the CI group ($p = 0.011$).

In the multiple logistic regression analysis with caries group as the dependant variable, three independent variables from the questionnaire remained in the model: xerostomia, daily use of extra fluoride and sleep disturbances (Table V). The use of extra fluoride had a 3.5-times elevated odds for caries activity, sleep disturbances elevated the odds ~ 4-times, whereas xerostomia had over 20-times elevated odds. The model explained ~ 40% of the variance in caries activity, as indicated by Nagelkerke's R^2.

Discussion

The results showed that perceived experience of caries activity correlated well with recorded caries activity over a long period of time. It was obvious that the caries active individuals were aware of their caries disease and made more frequent attempts to reduce caries activity by use of daily extra fluoride. Even if individual recall intervals had been used during the study time, this did not seem to reduce secondary effects of caries, such as root fillings and tooth extractions. The results also indicate that caries activity might be related to general health problems such as xerostomia and sleep disturbances.

We have only found one longitudinal study among adults, by Broadbent et al. [16], that described caries prevalence over time by repeated cross-sectional analysis. They presented three groups of different DMFS development: low, medium and high trajectory. At the age of 32 years, the DMFS for the three groups were 5.4 (± 3.7) 18.6 (± 6.8) and 42.3 (± 12.7), respectively. All three groups showed an increase of DMFS from the age of 5 years, but with different magnitudes. In the present study, the CA group had DMFS values (at end) approximately in between the two highest caries groups in the Broadbent et al. study, while our CI group had slightly higher DMFS than their low DMFS group. There were also similar relationships between these groups regarding increases in DMFS over time. The results from both studies show that caries active individuals continue to be caries active for many years. This supports the proposal that caries should be regarded as a chronic disease.

DMFS increase compared to the actual caries prevalence DT during the follow-up (Table II) were under-estimated for the CA group but over-estimated for the CI group. The under-estimate for the CA group are probably explained by the occurrence of secondary or recurrent caries which have been shown to be the main reason, up to 50%, for replacing old fillings [17]. The over-estimate for the CI group might be due to filling, because of enamel or dentin fractures. Even if the differences between DMFS and DT were small, the actual caries prevalence (DT) must be considered as more accurate.

The mean progress rate during the follow-up period, expressed by number of teeth with new manifest caries cavities per year, was one per year in the CA group, but 10-fold higher than in the CI group. This difference between the groups was more than 3-times higher than the cross-sectional caries

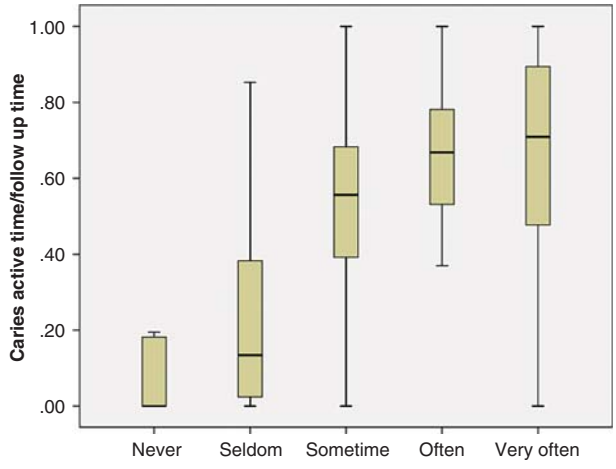

Figure 1. The relationship between caries active time during the follow-up period (caries active time divided by the follow-up time) and responses to the question; 'How often, as an adult, have you experienced that you have had caries at your dental examinations?' for all participant (medians and interquartile range). Spearman's rho 0.65 ($p < 0.001$).

Table V. Multiple logistic regression analyses examining risk factors for caries group (CA as reference). Independent variables: gender, general health, dietary, oral hygiene, smoking habits, education and socioeconomic status.

Variable	*n*	OR	95% CI	*p*
Xerostomia—Have you felt dry mouth? (Occasionally or more often)	43	22.66	2.86–179.42	0.003
Do you use any kind of extra fluoride? (tablets, chewing gum or rinses) (Once per day or more)	33	3.58	1.12–11.39	0.03
Do you sleep well? (Thoroughly rested? - no)	35	4.36	1.10–17.26	0.04
Nagelkerke R^2				0.40

difference at inclusion (DT) (Table II). The longest caries inactive period also gives some information about rates of progression. This could be interpreted as the slowest mean progress rate into manifest caries during the follow-up period and it was 3.5 years in the CA group (Table IV). This was slower compared with the median progression time from initial caries at the enamel dentin border to the outer half of the dentin, 3.1-years, presented by Mejare et al. [18]. The time factor for progression is important for diagnosis of caries activity [19,20], but has rarely been used in earlier caries studies, as most studies have been cross-sectional [4]. The lack of a standard definition of caries activity is a problem when comparing caries studies, as many different definitions have been used [20]. The definition of caries inactivity used in this study, no manifest caries in the last 3 years, has been used for the definition of low caries risk by dental insurance systems [11]. This definition of caries inactivity seems reasonable since a majority of the caries active individuals had new manifest dental caries within 3 years.

The significant difference in recall time between the two groups, with longer recall intervals for the CI group and shorter for the CA group, indicates that individual risk-based recall intervals for dental check-ups were used by the practicing dentists. This result was somewhat surprising as the Public Dental Clinic where the study was conducted did not have any systematic risk-based recall interval policy at the time of the follow-ups. Furthermore, the clinic had been part of a national training programme for new dentists, resulting in a large number of dentists performing the examinations of the involved participants; a total of 76 different dentists could be identified among the patient records. Despite this, it seems evident that a risk-based approach was used. One of the main intentions with risk-based recall intervals is to minimize secondary effects of caries such as root fillings and tooth extractions, but the results of the present study indicate that these goals have not fully been accomplished. Diagnosis of manifest caries is dependent on the decisions of the dentists performing the clinical examinations. The variability in decision-making between dentists is substantial [21]. In the present study, different subjective clinical judgements by dentists may have been of less importance as the mean number of examining dentists during the follow-up period was fairly high and about the same for both groups. Recall intervals might also depend on queue problems, but the clinic was sufficiently staffed during the entire follow-up period.

Regression analysis suggests that caries active individuals in this sample more often experienced xerostomia and sleep disturbances. In a population-based study, ~ 20% of 40 year-olds reported that their mouth usually felt dry [22]. In the present study, slightly more in the CA group had xerostomia frequently or very often, while it did not occur in the CI group. A relationship between sleep disturbances and caries has, as far as we know, not been described. However, a strong relationship has been reported between dry mouth (xerostomia) upon awakening in obstructive sleep apnea [23] and sleep disturbances have also been reported in patients with Sjögrens syndrome [24]. Further study of the associations between xerostomia, sleep disturbances and caries is warranted. The findings that caries active individuals have more often used daily extra fluoride might indicate that they, knowing about their caries problem, are trying to reduce the risk for new caries, although these attempts were not sufficient to stop caries progress.

The main task for the selection in this study was to create two groups that differed in caries activity and this was well achieved. The time factor used in the inclusion criteria (the development of manifest dental caries during the last 3 years) was important for the difference in caries activity between the two groups. The optimal study design to learn more about longitudinal caries prevalence would be prospective cohort studies, but such studies are expensive and take a long time to conduct. An ethical problem with prospective caries studies would be consideration of more efficient prophylactic interventions during the monitoring of a study, if the caries progress would be as evident as in the present study. To study retrospective data must be seen as a faster and less expensive alternative to reveal information of possible relationships, which might also be useful guidance in the planning of future prospective studies.

It is difficult to verify if these results of caries prevalence over time could be generalized to other populations, as comparable longitudinal caries data are rare. However, these results are in line with one previous study by Broadbent et al. [16], showing that caries active individuals continue to be caries active for decades of years. The actual clinic in Sala treats ~ 10% of the Public Dental Care patients in the county of Västmanland, epidemiologic data have

revealed almost the same mean values of caries prevalence for the clinic and the whole county and the clinic do not serve any special under-privileged area or with other social problems.

Regarding the correlation between recorded and perceived caries activity, more investigations are needed as there are, to the best of our knowledge, no previous studies on these relationships. The method used to analyse the drop outs might be questioned, as we have not found any studies comparing phone interview and written questionnaire using NRS scale, in a similar way. However, it gives some possibilities to compare groups perceptions of caries disease. Finally, the sample size in this study was small and results should be interpreted with caution. However, this study may serve as a guide for further studies of caries progression and caries prophylactics among caries-active individuals.

In conclusion, the results from this study support the notion that caries should be regarded as a chronic disease. Those who have manifest caries continue to develop new caries year after year and other health-related variables, such as sleep problems and xerostomia, may increase the risk. Even if risk-based recall intervals are used, they do not seem to eliminate the secondary effects of caries such as root fillings and extractions. Furthermore, results indicate that caries active individuals are aware of their disease and have made more attempts to reduce caries activity than caries inactive individuals. Further studies of caries prophylactics offered to and undertaken by caries active individuals are needed.

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