Dental caries and related factors in 88- and 92-year-olds

Cross-sectional and longitudinal comparisons

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Our aim was to compare two groups of 88- and 92-year-olds ($n = 92$ and $n = 40$), respectively, with regard to teeth, caries, and salivary and microbial conditions. Oral variables were analyzed in relation to functional capacity and use of cardiovascular agents and psychoactive drugs. Untreated root caries, plaque score, and counts of lactobacilli increased between the ages of 88 and 92 years ($P < 0.01$). Nine of the 24 longitudinally followed up subjects had lost 1–5 teeth over 4 years, and 17 subjects had developed new caries (DFS). The mean caries increment over 4 years was 1.3 coronal and 3.6 root surfaces, and new DFS per 100 surfaces at risk was 4.3 coronal and 17.5 root surfaces. Plaque score and final pH of buffer capacity increased ($P < 0.05$ and 0.01, respectively), whereas saliva flow, independent of gender, was unchanged. Use of cardiovascular agents and psychoactive drugs was associated with a deteriorated dental status.
☐ *Caries incidence; functional capacity; gerodontology; lactobacilli; mutans streptococci*

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For oral health care planning the rapid increase of dentate people with high age (1) has led to an increased need to survey caries development and risk factors among old people. Longitudinal epidemiologic studies are in this respect important tools (2). Caries incidence in elderly people, 65 years and older, has been investigated in some recent studies (3–11). Coronal caries incidence seems not to increase with increasing age (4), whereas increasing age seems to predispose for root caries (4, 9, 10). A trend towards higher caries incidence has been found in institutionalized and demented elderly people when compared with community-dwelling elderly people (7, 8). This may indicate a link between general health and dental caries.

Several variables have been identified as risk indicators for root caries in adults, such as plaque score, periodontal pockets >3 mm, past root caries experience, levels of lactobacilli and mutans streptococci in saliva, dietary habits, tobacco use, general health, and level of social integration (2, 3, 7, 9, 12, 13). However, few studies have focused on the oldest old people in this respect. The aim of this study was therefore to examine both coronal and root caries—cross-sectionally and longitudinally—and relate this to saliva and microbial conditions in 88- and 92-year-olds. The intention was also to study the relationship between dental caries and medication use and functional capacity. It was hypothesized that impaired functional capacity among these old persons contributes to deteriorated dental health status.

Materials and methods

Subjects

This investigation was part of the multidisciplinary gerontologic and geriatric population studies in Göteborg, Sweden (14, 15). From a representative sample of 454 persons we examined 92 dentate, 88-year-old persons living at home (16). Four years later, at the age of 92 years, 24 of these subjects were re-examined (group A) together with 16 newly admitted 92-year-old dentate probands (group B) (Fig. 1).

Analyses indicated that the dentate 88-year-old non-participants were significantly more disabled and had more difficulties with oral hygiene procedures than the participants, and that the 92-year-old non-participants were more disabled and had a higher drug consumption. Thus, very frail and demented persons were underrepresented in these studies.

Clinical examination and oral test variables

The examination, performed by one examiner (M. Lundgren), was carried out in the morning in a room with a dental chair and operating light, using a mirror and explorer. Caries criteria, bacteriologic procedures, and base-line data have previously been described in detail (16). Clearly visible plaque was recorded for the smooth surfaces of all teeth without using previous disclosing solution (17). The numbers of natural teeth, coronal and root caries lesions, restorations and fixed

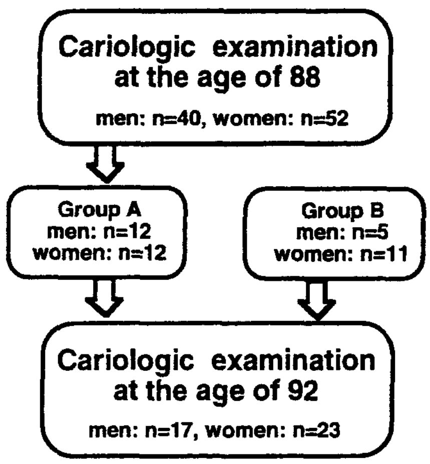

Fig. 1. Number of subjects examined at 88 and 92 years of age. Group A comprises the 24 subjects who were re-examined at 92 years, and group B denotes the 16 newly admitted probands.

and removable prostheses were recorded. The prevalence of root caries was described using Katz's root caries index (RCI) (18)—that is, the number of decayed and filled root surfaces in proportion to the number of decayed, filled, and sound root surfaces with gingival recession.

Whole saliva, stimulated by chewing a piece of paraffin wax, was collected for 5 min, and the secretion rate expressed in milliliters per minutes. Dentures were in situ during the saliva collection. The final pH of buffer capacity was determined electrometrically in accordance with the method described by Ericsson (19). If less than 1 ml of saliva was available, 0.5 ml was used, and the method modified accordingly.

The bacteriologic procedures were those described by Emilson (20). The saliva samples were dispersed on a Whirlimixer for 30 sec, and serial 10-fold dilutions were made in 0.05 M phosphate buffer (pH 7.3). Duplicate samples of 25 µl of the appropriate dilutions were cultured on selective agar media. Counts were made of colonies in Rogosa SL agar showing the typical morphology of lactobacilli, and of colonies on MSB agar with the typical morphology characteristic of *Streptococcus mutans* and *Streptococcus sobrinus* as described by Emilson (20). The number of colony-forming units (CFU) of these microorganisms per milliliter of saliva was determined.

Salivary glucose clearance in the group of 92-year-old persons ($n = 39$) was assessed by measuring the glucose concentration in saliva after chewing a glucose tablet (21). The salivary glucose clearance time was defined as the time in minutes necessary for the glucose concentration in saliva to drop to 5 mmol/l.

Medication and functional capacity

At home visits before each examination, information about medication use, based on a precoded questionnaire, was obtained by a registered nurse. The interview method was the same as earlier described (22). The drugs were classified in accordance with the Anatomical Therapeutic Chemical (ATC) classification system recommended by the WHO (23).

The ability/disability in performing activities in daily living (ADL) was assessed in accordance with Sonn & Hulter Åsberg (24). The level of ADL dependence on another person was assessed on the basis of four well-defined instrumental activities of daily living (I-ADL) (cleaning, shopping, transport, and cooking) and five personal activities (P-ADL) (bathing, dressing, going to the toilet, transfer, and feeding). These activities were ordered into a cumulative scale of dependence and were described by ADL steps from 0 (independent in all activities) to 9 (dependent in all activities). Independent means that no other person was involved in the activity.

A psychologic examination, which took an average of 1 h, was performed in 67 of the 88-year-olds and in 23 of the 92-year-olds. The following battery of cognitive tests were included in a cognitive index: i) *Digit Span Forward and Backward*, which are measures of immediate or primary memory; ii) *Identical forms*, measuring perceptual speed; iii) *Block Design*, measuring spatial ability; iv) *Thurstone Memory Test*, measuring secondary memory, modified with enlarged figures to minimize problems due to visual deficiencies in the subjects; v) *Synonyms*, measuring verbal ability; vi) *Memory in Reality (MIR) Test*, measuring long-term memory (25); and vii) *Draw-a-Clock Test*, a cognitive test in which the subjects are instructed to draw a clock and set the hands to a certain time (26). Identical forms, Thurstone Memory Test and Synonyms, are from Dureman & Sälde (27), who based their battery on Thurstone's theories of primary mental abilities (28). The Digit Span test and the Block Design test are parts of the WAIS battery (29). The cognitive index was calculated as follows: to examine whether it was possible to regard the different cognitive tests as measurements on a common one-dimensional scale, principal components were computed. It was considered that sufficient support for a one-dimensional scale was obtained (the first eigenvalue was 4.85, and the second 0.67). The cognitive index was constructed by summing the standardized values (mean, 0; standard deviation, 1) of the separate tests, and then transforming this sum to a scale with a mean of 50 and a standard deviation of 10. The lower the score in the index, the lower the cognitive ability.

Analyses of the test variables

Caries incidence was determined on the basis of surface-by-surface comparison of caries status at base line and at follow-up. Incidence rate is reported as the proportion of persons who developed one or more new caries lesions over the 4 years. New caries lesions were defined as the number of surfaces that were sound at

Table 1. Cross-sectional study. Number of teeth and tooth surfaces, caries prevalence, plaque score, stimulated salivary secretion rate, and final pH of buffer capacity in 88- and 92-year-old subjects. Mean and standard deviation (*s*) are given

	88 years, n = 92		92 years, n = 40	
	Mean	*s*	Mean	*s*
Teeth				
No. of teeth	14.1	7.3	13.4	8.1
Decayed and filled	11.3	5.8	11.1	6.3
Coronal surfaces				
No. of surfaces	62.2	33.1	58.7	36.7
Decayed	1.1	2.0	0.9	2.5
Filled	35.2	22.0	36.5	25.9
Root surfaces				
Exposed surfaces	19.5	14.4	19.9	17.2
Decayed	1.8	4.7	3.2	4.9
Filled	4.2	4.1	3.9	4.3
DSr%†	9.9	19.0	21.7**	28.4
RCI%†	36.6	28.5	44.0	32.7
Plaque score	29.5	28.2	43.8*	35.3
Secretion rate	1.5	1.1	1.2	0.8
Buffer pH	6.3	1.3	6.5	1.4

* Significantly different from the cross-sectional study at 88 years; $P < 0.05$.
** Significantly different from the cross-sectional study at 88 years; $P < 0.01$.
† Mean based on individual values.

base line and decayed or filled at follow-up, and as surfaces that had restorations at base line and recurrent decay 4 years later. Tooth surfaces provided with new crowns were not recorded as new fillings. Caries attack rate was determined by calculating the total number of new caries lesions developed per 100 surfaces at risk for caries. All uncrowned coronal surfaces were considered at risk for coronal caries, and all root surfaces with gingival recession were considered at risk for root caries. Teeth that were lost between base line and follow-up were not included in the analyses.

To evaluate the influence of some selected risk variables on tooth loss and caries increment between 88 and 92 years (validation criterion, ≥3 new DMFS), a risk border value was assessed for each variable as follows: plaque score ≥50%, lactobacilli $\geq 10^5$ CFU/ml saliva, mutans streptococci $\geq 10^6$ CFU/ml saliva, stimulated salivary secretion rate <0.7 ml/min, final pH of buffer capacity <4.5, salivary sugar clearance time >15 min, and the use of cardiovascular and/or psychoactive drugs.

Statistics

The bacteriologic counts were transformed to $\log_{10}$ before testing. When testing for differences in levels between groups, the *t* test, pairwise *t* test, and chi-square were used. Non-parametric tests were used to test correlations between two variables. The tests used may be described as special cases of the general Pitman permutation test (30). When testing for correlation between two variables that are recorded for the rank, the test used was Spearman's rank correlation test. To test for correlation when controlling for confounding factors, an extension of the Pitman permutation test using a technique similar to that suggested by Mantel (31) was used.

Results

Cross-sectional study

The number of teeth, caries prevalence, plaque score, stimulated salivary secretion rate, and final pH of the buffer capacity in the 88- and 92-year-old subjects are presented in Table 1. Plaque score was significantly

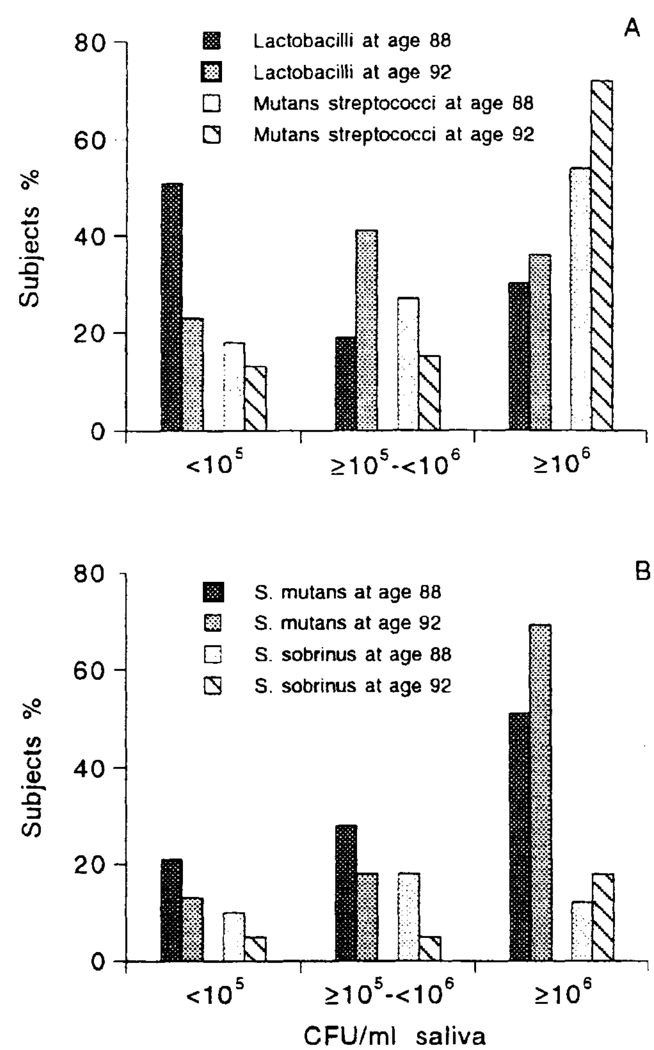

Fig. 2. Distribution of 88- and 92-year-old subjects with regard to various levels of lactobacilli and mutans streptococci (A), and *Streptococcus mutans* and *S. sobrinus* (B).

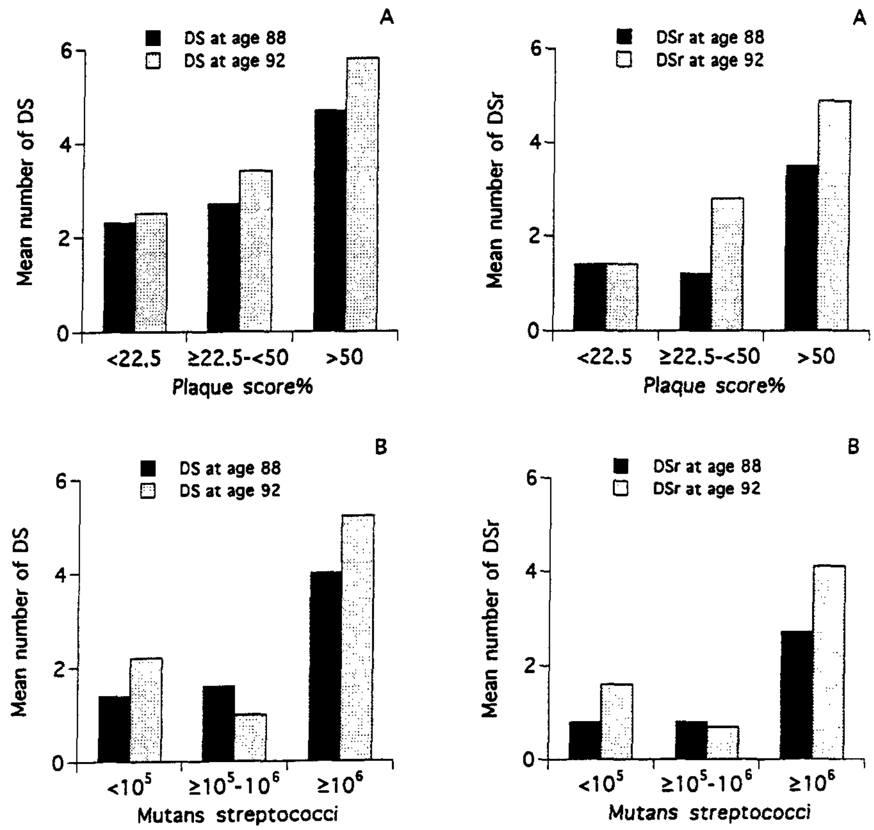

Fig. 3. Distribution of total decayed surfaces (DS) and decayed root surfaces (DSr) with regard to various levels of plaque score (A) and mutans streptococci (B) in the 88- and 92-year-old subjects.

higher in the total group of 92-year-old subjects than in the 88-year-olds ($P < 0.05$), whereas no significant differences were found in terms of number of teeth, coronal caries, stimulated salivary secretion rate, or final pH of the buffer capacity.

In the newly admitted probands (group B) (Fig. 1) no significant differences between this group and group A at the age of 92 years were found with regard to most tested variables, with the exception that the number of filled root surfaces was lower in group B than in group A ($P < 0.05$) and also lower than in the group of non-re-examined subjects.

Detectable levels of lactobacilli and mutans streptococci in saliva were found in 96% and 98%, respectively, of the 88-year-old subjects, and in 100% and 93% of the 92-year-olds. Fig. 2 shows the distribution of different levels of lactobacilli and mutans streptococci in the subjects. The proportion of subjects with high levels of lactobacilli ($\geq 10^5$ CFU/ml) and mutans streptococci ($\geq 10^6$ CFU/ml) was higher at 92 than at 88 years of age, but the differences between the age groups were significant only for lactobacilli ($P < 0.01$).

Of the 88-year-olds, 61% had one or more untreated caries lesions, and 41% had coronal and 46% root caries. For the 92-year-olds the corresponding figures were 65%, 30%, and 60%, respectively. For root caries, the differences between the age groups were significant only when the individual proportion of decayed root surfaces (DSr%) of exposed surfaces was calculated ($P < 0.01$) (Table 1). With regard to the number of decayed root surfaces (DSr), significant differences between the age groups were found only in subjects with a plaque score >22.5%, which was the median for the 132 observations ($P < 0.05$) (Fig. 3A). In both age groups, DS and DSr were higher in subjects with $\geq 10^6$ CFU mutans streptococci than in those with lower levels of these microorganisms ($P < 0.05$) (Fig. 3B).

Table 2 shows that the percentage of decayed coronal surfaces (DSc%) was correlated to plaque score at 88 years ($P < 0.01$), whereas the correlation at 92 years was insignificant. The percentage decayed root surfaces of the exposed root surfaces (DSr%) and the root caries index (RCI) correlated significantly with plaque score only in the 92-year-olds ($P < 0.01$). In both age groups the levels of lactobacilli and mutans streptococci were associated with DSr% and RCI.

Most subjects were taking medication: 93% of the 88-year-olds and 90% of the 92-year-olds. Among drugs with possible hyposalivatory side effects, cardiovascular

Table 2. Correlation coefficients for subjects in cross-sectional studies at 88 years (n = 92) and 92 years (n = 40) between percentage of decayed coronal surfaces of existing surfaces (DSc%), decayed root surfaces of exposed root surfaces (DSr%), and root caries index (RCI), and the variables plaque score, stimulated salivary secretion rate, final pH of buffer capacity, lactobacilli, and mutans streptococci

Variables	DSc%		DSr%		RCI	
	88 years	92 years	88 years	92 years	88 years	92 years
Plaque score	0.30**	0.13	0.14	0.48**	0.07	0.43**
Secretion rate	0.00	0.16	0.11	0.17	−0.13	−0.05
Buffer pH	0.03	0.02	−0.13	−0.19	0.07	0.05
Lactobacilli	−0.01	0.27	0.30**	0.31	0.24*	0.36*
Mutans streptococci	0.15	0.01	0.23*	0.47**	0.33**	0.29

* $P < 0.05$; ** $P < 0.01$.

Table 3. Correlation coefficients between the variables activities in daily living (ADL) scale, cognitive index, medication (number of cardiovascular and/or psychoactive drugs: 88 years, range 0–8; 92 years, range 0–4), and the examined oral variables

	ADL scale		Cognitive index		Medication	
	88 years	92 years	88 years	92 years	88 years	92 years
DSc%	0.06	0.31*	−0.21	−0.66*	−0.04	0.17
DSr%	0.25*	−0.11	−0.29*	−0.09	−0.23	0.16
RCI	0.16	0.04	−0.06	0.02	0.06	0.12
Plaque score	0.16	0.23	−0.32*	−0.22	−0.08	0.07
Secretion rate	0.02	0.06	−0.04	0.36	−0.16	−0.12
Buffer pH	0.09	−0.02	−0.12	0.44	0.15	−0.23
Lactobacilli	0.09	0.42**	−0.09	−0.15	−0.11	−0.06
Mutans streptococci	0.19	−0.09	−0.16	0.14	−0.01	0.22

DSc% = percentage decayed coronal surfaces; DSr% = percentage decayed root surfaces; RCI = Katz's root caries index.
* $P < 0.05$; ** $P < 0.01$.

and/or psychoactive drugs were used by 68% of the 88-year-olds and 65% of the 92-year-olds.

At the age of 88 years, 35% of the subjects were ADL-independent, whereas 51% were ADL-dependent in one to three activities and 14% in four to six activities. At 92 years, 17.5% were ADL-independent, 55% ADL-dependent in one to three activities, and 27.5% in four to six activities.

Table 3 shows the correlation coefficients between the examined oral variables and the ADL scale, the cognitive index, and the use of cardiovascular and/or psychoactive drugs. The two caries variables, DSc% and DSr%, correlated significantly with the ADL scale and the cognitive index—DSc% at 92 years and DSr% at 88 years. Of the two variables plaque score and lactobacilli (both of which had markedly increased between 88 and 92 years), plaque score at 88 years was negatively correlated with the cognitive index ($P < 0.05$). The single correlation between plaque score and ADL scale was weak at 92 years but became significant when adjusted for gender ($r = 0.35$, $P < 0.05$). Lactobacilli correlated significantly with the ADL scale at 92 years ($P < 0.01$). No significant correlations to the examined variables were found for medication.

Longitudinal study

In group A 9 subjects (37%) had lost 1 or more teeth (range, 1–5) between the ages of 88 and 92 years, with a mean of 0.75 teeth for the whole group (Table 4). During this 4-year period the number of exposed root surfaces increased from 19.2 to 21.1. Of this difference (1.9 newly exposed root surfaces), 1.1 surfaces were decayed and 0.2 filled, which means that 68% of all newly exposed root surfaces were either decayed or filled. The mean RCI% (based on individual values) increased from 43.3 to 45.8. The plaque score at 92 years (45%) was twice as high as that at 88 years ($P < 0.05$). The stimulated salivary secretion rate was the same at both examinations, whereas the final pH of the buffer capacity was higher at the age of 92 ($P < 0.01$).

The proportion of subjects with high salivary counts of lactobacilli ($\geq 10^5$ CFU/ml) increased from 63% to 79% ($P < 0.01$), whereas only small changes were found

Table 4. Longitudinal study (n = 24). Number of teeth and tooth surfaces, caries prevalence, plaque score, stimulated salivary secretion rate, and final pH of buffer capacity in 88- and 92-year-old subjects. Mean and standard deviation (s) are given

	88 years		92 years	
	Mean	s	Mean	s
Teeth				
No. of teeth	14.4	7.2	13.7	7.4
Decayed and filled	12.6	6.1	12.3	6.3
Coronal surfaces				
No. of surfaces	63.6	33.1	59.8	33.1
Decayed	1.0	2.1	0.9	2.9
Filled	41.5	26.5	41.2	27.0
Root surfaces				
Exposed surfaces	19.2	14.8	21.1	15.9
Decayed	2.3	4.2	3.4	4.2
Filled	4.8	4.4	5.0	4.7
DSr%†	15.2	25.5	20.7	27.0
RCI%†	43.3	29.8	45.8	33.9
Plaque score	22.0	21.4	44.5*	32.8
Secretion rate	1.3	0.7	1.3	0.9
Buffer pH	5.7	1.5	6.5**	1.4

* Significantly different from 88 years; $P < 0.05$.
** Significantly different from 88 years; $P < 0.01$.
† Mean based on individual values.

Table 5. Proportion of subjects with new caries lesions (incidence rate), net caries increment, and attack rate between 88 and 92 years of age in the 24 subjects who were re-examined at 92 years

	Surfaces		
	Coronal	Root	Total
Incidence rate	38%	67%	71%
Net caries increment			
Mean ± s	1.3 ± 2.9	3.6 ± 4.2	4.9 ± 6.4
Range	0–12	0–15	0–23
Attack rate*	4.3	17.5	—

* New DFS per 100 surfaces at risk over 4 years.

for mutans streptococci. At the age of 88 years 13 subjects carried *S. sobrinus*, and at 92 years 8 subjects.

Table 5 shows that 9 of the 24 subjects (38%) who were re-examined at 92 years had developed new coronal caries, and 16 subjects (67%) new root caries. The increment of new caries over the 4-year period comprised 1.3 coronal surfaces and 3.6 root surfaces. The caries attack rate per 100 surfaces at risk was 4.3 coronal surfaces and 17.5 root surfaces.

Fig. 4 shows that sound teeth were mainly found in the lower frontal region. There was, however, a greater number of decayed and filled teeth in this region at the age of 92 than at 88 years.

Table 6 presents caries increment by type of caries and location. No new caries was found on the occlusal surfaces. Most of both coronal (81%) and root caries (82%) increment was due to primary caries; the rest was recurrent caries. Buccal surfaces were involved in the root caries increment somewhat more often than other surfaces. Thirty-four per cent of the new caries lesions were filled, and two-thirds were accordingly not filled.

The number of new DFS was not significantly correlated with any of the examined variables alone. However, when the number of missing teeth over the 4 years between 88 and 92 years was considered together with the number of new DFS, and the subjects were dichotomized into two groups with i) ≤ two new DMFS and ii) ≥ three new DMFS, a significantly higher proportion of subjects using cardiovascular agents and/or psychoactive drugs was found in the group with ≥ three new DMFS than in the group with ≤ two new DMFS ($P < 0.05$) (Table 7). The total number of risk values was significantly higher in the group with a high number of new DMFS than in the group with few DMFS ($P < 0.05$).

Discussion

In the present study very frail persons were under-represented. This could have led to an overestimation of the number of teeth and an underestimation of the frequency of caries (32). However, the analyses of the non-response in both age groups showed similar results, which implies that missing data from non-participating subjects might have had less impact on group differences than on the prevalence data.

A comparison between the two age groups showed that the saliva flow was within the normal range for most subjects and on a group basis did not differ significantly between the ages of 88 and 92 years independent of gender. This observation supports previous studies in the same age cohort, in which the subjects were followed up between the ages of 70 and 82 years without any decline in stimulated saliva flow (33).

In the 24 persons who were followed up longitudinally and re-examined at the age of 92 years, new caries was found in 17 persons. The increment was dominated by root caries, with an incidence rate of 67%. This level is somewhat lower than the 78% incidence rate over 36 months reported for independent elderly persons in Iowa (4) but higher than that reported by Locker (10). MacEntee et al. (7) reported a 71% coronal and root caries incidence over 1 year in the disabled elderly and 59% in independent elderly subjects, whereas Joshi et al. (9) reported a 38% root caries incidence per year in healthy community-dwelling adults more than 70 years. Comparisons of caries increment in different populations measured over different time intervals involve some uncertainty. To transform the caries increment into annual increment implies a stable caries development over time, which is not certainly at hand. In the present study it was not possible to judge whether new fillings had replaced previous fillings, and accordingly, recurrent caries might

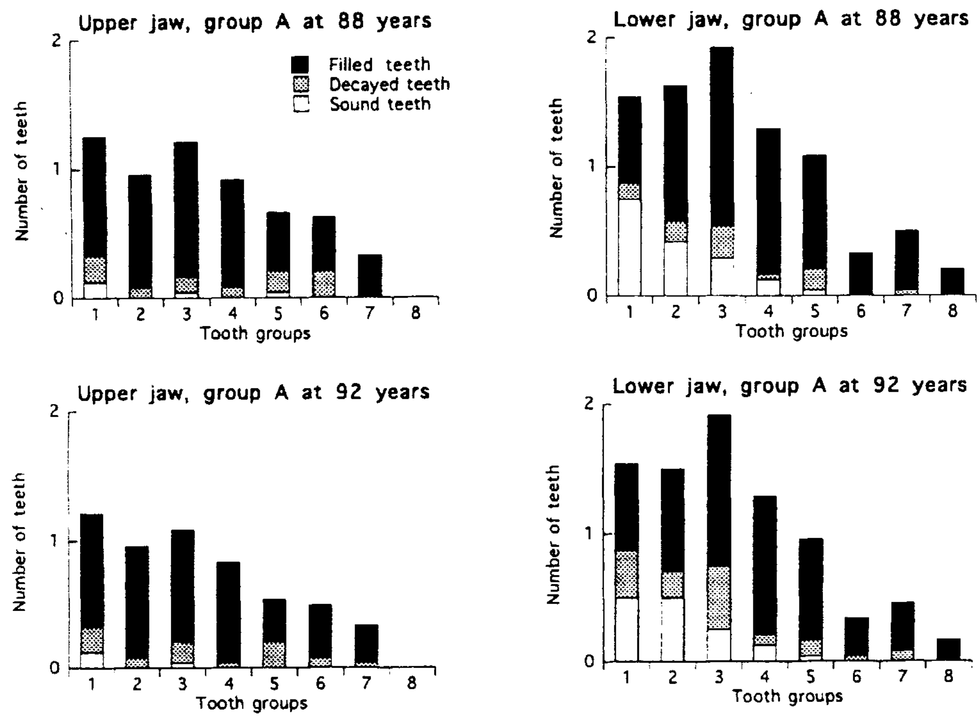

Fig. 4. Distribution of sound, decayed, and filled teeth in upper and lower jaw at the ages of 88 and 92 years in the 24 re-examined subjects (group A).

have been underestimated. Furthermore, missing teeth were not included in the calculations. With reservations for this, the coronal caries attack rate in the present study was similar to that reported in other studies (4, 6, 7, 11), whereas the root caries attack rate was higher than in other studies of adults and elderly people (4, 7, 9). The higher root caries attack rate indicates that a higher percentage of the surfaces at risk, due to gingival recession, became carious in the present study. Thus, the intensity of root caries development seems to increase in persons of very high age. Most of both coronal and root caries increment occurred on previously sound surfaces, which is consistent with observations in other studies (4, 9) and supports the opinion that caries is a life-long disease.

The cross-sectional studies showed that among other studied variables plaque score, DSr%, and number of lactobacilli in saliva increased significantly between 88 and 92 years. It could be expected that the marked deterioration in oral hygiene was due to impaired functional ability. However, the two variables measuring functional capacity, the ADL scale and the cognitive index, could not fully explain the differences in oral hygiene score between the two age groups. The correlation between plaque score and the ADL scale at 92 years was significant when adjusted for gender, an observation that indicates that the functional capacity has an impact on the increase of plaque score. The cognitive index also points in this direction as the association between mental status and plaque score was

Table 6. Caries increment by type of caries and location on coronal* (CS) and root surfaces (RS) between 88 and 92 years of age in the 24 subjects who were re-examined at 92 years

	Mesial		Distal		Buccal		Lingual		All	
Increment type	CS	RS	CS	RS	CS	RS	CS	RS	CS	RS
Sound to Decay	5	12	4	9	3	13	3	7	15	41
Sound to Filled	1	7	3	7	5	8	1	8	10	30
Sound to Filled to Recurrent	0	0	0	1	0	1	0	0	0	2
Filled to Recurrent	3	1	3	1	0	11	0	1	6	14
Total no.	9	20	10	18	8	33	4	16	31	87

* No new caries was found on the occlusal surfaces.

Table 7. Number and distribution of risk values for different variables at the age of 92 years. The subjects are dichotomized into two groups: i) ≤ two new DMFS and ii) ≥ three new DMFS over the 4 years between 88 and 92 years

Variable (risk border values)	New DMFS ≤ 2; range, 0–2; *n* = 11	New DMFS ≥ 3; range, 4–29; *n* = 13
Plaque score (≥50%)	4	6
Lactobacilli (≥10^5 CFU/ml)	8	11
Mutans streptococci (≥10^6 CFU/ml)	7	11
Salivary secretion rate (<0.7 ml/min)	4	2
Final pH of buffer capacity (<4.5)	0	3
Salivary sugar clearance time (>15 min)	4	6
Use of cardiovascular agents and/or psychoactive drugs (yes/no)	4	12**
Total no. of risk values	31	51*
Remaining teeth (mean ± *s*)	13.8 ± 7.8	13.5 ± 7.3

* Significantly higher value than in the group with ≤ two new DMFS ($P < 0.05$).
** Significantly higher proportion of subjects than in the group with ≤ two new DMFS ($P < 0.01$).

significant at 88 and showed the same trend, although not significant, at 92 years.

The positive correlation between plaque score and root caries which was found at 92 years is consistent with findings in other studies (7, 9, 12, 13, 34, 35).

Increased levels of lactobacilli and mutans streptococci with age in the age groups of 55, 65, and 75 years have been reported (36). In the present study the proportion of subjects with high salivary counts of lactobacilli (>10^5 CFU/ml) and mutans streptococci (>10^6 CFU/ml) increased from already high levels to 77% and 72% between the ages of 88 and 92 years, respectively.

A positive correlation has been observed previously between coronal and root caries, on the one hand, and the levels of lactobacilli and mutans streptococci, on the other hand (35, 37). In our study, however, only root caries was significantly associated with the levels of lactobacilli and mutans streptococci. Possible reasons for the weak correlation between coronal caries and these cariogenic bacteria might be that most people had high counts of lactobacilli and mutans streptococci and that the prevalence of untreated coronal caries, especially at 92 years, was fairly low. Consequently, high counts of cariogenic bacteria was found also in many of those without coronal caries.

It is of interest that the correlation analyses between medication and the examined variables in the cross-sectional studies did not show any significance. Most of the subjects had a stimulated saliva flow >0.7 ml/min. The resting saliva, however, was not measured, and it could be expected that the cardiovascular agents and psychoactive drugs might have hyposalivatory side effects (38) and thereby influence the oral conditions. Moreover, medication is considered to have little value for prediction of root caries in high age groups (2, 7, 13), possibly because of the widespread use of medications. However, in the longitudinal study, when the number of missing teeth over the 4 years between 88 and 92 years were considered together with the number of new DFS, it was observed that a deteriorated dental status was commoner in those who used cardiovascular agents and/or psychoactive drugs than in those who did not. This observation might partly be explained by hyposalivatory side effects of diuretics and psychoactive drugs (38). On the other hand, the differences between the two groups may reflect the level of vitality and general health in the subjects. Moreover, some recent studies have reported associations between poor oral health and heart diseases (39–41). Furthermore, the oral sugar clearance is slower in elderly than in younger persons (21). A slow oral sugar clearance increases the pH drop in plaque more than a fast clearance (42–44). Therefore, the oral conditions in the old persons in the present study with a large amount of plaque are unfavorable and may contribute to increased caries risk. Further studies are, however, needed to clarify the relationship between oral conditions and root caries.

The fact that about two-thirds of the new caries lesions were untreated indicates that the demand for dental services is low in this very old population. This is further underlined by the significant correlations between untreated caries lesions and ADL scale and cognitive index which were observed with regard to root caries at 88 years and coronal caries at 92 years. Mental impairments have also been identified as a barrier to demand for care in a previous interview study (45). Other preferences and more serious personal problems may overshadow the need for dental treatment in this age group.

To conclude, this study showed that the proportion of untreated decayed root surfaces, plaque score, and the levels of lactobacilli increased significantly between the ages of 88 and 92 years. New caries was found in two-thirds of the longitudinally followed up subjects and was dominated by root caries. It was observed that a deteriorated dental status was commoner in those who used cardiovascular agents and/or psychoactive drugs than in those who did not. The significant association between functional capacity—represented by the ADL scale and the cognitive index—and untreated caries lesions indicates a low demand for dental care among the most disabled persons and hence a risk for further deteriorated dental health status. The findings point to a need for more integrated medical and dental care in the oldest old and for the development of targeted preventive regimens and ways to increase the availability of professional dental care for the disabled elderly.

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