## ORIGINAL ARTICLE

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# Oral bacteria and clinical variables in dependent individuals at a special facility\*

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Abstract: The oral health of dependent residents at special facilities has often been reported as being poor, but it is difficult to relate oral health to general health and define the need for oral health care. Microbiological analyses of the oral flora have been suggested as a suitable method for evaluating oral health in this group of patients. A study was performed at a nursing facility where 33 individuals participated. The aim was to describe their oral flora in relation to other health variables and to classify the residents on different risk levels. An oral examination of the residents was made at the facility, together with a 3-day food record and an oral microbiological analysis. The analysis classified the residents in different categories according to both acid-producing bacteria and the flora correlated with a reduction in general health. The categories were based on previous studies conducted at the Department of Microbiology (Faculty of Odontology in Göteborg). The present study revealed that the level for acid-producing bacteria was high in 12 individuals and the micriobial level according to decreased general health was high in seven individuals. A high level of acid-producing bacteria was related to functional impairment, which was in turn related to nutritional problems and help with oral hygiene. The microbial level according to the reduction in general health did not significantly correlate with other variables.

**Key words:** oral health care; dependent individuals; elderly; oral flora

# Introduction

In a previous study we tested a new education model for nursing staff personnel at special facilities (1). In addition to traditional oral health care education, some of the nursing staff members passed an additional dental auscultation period and served as oral care aides. Compared with a control group the nursing staff in the intervention group gave higher priority to the oral health care work. However, there were no significant improvements in the presence of plaque and gingivitis/stomatitis of the residents in the intervention group (2), as also experienced by Mojon *et al.* (3). In both these studies the residents were dependent of help with their daily living, including personal hygiene. The use of oral hygiene-related measures aimed for independent individuals may not be appropriate when the ability to manage oral hygiene is lost and large amounts of plaque are generally present. The results could be misleading. This presents a problem when interventions are evaluated. Further it is a problem in evaluating oral health status and oral treatment need in dependent individuals.

Analysis of the oral microbial flora and registration of variables according to food intake among the residents have been suggested as suitable methods for measuring oral health in dependent individuals (3). Under normal conditions, the composition of the oral micro-flora is balanced and oral pathogens are seldom present. Knowledge about the oral microbial status in dependent caretakers at special facilities is scarce.

The development of new caries cavities was a problem in about 35% of the dependent individuals in the intervention study performed by Mojon *et al.* (3). High numbers of acidic micro-organisms such as mutans streptococci and lactobacilli, constitute a risk of caries and root caries in particular (4). The frequency of sugar-containing food intakes is strongly positively associated with the frequency and number of acidic micro-organisms (5).

With impaired general health, opportunistic micro-organisms such as *Candida*, *Staphylococcus aureus*, enteric rods and enterococci are frequent (6, 7). Oral mucosal infections are also associated with the presence of a large number of one or more of these micro-organisms (8). In dependent individuals, who often experience poorer general health, mucosal infections present a major problem (9, 10).

The aim of the present pilot study was to describe and test whether different amounts/levels of oral micro-organisms in dependent individuals living at a special facility related to the residents' oral and general health and whether these amounts/ levels of micro-organisms could be described in terms of risk categorization.

## Study population and methodology

This study was approved by the Ethics Committee (Faculty of Medicine, Uppsala University). An advocate gave informed

consent when the residents themselves were not able to decide.

The study was integrated in the system for dependent caretakers in the new dental remuneration that became law in Sweden in 1999. In addition to the standard oral health check, a 3-day food record was kept and oral microbiological samples were taken.

#### Subjects

A special facility for dependent caretakers with three wards, each with 12 beds, was studied. Thirty-three individuals participated.

The facility offered care not only for elderly caretakers but also for younger adults, totally dependent individuals even if the greater part of the residents were elderly. The majority suffered from both physical and mental impairment even if the facility was not specially aimed for demented residents. The workload was seen as high.

The ward staff consisted of 22.75 nursing assistants and nursing aides and 2.5 registered nurses. If needed during the night, a mobile home care unit recruited a registered nurse.

#### Oral health check record

The oral health check followed a protocol that is practised in an area comprising four counties in central Sweden. It includes both a medical/nursing part and an odontology part. The medical/nursing part includes data related to major diagnoses, pharmacy treatment, functional impairments and nutritional difficulties. A registered nurse was responsible for the data in that part of the record.

The clinical oral health control included registration of teeth, degree of gingival inflammation, restorations and crowns/bridges/prostheses. Caries was registered as visible cavities for the naked eye. Mouth dryness was registered when the mucosa and tongue appeared dry and/or the dental mirror could not move firmly over the oral surfaces. When the oral mucosa and tongue were not normal, it was registered as a mucosal infection. The amount of plaque accumulation was registered in three levels and based on the results of clinical observations. The general oral health was judged in three levels. There was also a note stating whether or not the nursing staff provided the resident with oral hygiene help and whether there was any need for further oral/dental treatment. In that case, the record was used as a referral to a dental team. This was also the situation when the oral health control was incomplete due to the residents lacking ability to cooperate or other

circumstances. The clinical examination was made by a dental hygienist and took place in the residents' own rooms at the facility, using a dental mirror and flashlight.

## Food record

The food records were kept by the caregivers for each separate food and fluid intake and nutritional supplements the residents consumed during a period of three consecutive days. Frequency and meal composition but not the amount was registered. The food records were analysed by counting the number of times the residents had been given nutritional supplements, in addition to normal meals.

#### **Microbiological procedures**

Duplicate samples for microbial analysis were collected, 1–2 weeks apart, by a trained dental hygienist and the author (I.W.). For the result of the analysis a mean of the values of the two measurements for each individual was calculated.

From dentate individuals with  $\geq 10$  teeth samples were taken from supragingival plaque and from individuals with <10 teeth or non-dentate individuals, from the dorsum of the tongue. Supragingival plaque was collected with sterile toothpicks. The sites that were sampled and pooled were mesially on the upper-right first molar, distally on the upper-right first premolar, mesially on the lower-left first molar and distally on the lower-left first premolar, along the gingival margin. If these sites were not present, other sites in similar teeth areas were chosen. Then all four supragingival samples from each individual were transferred to a bottle containing 3.3 ml of transport medium VMGA III (11). The tongue sample was collected with a sterile cotton pellet. To standardize the sampling area, a plastic spatula with a circular hole, 15 mm in diameter, was placed on the dorsal part of the tongue. The cotton pellet was first swept along the margins of the hole and then back and forth over the inside of the hole. The cotton pellet was then placed in a bottle with 3.3 ml of transport medium VMGA III. The samples were processed within 24 h.

For microbial analysis the samples were dispersed by shaking the transport bottles on a Whirlimixer (KeboLab REAX 2000, V.W.R International Inc., Fagerstagaten, Sweden) for 10 s before dilution, from  $10^1$  to  $10^5$  in VMGA I (12). The agar plates were inoculated with 0.1 ml portions of samples. The supragingival plaque samples were analysed for total number of bacteria growing anaerobically, growth of mutans strepto-cocci, lactobacilli, *Prevotella intermedia*/*P. nigrescens* and *Fusobacterium nucleatum*. The sample from the tongue was analysed

for total number of bacteria growing anaerobically and for growth of *P. intermedia*/*P. nigrescens*, *F. nucleatum*, *Candida* spp., *S. aureus*, enteric rods and enterococci.

Plates with *Brucella* agar, with 50 ml  $l^{-1}$  defibrinated horse blood, 20 ml l<sup>-1</sup> haemolysed human blood and 0.5 mg l<sup>-1</sup> menadione, were incubated using the hydrogen combustion technique (11) at 36 °C for 5-7 days. Plates with Mitis-Salivarius-Bacitracin agar and Rogosa agar were incubated in an atmosphere of 90% CO2 and 10% N2 at 36 °C for 3-5 days. Plates with Sabouraud T agar, Staphylococcus agar, Drigalski agar and Enterococcus agar were incubated aerobically at 36 °C for 3-5 days. The detection limit was 20 colony-forming units (CFU) ml<sup>-1</sup>. If possible, the number of the different microorganisms in a sample was calculated from their number on a plate giving 30-300 colonies. The total number of bacteria growing anaerobically, the number of P. intermedia/P. nigrescens and F. nucleatum were calculated from their growth on Brucella agar plates. Prevotella intermedia/P. nigrescens was identified as black, indole-positive colonies showing dark-red fluorescence in long-wave (360) UV light. Fusobacterium nucleatum was identified as grey colonies with nacreous appearance of Gram-negative long and slender cells with tapering ends. Mutans streptococci were calculated from their growth on Mitis-Salivarius-Bacitracin agar and identified as small, mucoid and irregular colonies. Lactobacilli were calculated from their growth on Rogosa agar and identified as Gram-positive rods. Candida albicans was calculated from their growth on Sabouraud T agar plates and identified as lustreless and creamy whitish-pink or pink, colonies. Staphylococcus aureus was calculated from its growth on Staphylococcus agar plates. Colonies of S. aureus were distinguished from S. epidermidis by their ability to degrade DNA on DNA agar plates. Enterics were identified as large yellow or green colonies of Gram-negative rods on Drigalski agar and enterococci on Enterococcus agar plates as small brown colonies of Gram-positive cocci surrounded by a black zone. In doubtful cases, further identification was performed with API biochemical tests.

The agar plates were made at the laboratory with material from Oxoid Ltd (Basingstoke, Hampshire, UK) and Difco Laboratories, Becton, Dickinson and Company (Sparks, MD, USA).

### **Microbiological categorization**

The levels used in Tables 1 and 2 are based on the results from microbial analysis of the oral flora in subjects aged 38–69, with hyposalivation of different origins and their healthy controls (12). For bacteria associated with caries a large number of mutans streptococci got a higher point than a large number of

Table	1.	Group /	A – re	ated	to	risk	of	car	ies c	leve	lopmen	t
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Micro-organisms	≤0.1*	>0.1 to <1*	≥1
No growth = 0 Lactobacillus Mutans streptococci	1	2 3	3 5

Levels based on total points: low <3, medium 3 to <4, high  $\geq$ 4. \*% of total count of micro-organisms.

Table 2. Group  ${\bf B}$  – related to impaired general health and risk of mucosal infections

Micro-organisms	≤0.1*	>0.1 to <1*	≥1*
No growth $= 0$			
Candida albicans, less violating	1	2	4
Candida albicans, more violating	1	3	5
Enterococci, less violating	1	2	4
Enterococci, more violating	1	3	5
Enteric rods, less violating	1	2	4
Enteric rods, more violating	1	3	5
Staphylococcus aureus, less violating	1	2	4
Staphylococcus aureus, more violating	1	3	5

\*% of total count of micro-organisms.

lactobacilli (group A) (see Table 1). *Candida albicans, S. aureus,* enterococci or enteric rods were judged as bacteria associated with mucosal infection/impaired general health. We calculated with high points for *C. albicans* and *S. aureus* in group Ba and high points for enterococci and enteric rods in group Bb (see Table 2).

Other signs of disturbed microbiological flora considered were >5% of *F. nucleatum* and *Prevotella intermedia* and <20% of streptococci. A level of 8 log 10 for the total amount of bacteria was also regarded as a general marker.

### Statistical methods

To normalize the microbial data, the numbers were logarithmically transformed. Zero counts were treated as 1 CFU ml<sup>-1</sup>. For the analysis of possible associations between variables in the oral health check record, food record and microbial risk levels, gamma statistics were used. A value >0.500 was considered to have clinical relevance. The age of the residents was categorized as follows: <60, 61–70, 71–80, 81–90 and >90 years old. The correlation between residents' age and number of medicines was analysed using Spearman's correlation coefficient with a 5% level of significance.

## Results

A total of 33 residents participated in the study. There were 21 women and 12 men with a mean age of 79 years (range 32–100 years). Of these, 55% had only natural teeth and 25% had total prostheses in one or both jaws. One resident had a fixed implant bridge in the upper jaw. Five residents had mucosal infections and eight suffered from mouth dryness.

In terms of general health, all but one resident was reported to have functional impairments at varying degrees. Ten of them were not receiving help with oral hygiene.

Figure 1 shows the microbiological profile of the residents. Five individuals had high levels ( $\geq$ 1) of *C. albicans, S. aureus*, enterococci or enteric rods. Of these five individuals, two were totally functionally impaired and three were sitting in a wheel-chair. All five individuals had nutritional problems and received help with oral hygiene (see Table 3). In microbiological group A, four individuals were categorized at low level, five at medium level and 12 at high level. These individuals had >10 natural teeth and supragingival plaque samples were taken. In microbiological group B (Table 4) the individuals were placed according to how the microbiological profile was weighted.

All but three tube-fed residents had a normal diet. Besides the normal diet five residents were receiving nutritional supplements. All these residents were reported by the nursing staff to have nutritional problems.

When we looked for possible associations between microbial levels and other variables, statistically significant correlations were found for group A but not for group B, independent of how we weighted the microbiological profile in group Ba and group Bb. High-risk levels in group A correlated with severe functional impairments which in turn correlated with more natural teeth, assistance with oral hygiene, nutritional problems and nutritional supplements. Independent of the microbial categorization, there was a correlation between the number of medications and mucosal infections and oral hygiene/oral health. Seven residents had both poor oral hygiene and poor oral health, while three had both good oral hygiene and oral health. Twenty-two residents had acceptable oral hygiene and oral health. One resident had poor oral hygiene and acceptable oral health. Four residents were referred for further dental care in addition to the oral health care check and related oral health care activities at the facility. Only one of them had poor oral health (see Fig. 2).

## Discussion

The present study was performed on a limited study material and it should be viewed as a pilot study. The results are not unexpected. Already among community-dwelling older people in Sweden associations have been found between functional



Fig 1. The oral microbiological profile among the 33 examined residents living at the special facility. The boxes describe minimal and maximal values, the medians and extreme values (outliers) > one quartile distance from the quartiles (Saliv, *Streptococcus salivarius*; Sang, *Streptococcus sanguis*; Mutans, Mutans streptococci; Sobrin, *Streptococcus sobrinus*; Lakto, Laktobacilli; Strept, Streptococci; Candi, *Candida albicans*; Coccer, Enterococci; Entbakt, Enteric rods; Staff, *Staphylococcus aureus*; Fus, *Fusobacterium nucleatum*; Prevo, *Prevotella intermedia*/*Prevotella nigrescens*).

status of the individual and aspects of oral health (13). Oral health in dependent individuals at special facilities has been reported to be poor (3). Somewhat surprising is that the majority of our residents had acceptable oral health, a nondefined expression. This is reflected by the fact that only one of the residents with poor oral health was referred for dental

Table 3. Description of the five individuals with high levels ( $\geq$ 1) of *Candida albicans*, *Staphylococcus aureus*, enterococci or enteric rods

Individuals	1	2	3	4	5
Nutrition problems Nutrition supplements Total functionally impaired Help with oral hygiene	Yes Yes Yes Yes	Yes Yes No Yes	No No No No	No No No	Yes Yes Yes Yes

Table 4. The distribution of the 33 examined residents in risk group B according to how the microbiological profile was weighted

	Group Ba (low level)	Group Ba (medium level)	Group Ba (high level)	Tota
Group Bb (low level) Group Bb (medium level)	16 2	2 5	0 1	18 8
Group Bb (high level)	0	3	4	7
Total	18	10	5	33

Group Ba: *Candida albicans* and *Staphylococcus aureus* are weighted as more violating than enterococci or enteric rods. Group Bb: Enterococci and enteric rods are weighted as more violating than *Candida albicans* and *Staphylococcus aureus*. Levels based on total points: low <4, medium 4 to  $\leq$ 6, high >6.

care. The decision not to refer could be due to short life expectancy for the residents, lack of cooperation or, in some cases, the opportunity to solve the problems at the facility by a dental hygienist supporting the nursing staff.

The oral health record or screening journal that was used in this study is a non-validated instrument that has been developed and used in public dental service. The value of such an instrument can be discussed, but in clinical practice we often have to use easily manageable measurements, especially for dependent and sometimes not cooperative patients. The problem with the present instrument is a wide range of subjective judgements such as the ranking of mouth dryness. Mouth dryness among elderly patients has been reported to be a considerable problem (14), sometimes related to malnutrition and poor general health (15). We found that a minor part of the residents were suffering from mouth dryness and that there was no significant association between mouth dryness and other variables. This can be an effect of using an instrument that is not sufficiently precise. Instead we did notice that the number of medications and mucosal infections related to each other, that can be due to mouth dryness. Mouth dryness has been shown to increase with the number of medications (16) and relate to oral mucosal infections (8).

Institutionalized elderly people have been found to have a higher level of *Candida* and *S. aureus* compared with non-institutionalized elderly individuals and to run a higher risk of opportunistic infections (17). This group of patients often requires help with daily oral hygiene as a result of physical and/or mental impairments (3). Oral health care in nursing is a low priority (18), a result of several interacting factors. It has been shown that poor oral health is a risk indicator for



Fig 2. The correlations between microbiological group A and oral health record variables/food record. Statistical level for gamma is shown by the different arrows.

all-cause mortality (19, 20), but it has not been established whether poor oral health creates poor general health or vice versa. Functional impairment has been said to influence the amount of oral bacteria as well as the nutritional state and physical status (21).

Compromised oral functional status has been found to be associated with nutritional deficiency in very old people (22, 23). In this study, we were not able to find any significant correlation between dental status and nutrition or between oral microbiological group B and nutrition. This could be due to the small study material and time. The developments of impaired oral and general health are processes over time. We are now following the residents with repeated measurements and we would therefore like to analyse future results before drawing any further conclusions.

There was a correlation between nutrition and functional impairment that correlated with levels in group A. This correlation is probably easier to recognize. Acid formation in the oral cavity starts immediately with the intake of fermentable carbohydrates. The study results must also be considered in relation to the way nutrition was measured. We did not register serum albumin or other blood markers related to nutritional status. The nursing staff at the studied facility was responsible for the cooking procedures, after advice from a nutritional consultant, with the exception of lunch that was obtained from another facility in the neighbourhood. The meal order could not be compared between the three wards at the studied facility. When the study started, we were planning to measure the residents' body mass index (BMI) but we soon realized that height was never registered and weight only in extreme cases. Nutritional measurements were therefore limited to registering whether or not nutritional supplements were given and whether nutritional problems were obvious. This was further complicated by the fact that nutritional supplements were to be given only when prescribed by a doctor. In reality, they appeared to be given more by chance when the staff noticed that a resident had a poor appetite or perhaps difficulty feeding him/herself due to functional impairment.

It is difficult to evaluate the level of oral health and oral health care for dependent caretakers (3). All the nursing staff cannot be expected to give high priority to oral health care (1), nor can all caretakers (2). There can be days or periods during which oral health care is of high quality and others when it is minimal or even lacking. In these circumstances, it is irrelevant to measure plaque amount. Gingival bleeding provides better information, but pocket depths are often unable to evaluate due to many residents' non-ability to cooperate. Similar circumstances exist in the caries situation. When the tooth restoration rate is high, a single cavity can spoil an entire bridge construction and DMF rates will be misleading. There is also a wide variation in dental status in this patient group, from removable prostheses to natural teeth and fixed implant bridges. The correlation between functional impairment and natural teeth is important to consider. It points to the present and future need of oral health care work among dependent caretakers.

The need for methods to evaluate the total oral health situation over time has changed the direction of focus to instruments that are not related to the dental status concerning dependent individuals. For example, the development of an open caries cavity is a relatively slow process that can be arrested with the help of strict oral hygiene procedures, with or without antimicrobial products added (24). Daily oral hygiene also minimizes systemic consequences of oral infections in elderly people (24). This makes oral microbial analyses an attractive alternative to the measurements of clinical variables when intervention studies are evaluated and for planning of further treatment in dependent caretakers. If such a method is also able to relate to general health status, it would perhaps be easier to introduce in a general care environment as an instrument to guide necessary and individual oral health care activities. The project is ongoing and the microbial categorizations will be further evaluated to decide how the different micro-organisms ought to be weighted in relation to oral and general health.

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