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Periodontal care attendance in Denmark in 2012–2016 – a nationwide register-based study

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ABSTRACT

Objective: Planning and evaluation of oral healthcare systems rely on monitoring of care patterns. Monitoring periodontal care patterns provide information on the burden and occurrence of periodontitis in the population and on the direct financial cost. The aims of the study were to describe patterns in periodontal care among dental care attenders that might incite subsequent investigation and revised treatment guidelines. Secondly, to estimate the direct societal costs of periodontal care.

Material and methods: A retrospective register-based study utilising data from the Danish Public Health Insurance which includes all dental care attenders in 2012–2016, three years before and one year after a national risk-based recall maintenance program was rolled out in Denmark.

Results: The 2.7 million yearly dental care attenders corresponded to ~60% of the eligible population and in the range of 20–24% received periodontal care. Total expenditure for periodontal care in Denmark increased by 13% from 2012 to 2016, from €78 to €88 million. The proportion of total healthcare funding spent on periodontal care was 0.61% in 2016.

Conclusions: Patients with periodontitis have large out-of-pocket yearly expenses for periodontal care. Despite small changes in periodontal clinical practice that may indicate improved targeting of patients in need of periodontal care, challenges of reaching non-attenders and non-adherence to care are unsolved. More research into outcomes from periodontal therapy in daily practice, seen from both normative and patient perspectives, would help establish knowledge of the efficiency of existing periodontal care systems and help identify barriers and facilitators for attending care in Denmark.

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Introduction

Periodontitis is a highly prevalent, multifactorial inflammatory disease induced by biofilms colonising the tooth surfaces along the gingival crevice [1]. Periodontitis manifests as the breakdown of the tooth-supporting tissues and if left untreated, periodontitis may cause tooth loss, although it is preventable and treatable in the majority of cases [1].

Periodontitis has been reported to affect 46% of the adult population (30 years or older) in the US [2]. However, a systematic review from 2014 including 72 studies and data from 291,170 individuals \geq 15 years of age from 37 countries estimated that the global prevalence of severe periodontitis in 2010 amounted to 10.8% (95% CI: 10.1–11.6%) with no difference observed between males and females, making periodontitis the sixth most prevalent disease worldwide [3]. In the Global Burden of Disease 2015 study, based on data from 195 countries, the prevalence of severe periodontitis was estimated at 7.4% [4]. The prevalence of milder forms of periodontitis has been found to be as high as 50% [5].

Direct treatment costs of periodontitis worldwide are estimated at \$54 billion and a further \$25 billion in indirect costs [6]. Additionally, periodontitis contributes significantly to the cost of dental diseases because teeth lost to periodontitis are expensive to replace. The total cost of dental diseases globally, in 2015, was an estimated \$544.41 billion, with \$356.80 billion being direct costs, and \$187.61 billion indirect costs [7]. Interestingly, lower overall medical treatment costs and fewer hospitalisations have been reported for patients receiving regular periodontal therapy [8,9]. Periodontitis is associated with a number of systemic diseases, including type 2 diabetes, cardiovascular disease, spontaneous preterm birth, rheumatoid arthritis, and lately also neurodegenerative diseases including Alzheimer's and Parkinson's diseases [10]. However, most epidemiological reports in this area of research are from selected patient populations, e.g. health insurance policyholders and other restricted cohorts, with limited results from nationwide studies being available only from Korea and Taiwan [11–14].

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Key findings: Periodontal care delivery patterns call for the need for further investigations into outcomes from periodontal treatment for clarification of whether periodontal care needs are met.

In Denmark, periodontology is not recognised as a specialty of its own and periodontal care is governed within the same legislation and guidelines as general oral healthcare. In 2013 the Danish Health Authority published new oral healthcare guidelines [15], revised in 2016 [16]. The guidelines formed the basis for the labour agreement between the Danish Public Health Insurance and the Danish Dental Association describing the periodontal care services and related indications and conditions for use and were put into effect April 1, 2015 [17]. The guidelines had a stated goal of inciting needs-based dental care and efficient resource allocation, for instance by aiming to provide more care for patients with active periodontitis and those at moderate/high risk, as well as to reduce the number of resources spent on patients in low or no risk for future periodontitis [15,16].

Public health insurance dental services (periodontal care services, dental examinations, bitewing radiographs, a preventive care service covering a broad range of preventive measures, composite fillings, endodontic care services, tooth extractions) are registered and administered in a database by the Danish Health Data Authority, however, diagnoses, treatment outcomes and certain dental services (prosthodontics, radiographic examinations and local anaesthesia) are not covered by the re-imbursment scheme and are therefore not registered. Still available data allow for a unique opportunity to monitor periodontal care patterns among all dental care attenders in Denmark

Receiving periodontal care services in Denmark always includes subgingival scaling, and requires a diagnosis of periodontitis either localised or generalised. Consequently, patients with periodontitis will be subjected to subgingival scaling except for patients, who actively decline periodontal treatment [16]. As such, receiving periodontal care services appears to be a reasonable proxy for the prevalence of periodontitis among adult attenders of dental care in Denmark. Furthermore, following periodontal surgery, positive treatment outcomes would expectedly lead to changes in periodontal care service patterns in ways of the less frequent need of periodontal care, assuming that any positive effects of the periodontal surgery can be identified through multiple competing factors unadjusted for. These are examples of patterns in periodontal care worth studying closer to give insights into the burden and occurrence of periodontitis among dental care attenders and to further provide data on the direct society financed burden of periodontal care services. Indirect financial burdens from undiagnosed and untreated periodontitis are outside the scope of this study. Furthermore, pre- and post-April 2015 labour agreement [17] differences in periodontal care patterns may be indicative of effects of the legislative changes.

The aims of the study were twofold: Firstly, to identify and describe expected and potentially irregular patterns in periodontal care among all adult dental care attenders in Denmark during 2012–2016 that would point to the need for further investigation and revised treatment guidelines. Secondly, to estimate the direct societal costs of periodontal care.

Material and methods

Study design

The present study was register-based and utilised data from the Public Danish Health Insurance, which included all dental care attenders between 2012 and 2016 in Denmark, three years before and one year after the 2015 rollout of a national risk-based recall maintenance program. The presentations of the distribution of periodontal treatment procedures are of a descriptive nature.

Data source

Data were obtained from the Danish Health Insurance Register. Information on age, gender, residential municipalities of the dental care attenders were obtained together with data on all periodontal dental procedures within the dental care system in the period 2012–2016. Data from private dental hygienist practitioners (code 49) are registered and handled separately from data from dentists and dental hygienists, who are employed in private practice owned by dentists (code 50). Information on the number of services delivered by private dental hygienists shown in the results section was obtained via the Danish Health Data Authority in September 2020. In the present study, data were derived exclusively from authorised dentists (code 50).

Periodontal care service variables

Periodontal care services such as periodontal examinations, diagnostics and treatment, including scaling, preventive care, periodontal surgical care and follow-up care are covered under the treatment codes 1420, 1425, 1430, 1431, 1440, 1452, 1454. After the labour agreement change in 2015, codes 1420, 1430, and 1452/4 were collapsed into a new code 1415 and all codes are described in the labour agreement [17] based on guidelines from the Danish Health Authority [16].

For identification of patients with periodontitis, we set up the criteria that if a patient had received periodontal treatment in the form of at least one of the subgingival scaling procedures (codes 1425 and 1431, both pre- and post the 2015 labour agreement change) that would encompass periodontitis. The variable 'subgingival scaling service' therefore covers the treatment codes 1425, entailing subgingival scaling at the patient level (one service per visit per patient) and the code 1431, entailing subgingival instrumentation at the tooth level (one service maximum per affected tooth per visit), sometimes referred to as 'periodontal treatment' in the following for the sake of convenience, for instance as seen in [Table 1](#). The term 'periodontal care services' refers to when either one or all six (2012–2014) and four (2016) types of periodontal care services are included in the variable used.

Periodontal surgery was also studied separately. Periodontal surgery (treatment code 1440, pre- and post labour agreement change) comprises gingivectomy, open flap surgery, and guided tissue regeneration (GTR) surgery.

Table 1. Dental attendance, periodontal care attendance, and periodontal care expenditure per patient during 2012–2016.

Year	Description	Number of Danish persons aged 18+	Total popu. % (CI95%)	Total n. of attenders. % (CI95%)	Mean age	Total number of dental care services	Dental care services per user	Total number of periodontal services	Periodontal care services per periodontal patient	Periodontal expenditure/periodontal patient*year(Euro)
2012	Population	4,390,173	100	–	48.6	–	–	–	–	–
	Total number of attenders	2,756,157	62.78 (62.73; 62.83)	100	50.18 (50.16; 50.20)	13,811,465	5.0	–	–	–
	Persons having received periodontal treatment	559,416	12.74 (12.71; 12.77)	20.30 (20.25; 20.34)	58.33 (58.29; 58.37)	–	–	1,624,316	2.9	137.5
2013	Population	4,425,183	100	–	48.7	–	–	–	–	–
	Total number of attenders	2,732,002	61.74 (61.69; 61.78)	100	50.91 (50.89; 50.93)	12,236,137	4.5	–	–	–
	Persons having received periodontal treatment	602,463	13.61 (13.58; 13.65)	22.05 (22.00; 22.10)	60.01 (59.99; 60.03)	–	–	1,817,600	3.0	145.9
2014	Population	4,465,283	100	–	48.8	–	–	–	–	–
	Total number of attenders	2,703,518	60.55 (60.50; 60.59)	100	50.91 (50.88; 50.93)	12,299,662	4.5	–	–	–
	Persons having received periodontal treatment	636,527	14.26 (14.22; 14.29)	23.54 (23.49; 23.59)	59.35 (59.31; 59.38)	–	–	2,004,241	3.1	149.7
2015	Population	4,489,821	100	–	48.9	–	–	–	–	–
	Total number of attenders	2,680,248	59.70 (59.65; 59.74)	100	51.27 (51.25; 51.29)	16,060,010	6.0	–	–	–
	Persons having received periodontal treatment	634,057	14.11 (14.07; 14.14)	23.63 (23.58; 23.68)	60.13 (60.09; 60.16)	–	–	1,988,854	3.1	–
2016	Population	4,556,030	100	–	48.9	–	–	–	–	–
	Total number of attenders	2,745,317	60.26 (60.21; 60.30)	100	51.40 (51.38; 51.42)	17,705,198	6.4	–	–	–
	Persons having received periodontal treatment	607,490	13.33 (13.30; 13.36)	22.13 (22.08; 22.18)	61.00 (60.96; 61.03)	–	–	1,956,623	3.2	145.2

*Periodontal treatment short for at least one subgingival periodontal service.

Since there are no available measures of periodontitis activity, severity, and extent, we hypothesised that the number of subgingival scalings (code 1425, patient-level service) needed per year can work as a crude measure for the activity and extent of the disease. In accordance, code 1425 is applied as a crude measure for the effect of periodontal surgery in subsequent years. Less need for active periodontal care services in the years following periodontal surgery indicates a positive effect of the treatment. Therefore 'subgingival scaling' (code 1425) was constructed as a separate outcome measure when exploring whether periodontal patients having received periodontal surgery have different subsequent patterns of subgingival scaling.

Participants

All individuals, who attended dental care under the reimbursement scheme at any time during 2012–2016 were included. Each individual was identified based on their personal social security number provided to all Danish citizens and individuals living in Denmark. Periodontitis patients were defined as recipients of periodontal care services as described in the section about variable constructions. At least one probing pocket depth (PPD) of ≥ 5 mm with bleeding on probing (BoP) is a clinical prerequisite for any periodontal care services with subsidisation by the Danish Public Health Insurance.

Cost estimations and outcomes

Three cost outcomes were used for the description of periodontal care services. Firstly, the patient out-of-pocket expense, which covers the fee for the periodontal care service paid by the patient. Secondly, the public health insurance expense for periodontal care services and thirdly, the combination of the two, total expenditure, available at the service level for all periodontal care services and measured on a yearly basis [17]. Patient and public periodontal care services expenses are based on the official fee charts from the Danish Public Health Insurance except for patient expenses for periodontal surgery because the price setting is free and no central registration of prices is available. In order to take periodontal surgery expenses into account, an estimated periodontal surgery fee was imputed in secondary calculations of periodontal care expenditure. A survey of fees sampled from two selected dental clinics gave an average fee of €520. Several dental clinics did not respond to fee inquiries and periodontal surgery fees were often not available from dental clinic webpages and are not part of the public price comparison engine at "www.sundhed.dk". When fees were available at websites, often it was unclear exactly what periodontal surgery entailed with regard to the type of periodontal surgery and the number of teeth/area included. The relevant guidelines describe the surgical treatment service to include 1–6 teeth, so if more teeth are involved several services can be charged for.

Statistical analyses

A descriptive-analytical approach was used for exploring periodontal care delivery patterns. Stratification by age was done to explore whether the expected increase in periodontal care need by age was reflected in the delivery pattern. The severity of periodontitis was illustrated by categorising the number of all types of periodontal care services received within a year into three groups (1–4, 5–9, and 10+ periodontal care services) stratified by age. Exploration of whether there were signs of lack of adherence to periodontal follow-up care, patients, who received at least one subgingival scaling service in 2012, were tracked for the four consecutive years plotting the proportion, who continued to receive at least one of any periodontal care service. Five-year changes to total periodontal care expenditure compared to five-year changes to total health care expenditure were done to illustrate and form the basis for a discussion on health political prioritisation of periodontal care within the overall health care system, including estimates of out-of-pocket expenses for the most severely affected periodontitis patients. Finally, unadjusted comparisons were made of periodontal patients who did and did not receive periodontal surgery in 2012 and their receipt of subgingival scaling during two consecutive years in order to explore, whether signs of different patterns might indicate effects of periodontal surgery. Differences were tested using Pearson's Chi-squared test, with $p = .05$ set as the significance level, using IBM SPSS Statistics version 27.

Ethics

Personal social security numbers are unique and were encrypted before transmission to the investigators. Data were handled in accordance with the permissions from the Danish Data Protection Agency with references: 2015-41-4167 and SUND-2016-82.

The study was conducted in accordance with the Helsinki declaration. Confirmation was obtained by e-mail from the regional ethical committee that formal application for permission was unnecessary; the study is considered a quality assurance study of activities already taking place within the health care system.

Results

Study population characteristics

In the period January 1, 2012 to December 31, 2016, 13,617,242 visits were registered in the private practice-based Danish dental care system for adults. A total of 72,189,602 dental care services were delivered over the five-year period. The total number of dental care services provided by private dental hygienist practitioners in the period 2012 to 2016, not accounted for in the present study, was 350,042; equivalent to 0.5% of the total number of dental services. Hence 99.5% of delivered dental care services are included in this study.

Dental care attenders were in the age range of 18 to 107 years. Overall dental attendance rates dropped from 63%

to 60% from 2012 to 2016 (Table 1). In the period 2012–2014 an increased proportion of dental care attenders received periodontal services (20.3–23.5%) (Table 1). Following the April 2015 change to the dental care labour agreement [17], a smaller proportion of dental care attenders received periodontal services in 2016 (22.1%) compared to the preceding years.

The proportion of dental care attenders who received at least one subgingival scaling service, (stratified according to age within 2012 and 2016) is shown in Figure 1. The proportion of dental care attenders, who received at least one subgingival scaling service, increased with age until attenders reached the age of 70–74 years, meanwhile, a decrease was seen among persons >74 years. For the 18–40 year-olds, the proportion of female dental care attenders who received at least one subgingival scaling service was in the range of 0.06–0.07; meanwhile, the corresponding proportion for male patients was in the range of 0.08–0.10. The vast majority of patients in all age groups received in the range of one to four periodontal care services (all types of periodontal care services) per year in 2016 as shown in Figure 2. The frequency of periodontal care services was highest for the 50–69-year-olds, where 26% received five to nine periodontal services. Approximately, one percent of periodontitis patients had 10 or more periodontal care services per year.

Discontinuation of periodontal care

Among the dental care attenders, who received at least one subgingival scaling service in 2012 ($n = 559,416$), 27% did not receive periodontal follow-up care the following year (Figure 3). During a five-year period (2012–2016) 59% of the dental care attenders, who initially had periodontal care stopped receiving it later (Figure 3).

Periodontal care expenditure

In the period 2012–2014, the total expenditure for periodontal care increased from approximately €78 million in 2012 to €88 million in 2013 and €95 million in 2014, equal to a 22% increase. The inter-relationship between public reimbursement 40.1% and patient (out-of-pocket) expense of 59.9% was unchanged during this period. The observed changes during 2012–2014 are unrelated to inflation and sole expressions of changes in treatment provision patterns, as all expenses are based on 2012 tariffs. In 2016, the total periodontal care expenditure had dropped from €95 million to approximately €88 million, based on April 2015 tariffs, hence compared to 2012 (€78 million), expenditure in 2016 had increased ~13%. Inflation during this period explains approximately 2.2% of the increase, according to the official consumer price index from Statistics Denmark. The 2016 public reimbursements and patient (out-of-pocket) expense interrelationship of 40.2%/59.8%, represented a 0.1 percentage point change from 2012 to 2014. During 2012–2014, the proportion of dental care attenders who received periodontal treatment increased from 20.3% to 23.4%, the total number of periodontal treatments provided increased and the patient

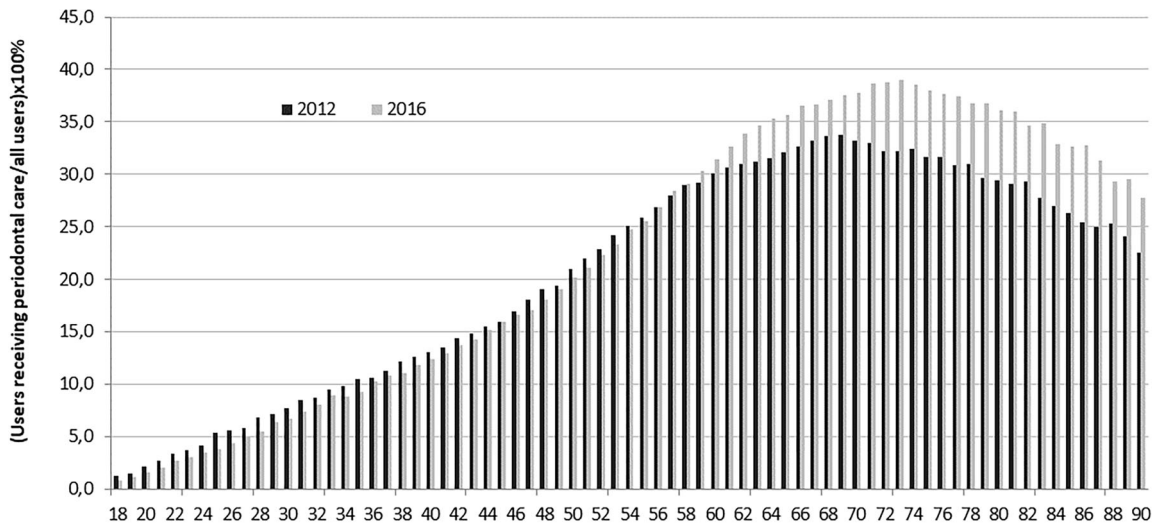


Figure 1. The proportion of dental care attenders, 18–90-years-old, having received at least one subgingival scaling service.

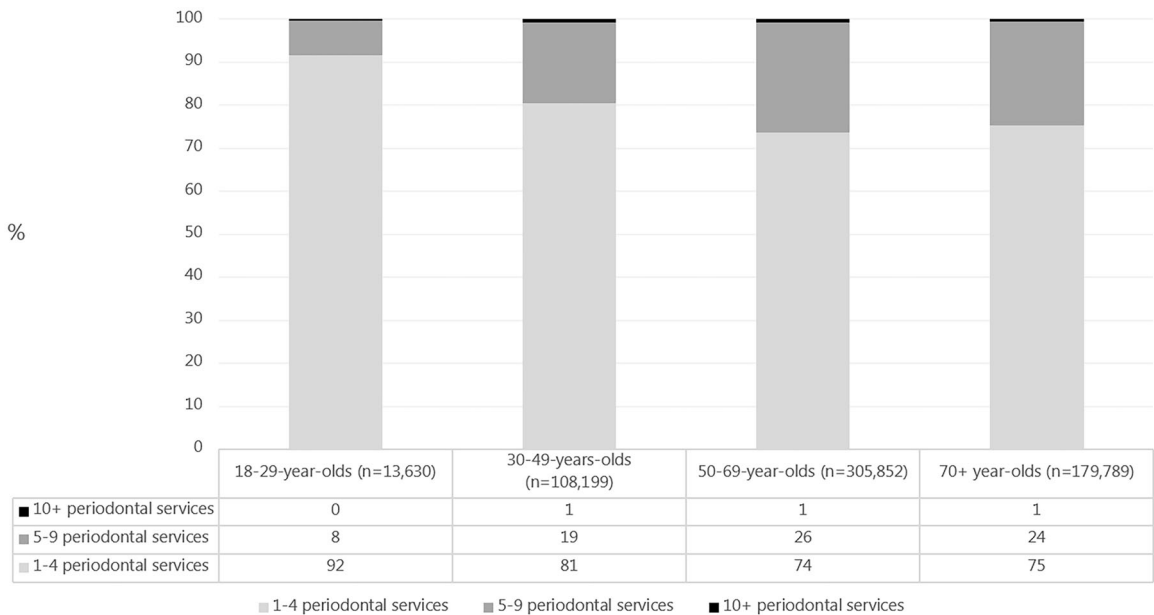


Figure 2. Distribution according to the total number of all types of periodontal care services within age-groups in the year 2016.

(out-of-pocket) expense increased 9% per patient (3%/year). With calculations based on 2012 tariffs, inflation explains zero percent of this change. In 2016 the proportion of patients who received periodontal treatment had dropped to 22.1%, the total number of periodontal treatment procedures provided had dropped slightly compared to 2014 and the periodontal care expenditure (out-of-pocket and public expense combined) per patient also dropped to €145.2/patient per year. This amount is 6% higher than the 2012 figure with inflation accounting for ~1.9% points of the change.

From 2012 to 2016 total health care expenditure in Denmark increased by ~9%, according to the official consumer price index from Statistics Denmark, with ~2.2 percentage points explained by inflation. Correspondingly, the proportion of health care funds used for periodontal treatment increased from 0.58% in 2012 to 0.61% 2016, equal to an absolute increase of 0.03% percentage points (primary

axis in Figure 4) seen in the context of the 9% increase in total health care expenditure (secondary axis in Figure 4).

Periodontal surgery

During 2012–2016 the number of periodontal surgery services provided per year was in the range of 5,000–10,000. Periodontal surgery constitutes a decreasing proportion of the total number of periodontal services provided, going from 0.58% in 2012 to 0.46% in 2013, and 0.40% in 2014, and finally 0.28% in 2016. With the patient expense for periodontal surgery set at €520, the average patient expense for dental care attenders receiving periodontal treatment in 2016 ($n = 607,470$) was ~€81/year. For the 4,247 patients (0.7% of dental care attenders receiving periodontal treatment) with 10 or more periodontal treatments procedures/

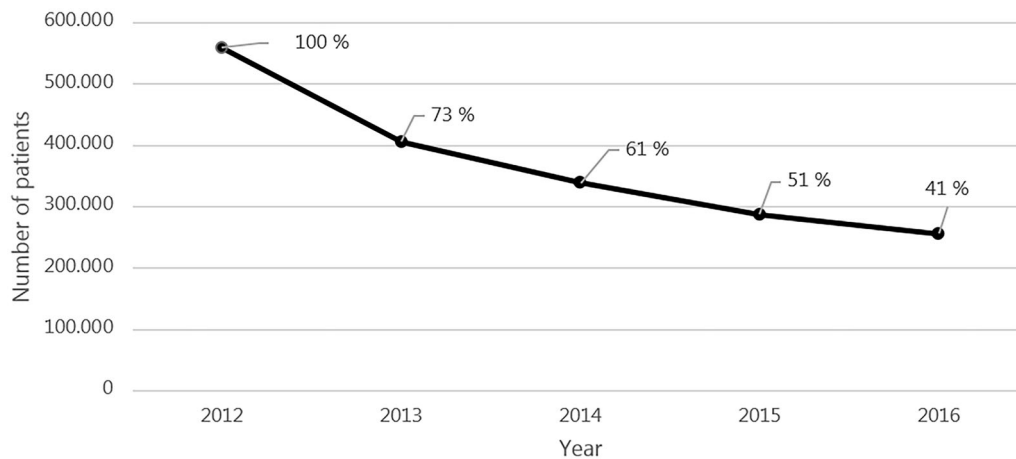


Figure 3. Periodontal care attrition rate.

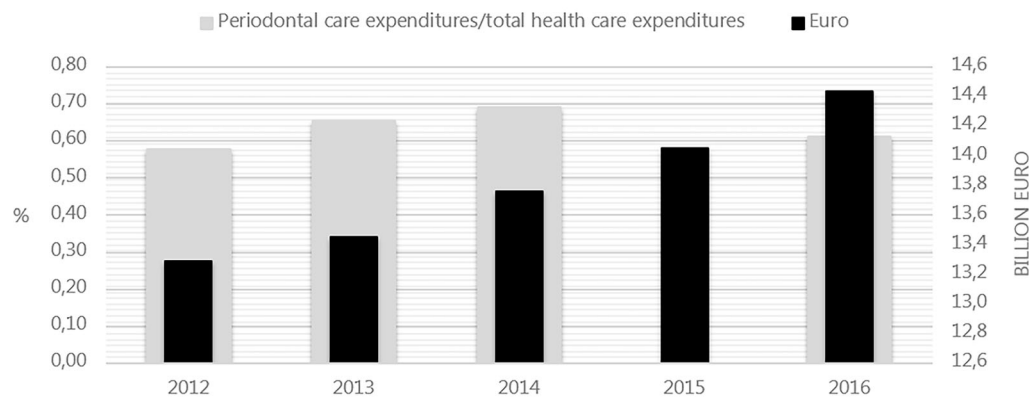


Figure 4. Total public health care expenses and proportion used on periodontal care.

year (Figure 2) the mean expense equals $\sim\text{€}300/\text{year}$ (SD $\text{€}228$).

Dental care attenders, who received periodontal surgery in 2012 ($n=8,351$), had a mean number of 1.3 subgingival scaling services (tooth level) in 2012 which dropped to 0.9 in both the two consecutive years corresponding to 32% fewer tooth level subgingival scaling services (not shown in any figures).

In comparison, dental care attenders, who did not receive periodontal surgery in 2012, but had at least one subgingival scaling service ($n=350,263$), had a mean number of 1.8 tooth level subgingival scaling services in 2012, which dropped to 1.2 and 1.1 in 2013 and 2014 respectively, corresponding 31% and 37% fewer tooth level subgingival instrumentation services.

Of the 8,351 patients, who received periodontal surgery in 2012, 63% of them received zero subgingival scalings services (patient-level) (Figure 5). Two years following periodontal surgery, the proportion of these patients that received 2 or '3 or more' subgingival scaling services (patient-level) increased statistically significantly compared to the reference year 2012 (Figure 5). Furthermore, of the initial 8,351 attenders who received periodontal surgery in 2012, 13% in 2013 and 16% in 2014 did not receive any dental care and hence were included in the calculations as having received zero subgingival instrumentation services.

Discussion

In the present study, we have for the first time analysed periodontal treatment patterns over several years among dental care attenders in Denmark. We found that 20–24% of dental care attenders during 2012–2016 received periodontal treatment (subgingival scaling service) within a year. The prevalence of periodontitis, in a strict epidemiological sense, cannot be revealed from the present data, since some patients may have declined periodontal examination or treatment and since approximately 40% of the Danish population, each year had no dental care registrations (Table 1). Furthermore, dental care users are not representative of the general population. However, since non-attenders on average have poorer oral health [18] and a higher incidence of attachment loss [19] compared to regular attenders, it is plausible that the prevalence of periodontitis in the general population is higher than among dental care attenders (20–24%), as revealed in the present study. A previous study of 1,115 Danes found that among 35–44-year-olds, approximately 20% had at least one site with a clinical attachment loss (CAL) of 4–5 mm [20]. Among the 65–74-year-olds, approximately 50% had their highest CAL score of 4–5 mm and approximately 15% had at least one site with maximum 6–8 mm CAL [20]. Obviously, the case definitions complicate the comparison of results. However, the present results seem

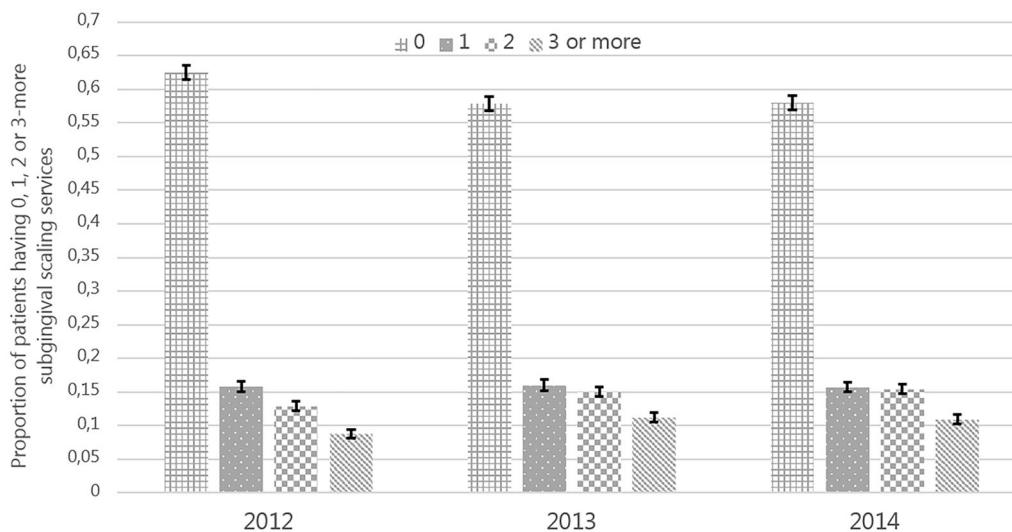


Figure 5. The proportion of patients who received patient-level subgingival scaling services (0–3 or more/year) in the years 2012–2014. Among patients who had periodontal surgery in 2012 ($n = 8,351$).

to correspond well with the previous Danish outcomes, although they evaluated the mean CAL instead of the clinical indication for periodontal treatment.

The unchanged total number of periodontal care services provided to a smaller fraction of patients with periodontitis after the implementation of the labour agreement in April 2015 [17], may indicate that the agreement had the intended effect of dental care services to be based more on individual need and less on the previous “same for all”-paradigm. This finding is in accordance with a study by Gabel et al., who found that legislative changes resulted in changes in care provision, but not always in a predictive way [21]. It is important that stakeholders see guidelines as meaningful and value them since it will enhance intrinsic motivation for following the guidelines [22]. Whether the observed changes in clinical practice are lasting, will require more than one year of observation.

Among 70–90-year-olds in 2012, who were 74–94-year-olds in 2016, the proportion of patients receiving periodontal care services decreased with increasing age (Figure 1), which seems contra-intuitive. [23] Assuming that the periodontal care need of this group of elderly is not sufficiently met, underlying causal factors interact in complex ways, and relate to the patient, the oral health condition, characteristics of the treatment, the oral healthcare team, and the dental care system [24]. A study by Lester et al. describes how age among elderly people was a statistically significant independent explanatory variable for the time since the last reported dental visit [25]. Socially disadvantaged old-age pensioners may experience further reduced economic capabilities around the age of 70 and the observed periodontal care pattern may be an expression of aggravated underlying socio-economic inequalities in access to care [26]. On the other hand, the observed care pattern may also represent appropriate care for this age group due to the loss of the more complex severely affected teeth [23] or a reduced periodontal inflammatory response meaning they require less treatment. This was supported by the oral health study of the Danish Health Examination Survey (DANHES) 2007–2008,

where 14% of those aged 65–74 and 26% of people aged 75 years or more had less than 20 teeth [27]. Furthermore, the observed pattern may be an expression of positive selection within the group of elderly; where healthier elderly adhere to regular dental care in private practice, while the fragile co-morbid elderly are transferred to other sectors or even die as periodontitis increases mortality due to e.g. cardiovascular diseases [28,29]. Death or emigration explains 1.2% and 0.3% respectively of non-adherence per year in 2016 among all age groups [30,31]. An unknown number of patients are transferred to other sectors such as “Dental care for the elderly in care-homes” or “Dental care for institutionalized adults with mental or physical disabilities”, but probably cannot account for the drop in periodontal care for the elderly or for the yearly periodontal care attrition rate observed.

The observed declining proportions of patients receiving periodontal care services for above 70-year-olds and the periodontal care attrition rate may be indicative of the inability of the care system to support patient adherence to needed care.

The presumption that periodontal surgery would lead to different periodontal care patterns post-surgery compared to patients, who did not receive periodontal surgery cannot be supported or opposed by our findings. It was found that periodontal surgically treated patients, compared to non-surgically treated periodontal patients, had a lower mean number of tooth level subgingival scaling services both pre- and post-periodontal surgery. Furthermore, there was a statistically significantly larger proportion of surgically treated patients with two or ‘three or more’ subgingival scalings (patient-level) per year in the two following years compared to the reference year. These findings may be indicative of periodontal surgery is applied for the most severely affected periodontal patients explaining the lower need for tooth level subgingival scaling, perhaps due to fewer teeth present at baseline and at follow-up. Patients dropping out of follow-up care, either due to them being less seriously affected patients who may be more prone to non-adherence, or

successfully treated patients in need of less frequent periodontal care, were accounted for by setting them for zero subgingival scaling per year in the analyses. Despite this, larger proportions of surgical patients experienced increasing treatment needs after periodontal surgery, indicative of severe baseline disease level or poor outcomes of the surgical treatment, the last being more likely the more severe patients are affected at baseline. Therefore, it would be interesting to study closer the decisions lying behind the application and recommendation of periodontal surgery, as it can be concluded that periodontal surgery, surprisingly, is very rarely used despite its positive treatment outcomes in the hands of experts [32].

Some limitations apply to the present study. Except for the tooth level subgingival scaling service, periodontal care services are recorded at the patient level, and neither relate to the number of teeth present nor allow derivation of treatment outcomes at the tooth level. Causal factors behind the potentially irregular periodontal care pattern findings are not possible to identify due to the nature of data and design of the study. The reasons for less periodontal care among those above 70, the discontinuation of periodontal care, and seldom use of periodontal surgery may be perfectly sound. Furthermore, the characteristics of data cannot and should not be used for deeming whether provided care is appropriate or not. Variations in oral healthcare provision should reflect variations in underlying oral health and hence health care needs. The inability to adjust for underlying oral health status limits the inferences that can be drawn from the data. This underlines the need for more systematic use and central registration of the widespread electronic health record data on diagnoses and related treatments and outcomes. A fundamental limitation of using claims data is the lack of knowledge of how well claims data represent true disease prevalence. Validation by comparison of the data set with external data was not possible.

Periodontal care was provided for 20–24% of Danish dental care attenders in the period 2012 to 2016 and constitutes a proportionally greater financial burden for the one percent requiring the most care, with yearly mean expenses around €300. Furthermore, the average out-of-pocket expense for periodontal patients was shown to increase by an estimated 3%/year (2012–2016) which seems disproportional to the minimal absolute increase in the proportion of total health care funding being spent on periodontal care. Especially considering the 9% overall increase in health care expenditure, which suggests that periodontal care was given a lower priority during the five-year period. Such a down prioritisation seems inexpedient considering the demographic projections of the Danish population with increasing proportions of elderly citizens and increasing numbers of retained teeth, which unavoidably, will lead to a larger prevalence of periodontitis both at patient and tooth level. Direct and indirect health care expenditure for periodontal treatment is therefore likely to increase unless efficient periodontal treatment and oral health promotion are provided. For instance by better support of patients' ability and motivation for adherence to regular lifelong periodontal maintenance care, first of all,

because it is a well-documented and important part of successful periodontitis treatment, and furthermore, in a Norwegian study it has been shown to be cost-effective compared to irregular/no periodontal care with end-stage replacement of lost teeth due to periodontitis [33]. Adding to this, with increasing knowledge of associations between periodontitis and other systemic diseases and negative relations between dental care non-attendance and oral health-related quality of life, [34] it seems increasingly more in divergence with the principles of equal access to health care that patients with periodontitis are left with relatively large out-of-pocket yearly expenses for periodontal treatments and follow-up care. Interpretation of the irregular periodontal care patterns is ambiguous, calling for closer monitoring and investigation; for instance by expanding the existing monitoring system with the registration of diagnoses, related treatments, and outcome measures to enhance transparency and accountability of the dental care system [35].

Despite small changes in clinical practice that may indicate improved targeting of patients in need of periodontal care, challenges of reaching non-attenders and of non-adherence to care are unsolved. More research into patient experiences with periodontal therapy and into outcomes from periodontal care in daily practice, seen from both normative and patient perspectives, would help to establish knowledge of the effectiveness and efficiency of the existing periodontal care system and help identify barriers and facilitators for attending care.

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Disclosure statement

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