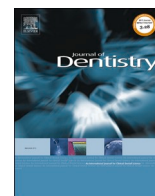


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# Age-related variation in volume and content of restorative private dental care for adults in Finland in 2012–2017: A nationwide register-based observation

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## ABSTRACT

**Objectives:** This study assessed age-related variation in the volume and content of restorative dental care performed by private dentists for adults in Finland in 2012–2017.

**Methods:** This retrospective register-based observational study utilized the Social Insurance database of private dental services in 2012 and 2017, including all patients. The data were aggregated into 5-year age groups for 20–89-year-olds; those aged 90+ formed one group. A patient was one who had received at least one treatment, and a restoration patient one who received at least one restoration (direct/indirect), excluding prosthetic crowns. Attendance rate was the proportion of the population treated. Volume of restorative treatment was the proportion of restoration patients among all patients using private dental services. Content of restorative treatment was described as the number of teeth receiving restoration and the size of restoration (number of surfaces restored). Correlation coefficient demonstrated associations between age groups and numbers of restorations.

**Results:** Rate of restoration patients was 64.8 % in 2012 and 61.1 % in 2017, the rate for individuals aged under 80 years in each calendar year being smaller than in previous years. Mean number of restorations received per patient was 1.59 in 2012 and 1.42 in 2017, increasing with age ( $r = 0.85$  in 2012;  $r = 0.95$  in 2017). Small restorations dominated; one to two surfaces were covered in 72.3 % and 75.5 % of restorations in 2012 and 2017, respectively.

**Conclusions:** Volume and content of restorative dental care for adults vary by age and have decreased slightly over time.

**Clinical significance:** Restorative treatments are a prominent part of dental care for adults. This paper sheds light on the entity of restorative dental care for adults visiting private dentists. Variation in restoration volume and content is shown according to patient's age group, and changes are assessed across six years.

## 1. Introduction

Restorative treatments form a large part of directly provided chair-side services in general dental practice. A questionnaire from Norway reports that “dentists spent on average 57.5 % of the working day placing restorations” [1]. In line, a report from Helsinki, Finland, based on chair-side data, showed the restorative treatment taking the huge part of the time per patient used [2]. However, nationwide studies about the realized volume and content of this important field of clinical dentistry are rare.

In the USA, the Medical Expenditure Panel Survey (MEPS) provides information on health care using large-scale surveys of families and individuals, and their medical providers, across the country. Based on the questionnaire inquiring about “types of dental procedures (services) that were received during a dental visit in the last year”, 20.3 % of patients aged 21–64 years and 20.0 % of those aged 65 years or over received at least one restorative treatment [3,4].

Another report from the USA measured the annual per capita use of dental services. The data were based on insurance claims for care provided by dentists in Michigan, and the report presents the numbers of

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treatments per patient for each type of service and according to patient's age [5]. The findings regarding restorative treatment (including crowns in fixed partial dentures) are presented as graphics per year and by age. For ages 20–90 years, the number of restorations per user of dental care seems to be some 0.8–0.9 in 2007, having been around 0.9–1.1 in 1992. Further details are illustrated by type of restoration as amalgam or composite restorations and as crowns, but no information is given by the size of restoration.

Decreasing trends in restorative treatment have been reported in Ireland based on Dental Treatment Benefit Scheme of treatments from 1997 to 2008 [6]. The authors had included crowns and endodontics in restorative treatment and reported a decrease from 1.7 to 1.2 in the mean number of restorations per patient, also by material and type of tooth (anterior/posterior). In Scotland, 4211 regularly attending patients were recruited by 23 general dental practitioners in 1991, and 40 % of the patients had received restoration and/or extraction in each year of the five years studied [7].

In Finland, a report of the public dental services (PDS) was based on cross-sectional data of actual treatments for over a million patients in 2009 [8]. The report shows 1457 restorative treatments per 1000 patients in the group of 18–64-year-olds and 1561 for patients aged 65 years and over, corresponding to 1.46 and 1.56 treatment items per patient in these groups, respectively. Based on the findings reported, it can be estimated that restorative treatment accounted for 25.8 % of all treatments in 18–64-year-olds and for 28.9 % in those aged 65 years and over, but no further details of restorations were provided.

This study assessed age-related variation in volume and content of restorative dental care performed by private dentists for adults in Finland in 2012–2017.

## 2. Materials and methods

In Finland, all inhabitants using private dental services are entitled to reimbursement of dental expenses, generally excluding prosthetics and orthodontics [9]. At each visit, dentists submit patient-based official records of the treatment to the Social Insurance Institute (SII) using codes [10] uniform to all service providers and maintained by the National Institute for Health and Welfare (THL). SII accumulates the treatments per patient per year and provides population data classified by patient's age and area of residence. From this database, aggregated information can be interactively selected by, for example, main treatment category and area of residence [11].

This retrospective register-based observational study utilized the SII database of private dental care services in 2012 and 2017. No sampling was done since this study included all cases and treatments in the years observed. Instead of individual-based micro-level data, aggregated macro-level data were used. Such data provide information constructed by combining information on the lower-level units (here: patients), forming the basis for the higher-level units (here: age groups) [12]. Since register-based data gathered for this study are aggregated, no information exists on patient's identity, with the observation unit being age group. Consequently, no ethics approval was required.

Attendance rate for private dental care was calculated as the proportion (%) of patients of the general population in the corresponding age groups. Volume of restorative treatment was defined as proportion (%) of restoration patients among all patients having used private dental care services. A patient was one who received at least one treatment, and a restoration patient one who received at least one restorative treatment, i.e. direct or indirect restorations. Prosthetic crowns and crowns in fixed partial dentures were excluded. Content of restorative treatment was described as numbers of teeth receiving a restoration and, according to the size of the restoration, generally defined by the number of surfaces restored. Numbers of teeth receiving a restoration were counted separately for direct and indirect restorations and by the size of the restoration. The THL codes for recording restorations are described in Table 1. Each restoration code includes removal of old restoration

**Table 1**

Description of codes for restorative treatment by tooth used in Finnish dental care.

Type and code	Description
Direct restorations	
• SFA00	Minor restoration or small repair
• SFA10	One-surface restoration
• SFA20	Two-surface restoration
• SFA30	Three-surface restoration
• SFA40	Four- or five-surface restoration
Indirect restorations	
• SFB10	One-surface indirect restoration
• SFB20	Two-surface indirect restoration
• SFB30	Three-surface restoration
• SFB40	Four- or five-surface restoration

material (when needed), cavity preparation, lining and base materials, finishing and polishing. In the analyses, the codes SFA00 and SFA10 were combined into one-surface restoration and in the graphics, the indirect restorations were combined with the direct ones. The aggregated data included no information on restored teeth by type of tooth.

The data covering a 6-year period comprise the numbers of all patients ( $n = 6\,252\,039$ ) and of restoration patients ( $n = 3\,938\,960$ ) by year from 2012 to 2017. In addition, the data include details of restorative care in 2012 and 2017 as numbers of restorations by their type and size. The data were originally aggregated by SII into 5-year age groups from 20 to 24 years to 99 + . For the analyses, we combined the oldest groups into one: those aged 90 years and over. Data of the population aged 20 years and over were extracted from vital statistics and were already aggregated into 5-year age groups from 20 to 24 years and onwards [13].

### 2.1. Statistical analysis

Statistical analyses were carried out on the aggregated data instead of individual-based micro-level data. The data cover all patients from age 20 years on who used private dental services and the presented percentages are population-based parameters. Comparisons were based on numbers of patients and treatments. Descriptive statistics for the variables of interest included actual numbers and proportions of restoration patients (attendance rate) by age group. Further, percentage distributions of numbers of restorations by type (direct or indirect) and size (number of surfaces) were calculated by age group. Changes from 2012 to 2017 were described as percentage increases or decreases in numbers of patients or restorations, and for comparison of proportions, as percentage points (pp), i.e. arithmetic differences between the percentages. Correlation coefficient demonstrated associations between patients' age and number of restorations received. Data handling, analyses and graphics were performed with Survo MM software (version 3.4.1; Survo Systems, Helsinki, Finland).

## 3. Results

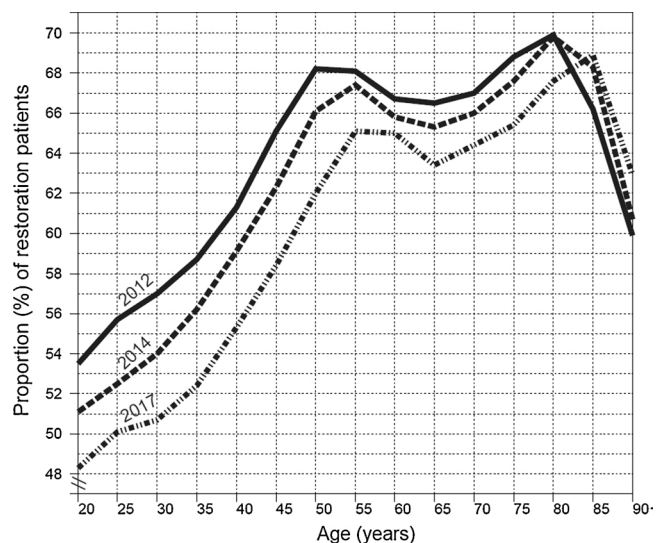
Over the six years, around one million patients per year visited a private dentist, the number of patients showing a 6.9 % decrease across the years (Table 2). Consequently, the attendance rate decreased from 25.1 % in 2012 to 22.8 % in 2017. The number of patients receiving at least one restorative treatment decreased by 12.2 % and their proportion of all patients by 3.7 pp, from 64.8 % in 2012 to 61.1 % in 2017.

Fig. 1 shows the proportions of restoration patients by age group for the years 2012, 2014 and 2017. In 2012, 54 % in the age group 20–24 years and 68 % in the age group 50–54 years received restorations. In 2017, the corresponding figures were 48 % and 62 %. The rates of restoration patients increased from the age group 20–24 years to 50–54 years by 14 pp in both years but were in 2017 for each age group 6 pp smaller than in 2012. From the age 55 years onwards, the values levelled

**Table 2**

Annual data and 6-year change in the Finnish population aged 20 years and over and in numbers of patients attending private dental care and receiving restorative treatment. Changes from 2012 to 2017 are shown as proportions (%) or percentage points (pp).

Basic findings	2012	2013	2014	2015	2016	2017	Change
Population x 1000	4215	4243	4269	4290	4315	4327	+2.7 %
Patients x 1000	1058	1075	1066	1065	1004	985	-6.9 %
Attendance rate, %	25.1	25.3	25.0	24.8	23.3	22.8	-2.3 pp
Restoration patients x 1000	686	688	676	665	624	602	-12.2 %
Restoration patients, %	64.8	64.0	63.3	62.5	62.1	61.1	-3.7 pp



**Fig. 1.** Patients who received restorative treatment as proportion (%) of all patients (n = 1.1-1.0 million/year) in private dental care in Finland according to the patient's age group and the year of treatment.

off and showed only minor fluctuations until a steep decrease occurred for the oldest age groups. The shapes for the years not shown were similar, all values being situated between the curves for 2012 and 2017.

In both 2012 and 2017, one- and two-surface restorations together comprised the majority of all restorations, while one out of four was a larger restoration and only a small proportion was a minor restoration or repair or an indirect restoration (Table 3). The number of all restorations

**Table 3**

Distributions (%) of restorations by type (direct/indirect) and size (no. of surfaces filled) in 2012 and 2017. The 6-year change is shown as percentage points (pp) or proportions (%).

Type and size of restoration	2012		2017		Change 2012-2017	
	n x 1000	%	n x 1000	%	n x 1000	%
Direct, minor or repair	50	3.0	56	4.0	+6	+1.0 pp
Direct, 1 surface	556	33.0	480	34.4	-76	+1.4 pp
Direct, 2 surfaces	610	36.3	518	37.1	-92	+0.8 pp
Direct, 3 surfaces	278	16.5	230	16.5	-48	±0.0 pp
Direct, 4-5 surfaces	146	8.7	98	7.1	-48	-1.6 pp
Indirect, all sizes	43	2.5	13	0.9	-30	-1.6 pp
All restorations	1682	100.0	1397	100.0	-286	-17.0%

Calculations are based on actual numbers of restorations, not on the rounded figures presented here.

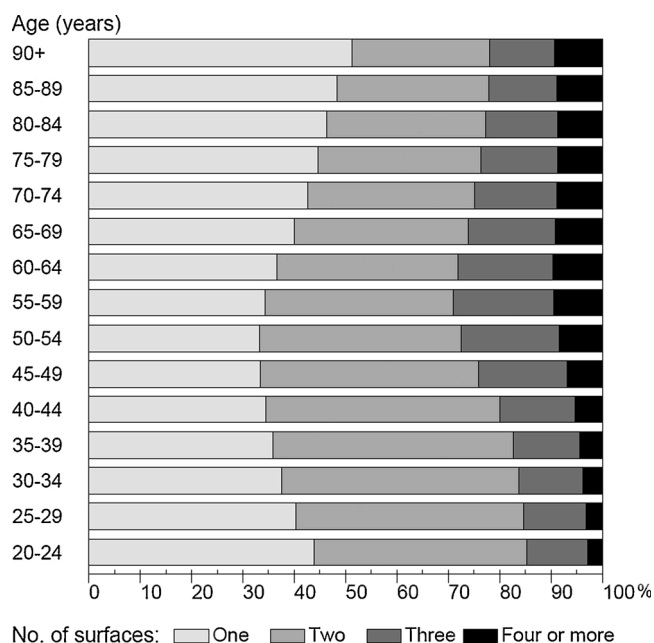
decreased by 17 % from 2012 to 2017, and the content according to the size of the restoration yielded greater proportions of one- and two-surface restorations.

In 2017, almost 1.4 million restorations were performed on patients in the target age groups. Fig. 2 shows distributions (%) of the restorations by size, within each age group. One-surface restorations accounted for 40-45 % of all restorations in patients aged 20-30 years and in patients aged 65-79 years, while the proportion was around 50 % in the oldest patients. In patients below 50 years of age, two-surface restorations comprised 41-47 % of all restorations, whereas three-surface restorations had the highest proportion (19 %) in patients aged 50-64 years. From the age of 55 years onwards, the proportion of four (+)-surface restorations increased to 10 % of all restorations. Simultaneously, the proportion of two- and three-surface restorations decreased and that of one-surface restorations increased.

The mean number of restorations per patient was 1.59 in 2012 and 1.42 in 2017, decreasing by 10.7 % (0.17 restoration). Table 4 shows the corresponding figures separately for each age group. Within age groups between 20 and 54 years, the mean numbers of restorations decreased by 14-18 %, whereas from the age 85 years onwards an increase occurred, particularly in patients aged 90 years and over. In both years, the mean number of restorations was greater for the older age groups, the correlation coefficients being 0.85 in 2012 and 0.95 in 2017.

**4. Discussion**

Restorative treatment comprises a prominent part of dental care, as seen also in this study, which covered all private treatments reimbursed by the SII, i.e. about half of adult dental care in Finland. Since the data cover all patients from age 20 years on who used private dental services and no sampling was done, the presented percentages are not sample-based estimates but population-based parameters. Our study showed that both the volume and content of restorative treatment were strongly age-related. In the age groups below 80 years, the proportions of restoration patients decreased across the calendar years, while the trend shapes remained similar from year to year. Based on a nationwide survey from Finland in 2000, 66 % of adults reported having received



**Fig. 2.** Distributions (%) of direct or indirect restorations (n = 1.4 million) by size (no. of surfaces filled) according to the patient's age group in private dental care in Finland in 2017. Minor repairs are combined with the one-surface category.

**Table 4**

Changes from 2012 to 2017 in mean numbers of restorations according to the patient's age group in private dental care in Finland.

Age (years)	2012		2017		Change per patient
	Patients n	Restorations per patient	Patients n	Restorations per patient	
20–24	30 448	1.44	24 011	1.19	–0.25
25–29	45 576	1.44	37 207	1.20	–0.24
30–34	59 475	1.37	46 716	1.12	–0.25
35–39	66 829	1.34	56 679	1.12	–0.22
40–44	73 333	1.38	63 885	1.18	–0.20
45–49	98 802	1.47	71 917	1.26	–0.21
50–54	121 850	1.57	98 492	1.35	–0.22
55–59	140 124	1.58	117 920	1.47	–0.11
60–64	139 620	1.56	129 572	1.48	–0.08
65–69	113 998	1.60	121 858	1.45	–0.15
70–74	71 791	1.66	98 569	1.53	–0.13
75–79	48 237	1.82	59 413	1.62	–0.20
80–84	30 612	1.97	35 003	1.77	–0.20
85–89	13 439	1.89	17 704	1.92	+0.03
90+	4 171	1.65	6 097	1.79	+0.14
<b>Total</b>	<b>1 058</b>	<b>1.59*</b>	<b>985</b>	<b>1.42*</b>	<b>-0.17</b>
	<b>305</b>		<b>043</b>		

\* Weighted mean.

restorative treatment during their most recent treatment course [14]. In our study, 64.8 % in 2012 and 61.1 % in 2017 received restorative treatment, confirming thus how minor the change in the volume of restorative treatment has been in the 2000s. Similar findings have been reported from the USA, where the corresponding decrease for adults (aged 21–64 years) was from 25.3 % in 1996 to 22.6 % in 2004 [15]. In Australia, the number of restorative services had remained virtually the same from 1983 to 2004 [16] and to 2010 [17].

The proportion of adult patients receiving restorative treatment in Finland was almost the same as reported in Ireland [18] and in Australia [17]. However, a surprising difference was found relative to the UK nationwide figures of 30–31 % for 25–64-year-olds in 2009 [19] and the USA figure of around 20 % in 2009 [3,4]. This may indicate that Finnish patients do not seek dental care until they perceive a need for it. This may also reflect a tendency for private dentists to place, replace or repair restorations slightly ahead of an actual need. However, neither previous publications nor our data were able to support this speculation.

A further suggestion may be that fewer patients in Finland accept fixed prosthodontic constructions as a treatment option, instead preferring traditional directly placed restorations. In line with this reasoning, the number of indirect restorations in our data was insignificant. In the USA data, the volume of prosthetics was around 16 % for those aged 21–64 years and 26 % for older patients [3,4]. No data, however, are available on the volume of prosthodontic treatment in private dental services in Finland.

In this study, the similarity across the years in the shapes illustrating the volume of restorative treatment for the age groups is a notable finding. Over the six years, the proportion of restoration patients among all patients decreased by 5–6 pp in each age group below 50 years and by 2–3 pp in older age groups. The decrease in the proportion of restoration patients may reflect improvements in patients' dental state. Unfortunately, the SII data include no information of dental health. Improvement in dental health of adults in Finland from 2000 to 2011 has, however, been documented as a clear increase in number of teeth remaining and number of sound teeth, whereas the need for restorative therapy (due to dentin caries or failed or fractured restorations) showed practically no change over the 11 years [20].

Little is known about the proportion of different sizes of restorations provided in dental care. In the UK, an administrative large database was analysed on patients who received at least one directly placed restoration during 1991–2001 [21,22]. Based on their reports of different types of direct restoration, it can be estimated that two-surface amalgams

accounted for 33 % and three-surface ones for 12 % of the total of half a million restorations, whereas composite restorations, not reported by size, accounted for 26 %. In the Netherlands, a Practice Based Study of general dental practices reported that out of about 360 000 restorations (mainly composite) placed from 1996 to 2011 in adults, 30 % were one-surface restorations and 40 % two-surface restorations, with only 4 % being four-surface restorations or larger [23].

Our study showed that the proportion of restorations, smaller than three surfaces, increased by 3.2 pp across the 6 years. This may be due to increased use of composites or more emphasis on minimal intervention dentistry or on repair of restorations, as previously noted [1,24,25]. The findings in this study confirm earlier reports from Finland about the proportions of different sizes of restorations provided for adults. Both a chair-side report on restorative treatment in the Helsinki PDS [26] and a questionnaire-based report of private dentists [27] have verified the majority being one- or two-surface restorations over larger ones.

The number of restorations received per patient decreased in all age groups below 85 years, indicating an improvement in adults' dental health. This finding confirms a recent report of a population survey in Finnish adults [20]. The mean numbers of restorations placed per patient is near those reported from Ireland for patients being employed or less well-off [18]. Unfortunately, our data cannot categorize patients according to their welfare status. In Michigan, USA, insurance-based data report the mean numbers of restorations placed per patient as being some 0.8–0.9 in 2007 [5]. In line with this, adults in Australia received 0.7–0.8 “fillings” in 2015 [28]. In both countries, the figures were notably smaller than in our study.

Comparison between countries is complicated since the reports use a wide set of indicators to describe the volume and content of restorative dental care. Therefore, standardized methods and measurements should be developed for this important field of clinical dentistry. The basic tools to describe the extent of restorative dental care could be proportion of patients receiving restorations and number of teeth restored per patient. In addition, definitions for restorations should be calibrated to distinguish between their sizes and materials and their types (direct or indirect restorations or fixed prosthodontic procedures). Furthermore, recording the reason for each restoration would facilitate assessment of the quality of restorative care.

Our study reports volumes of restorations in the private sector in Finland, but the volume of dental procedures cannot be used directly as a measure of good oral health. Regarding dental caries disease, placement of a restoration is pointless unless the disease is managed properly by oral self-care behavior and lifestyle changes [29]. Dental professionals should thus concentrate on maintaining patients' good oral health and avoid solving other health-related problems only by doing more and more treatment procedures, moving the dental profession towards value-based oral health care [30].

## 5. Conclusion

Volume and content of restorative dental care for adults vary by age and have decreased slightly over time.

## CRedit authorship contribution statement

**Miira M. Vehkalahti:** Conceptualization, Data curation, Methodology, Visualization, Writing - original draft. **Ulla Palotie:** Conceptualization, Methodology, Writing - review & editing. **Maria Valaste:** Conceptualization, Data curation, Methodology, Writing - review & editing.

## Declaration of Competing Interest

The authors report no declarations of interest.

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