

Dental Caries in European Adults and Senior Citizens 1996–2016: ORCA Saturday Afternoon Symposium in Greifswald, Germany – Part II

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Keywords

Dental caries · Epidemiology · Adult · Oral health survey · Prevalence · Incidence

Abstract

This review assesses the development of oral health habits and status in European adults (35–44 years old) and senior citizens (65–74 years old) over the period of 1996–2016. There seem to be good opportunities for improving oral health habits by brushing twice daily with fluoride toothpaste among adults, as only 33–85% reported doing so. Caries experience was extensive among adults ($\geq 92\%$). In adults of 23 countries, the mean DMFT score ranged from 6.6 to 17.6 (median 12.1). In senior citizens of 21 countries, the mean DMFT score varied from 14.7 to 25.5 (median 22.0). Repeated cross-sectional studies on caries trends in adults revealed a reduction of the DMFT value by 20%, referring to country-wide data. Among senior citizens, the corresponding reduction was 13%, with a shift in the DMFT components, i.e., with lower MT and higher FT scores. Edentulousness in the age group of 35- to 44-year-olds started disappearing in Europe from the year 2000, and had been markedly reduced in some countries during the last decade. However, the eradication of edentulousness among 65- to 74-year-olds has not

yet been reported. Further epidemiological surveys should apply caries diagnostic criteria that, besides representing our contemporary understanding of oral health care, allow comparisons with previous surveys using the WHO criteria. In conclusion, in the last two decades, a decline in caries was observed among European adults, and to a lesser extent among senior citizens. It is expected that the decline in caries will contribute to better oral health of individuals.

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Introduction

In 1995, the second Saturday Afternoon Symposium on Caries Epidemiology in Europe organized by the European Association for Caries Research took place in Noordwijkerhout, The Netherlands. In this symposium, the prevalence of dental caries in Europe (1990–1995) and the factors influencing caries decline were discussed. The data presented covered children, adolescents, and adults [Marthaler et al., 1996].

In 2014, the third Saturday Afternoon Symposium on Caries Epidemiology in Europe was held in Greifswald, Germany. The present review is based on oral health data on adults and senior citizens – age groups with hitherto

limited availability of information – collected for the symposium in Greifswald which were further completed with data from the related literature up to 2016.

The aims of this review may be described as follows: (1) to assess the oral health habits and status of adults and senior citizens across Europe; (2) to describe trends in dental caries among adults and senior citizens across Europe; and (3) to comment on the impact of oral health conditions on daily life performances and on the use of clinical caries diagnosis in epidemiological studies.

Subjects and Methods

In accordance with current recommendations, adults were represented by 35- to 44-year-olds and senior citizens by 65- to 74-year-olds. These age groups are reference groups recommended by the World Health Organization [WHO, 2013; WHO/CAPP, 2014].

The literature review was performed by means of MEDLINE via PubMed using various combinations of MeSH terms such as dental caries, epidemiology, adult, prevalence, incidence, oral health survey, Europe, caries trends, and DMFT index and complementing this approach by manual search, including reports of national oral health surveys, the WHO/CAPP database [WHO/CAPP, 2014], and *The Oral Health Atlas* [FDI World Dental Federation, 2009].

Included were cross-sectional or longitudinal studies of European populations in the age groups of 35–44 or 65–74 years which were representative at the national, regional, or municipal level. A total of 1,086 papers including clinical or nonclinical data were initially selected. Filtering the results in terms of the time frame from January 1, 1996, to December 31, 2014, reduced the number of papers to 558. A complementary search up to December 2016 was carried out, which produced 18 more articles.

Excluded were papers without abstracts as well as papers published in other languages than English, German, Dutch, French, Spanish, or Portuguese. In addition, papers reporting data at the national level were given priority over those reporting at the regional or municipal level, leading to 103 articles. In cases in which multiple papers from the same country were available, those with the more recent years of data collection were chosen. However, more than one paper per country could be selected to gather information about the various oral health indicators included in the present review. Finally, 62 publications were included.

In order to present the oral health habits and status of adults and senior citizens in Europe during the study period, data on oral health indicators that have traditionally been reported in epidemiological surveys were described as follows:

1. Oral health habits, defined as the percentage of adults reporting brushing their teeth twice daily together with the use of fluoride toothpaste
2. Dentition status according to the DMFT index (D = dentine caries lesion; M = missing due to caries; F = filled; T = tooth) equal to zero, defined as the percentage of adults without caries experience according to the WHO criteria for clinical caries diagnosis [WHO, 2013]

3. Dentition status according to coronal caries experience, defined as the mean DMFT index and its components in adult and senior citizens
4. Dentition status according to the prevalence of root caries, defined as the percentage of senior citizens with this condition
5. Edentulousness, defined as the percentage of edentulous adult and senior citizens

The data were retrieved from the selected studies and reports and recorded in an Excel file by the authors.

Results

Oral Health Habits

Table 1 summarizes studies on oral health habits regarding the frequency of tooth brushing and use of fluoride toothpaste among 35- to 44-year-old European adults. These data were essentially gathered by means of questionnaires from national and municipal surveys published during the period from 1998 to 2016. Between 33 and 81% of the adults in 9 European countries reported tooth brushing twice daily with fluoride toothpaste [Petersen et al., 2000; Skudutyte-Rysstad and Eriksen, 2007; Chadwick et al., 2009; Tseveenjav et al., 2010; Llodra Calvo, 2012; Schuller et al., 2014; Bottenberg et al., 2015; Calado et al., 2015; Jordan and Micheelis, 2016].

Adults without Caries Experience according to the WHO Criteria for Caries Diagnosis

The percentage of individuals at the age of 35–44 years with a DMFT index equal to zero in European countries is shown in Table 2. Low percentages ranging from 0 to 8% were registered for almost all countries included [Vrbic, 2000; Ivanković et al., 2003; Petersen et al., 2004; Hugoson and Koch, 2008; Zitzmann et al., 2008; Pashayev et al., 2011; Llodra Calvo, 2012; Mamai-Homata et al., 2012; Schuller et al., 2014; Bottenberg et al., 2015; Calado et al., 2015; Jordan and Micheelis, 2016], except for Turkey with 24.2% of adults presenting a DMFT index equal to zero [Gökalp et al., 2010]. These data indicate that the caries prevalence in European adults is high, reaching more than 90% of the population.

Mean Number of DMFT Scores in Adults

Twenty-three countries reported mean DMFT scores for the age group of 35- to 44-year-old adults. The mean DMFT scores varied largely between 6.6 and 17.6, as shown in Figure 1. The median of the reported DMFT scores for all countries was 12.1 [Skudutyte et al., 2000; Vrbic, 2000; Menghini et al., 2002; Ivanković et al., 2003; Tubert-Jeannin et al., 2004; Broukal et al., 2006; Madléna

Table 1. Percentage of 35- to 44-year-old European adults reporting tooth brushing twice daily or more with fluoridated toothpaste by country and year of data collection

Country (number of subjects)	Year	Twice daily tooth brushing	Study
Lithuania (<i>n</i> = 381)*	1997–1998	33.0%	Petersen et al., 2000
Finland (<i>n</i> = 2,148)*	2000	61.0%	Tseveenjav et al., 2010
Norway (<i>n</i> = 149)***	2003	81.0%	Skudutyte-Rysstad and Eriksen, 2007
England, Northern Ireland, and Wales (<i>n</i> = 6,469)*	2009	80.0%	Chadwick et al., 2009
Spain (<i>n</i> = 512)*	2010	73.3%	Llodra Calvo, 2012
The Netherlands (<i>n</i> = 332)***	2013	51.0%	Schuller et al., 2014
Belgium (<i>n</i> = 330)*	2012–2014	52.1%	Bottenberg et al., 2015
Portugal (<i>n</i> = 1,296)*	2012–2014	68.7%	Calado et al., 2015
Germany (<i>n</i> = 966)*	2014	80.3%	Jordan and Micheelis, 2016

In Norway, only 35-year-olds were included. In England, Northern Ireland, and Wales, the data refer to adults. * National oral health survey. *** Municipal oral health survey.

Table 2. Percentage of 35- to 44-year-old European adults without caries experience according to the WHO criteria for clinical caries diagnosis

Country	Year	DMFT = 0, %	Study
Bosnia and Herzegovina**	1997	2.0	Ivanković et al., 2003
Slovenia*	1997	0.0	Vrbic, 2000
Denmark*	2000	0.1	Petersen et al., 2004
Switzerland*	2002	0.4	Zitzmann et al., 2008
Sweden***	2003	8.0	Hugoson and Koch, 2008
Turkey*	2004–2005	24.2	Gökalp et al., 2010
Greece*	2005	0.2	Mamai-Homata et al., 2012
Azerbaijan*	2006	1.6	Pashayev et al., 2011
Spain**	2010	8.2	Llodra Calvo, 2012
The Netherlands***	2013	0.6	Schuller et al., 2014
Belgium*	2012–2014	4.6	Bottenberg et al., 2015
Portugal*	2012–2014	2.5	Calado et al., 2015
Germany*	2014	2.5	Jordan and Micheelis, 2016

In Sweden, the data refer to 30-year-olds. * National oral health survey. ** Regional oral health survey. *** Municipal oral health survey.

et al., 2008; Suominen-Taipale et al., 2008; Gökalp et al., 2010; Kuzmina et al., 2010; Holst and Schuller, 2011; Pashayev et al., 2011; Yudina et al., 2011; Damyanov et al., 2012; Llodra Calvo, 2012; Mamai-Homata et al., 2012; Kongstad et al., 2013; Bernabé and Sheiham, 2014; Schuller et al., 2014; Bottenberg et al., 2015; Calado et al., 2015; Jordan and Micheelis, 2016; Arrica et al., 2017].

Even though there was variation in the year of examination and the methodology applied, the WHO criteria for caries diagnosis were used in all surveys. Filled teeth (FT) represented the largest component of the mean

DMFT index in the majority of the countries. In contrast, the proportion of missing teeth (MT) was the largest component of the mean DMFT index in Azerbaijan [Pashayev et al., 2011], Belarus [Yudina et al., 2011], Hungary [Madléna et al., 2008], Russia [Kuzmina et al., 2010], and Turkey [Gökalp et al., 2010].

Mean Number of DMFT Scores in Senior Citizens

Figure 2 illustrates the mean DMFT scores among 65- to 74-year-old senior citizens, which varied largely between the 20 countries included, ranging from 14.6 to

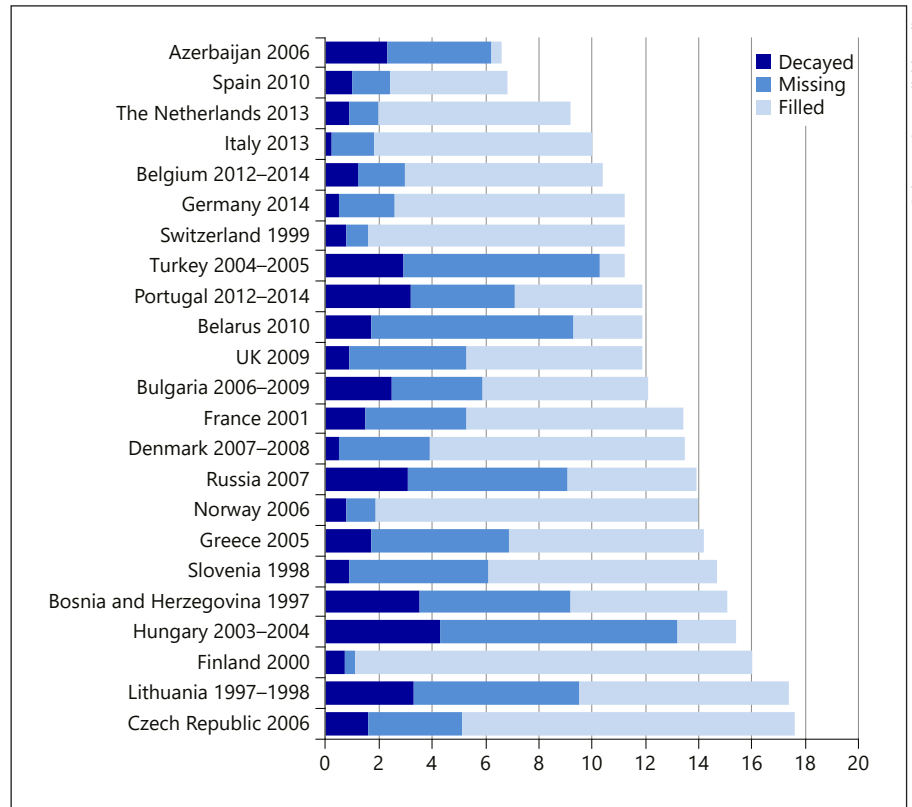


Fig. 1. Mean number of decayed, missing, and filled teeth (DMFT) in 35- to 44-year-old European adults.

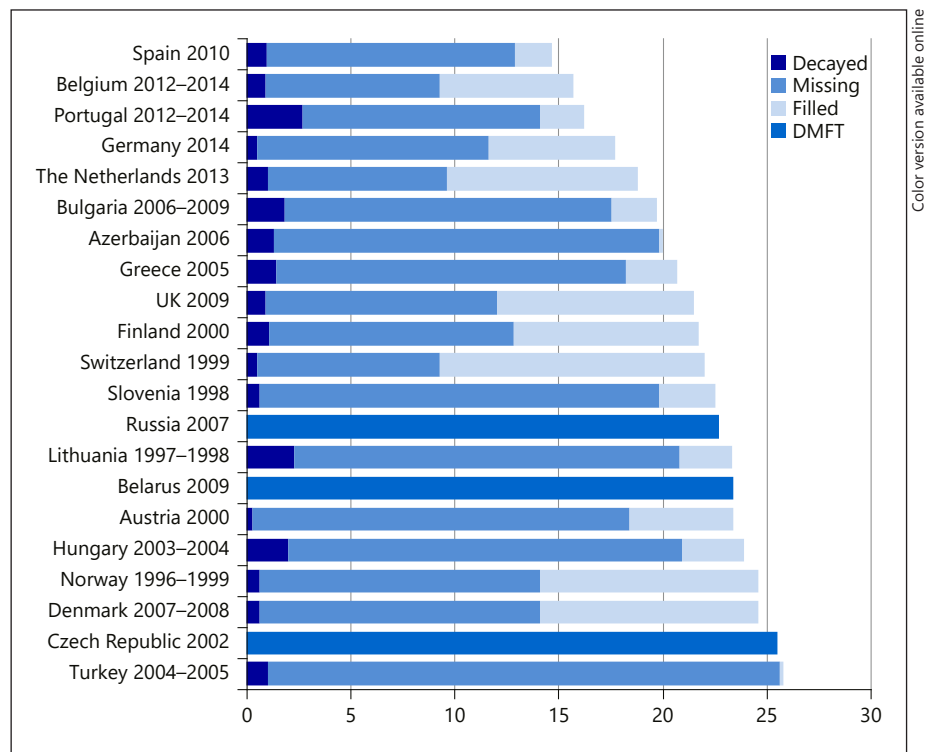


Fig. 2. Mean number of decayed, missing, and filled teeth (DMFT) in 65- to 74-year-old European senior citizens.

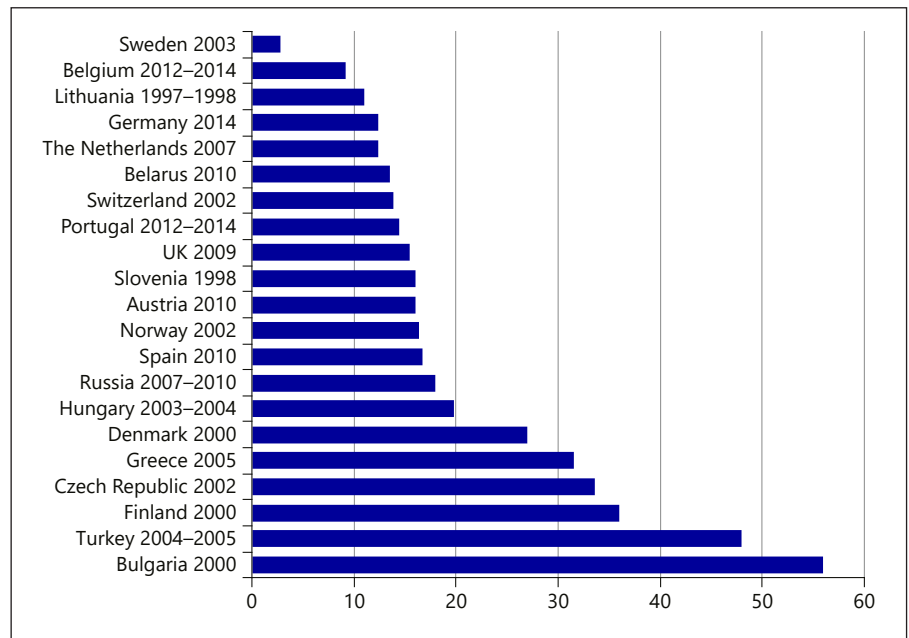


Fig. 3. Prevalence of edentulousness among 65- to 74-year-old senior citizens in Europe.

25.8 [Skudutyte et al., 2000; Vrbic, 2000; Menghini et al., 2002; Städtler et al., 2002; Broukal et al., 2003; Henriksen et al., 2004; Madléna et al., 2008; Suominen-Taipale et al., 2008; Gökalp et al., 2010; Janushevich et al., 2010; Pashayev et al., 2011; Tserakhava et al., 2011; Damyantov et al., 2012; Llodra Calvo, 2012; Mamai-Homata et al., 2012; Kongstad et al., 2013; Bernabé and Sheiham, 2014; Schuller et al., 2014; Bottenberg et al., 2015; Jordan and Micheelis, 2016]. For this age group, MT represented the largest component of the DMFT index for all countries, except for Switzerland and the Netherlands, where FT were the largest component [Menghini et al., 2002; Schuller et al., 2014]. The median of the DMFT scores of all countries was 22.0.

The prevalence of individuals with root caries in the senior age group turned out to be less frequently reported in the current literature, with the lowest value being 14.4% in Spain [Llodra Calvo, 2012], followed by 24.0% in Belgium [Bottenberg et al., 2015], 28% in Germany [Jordan and Micheelis, 2016], 28.4% in Turkey [Gökalp et al., 2010], and 38.3% in Greece [Mamai-Homata et al., 2012].

Edentulousness in Adults and Senior Citizens

From the year 2000 onwards, edentulousness has no longer been observed in the age group of 35- to 44-year-old adults in some European countries such as Denmark [Petersen et al., 2004], Sweden [Hugoson and Koch, 2008], England [Steele et al., 2011], and Spain [Llodra

Calvo, 2012]. Similarly, in other countries the prevalence of edentulousness was very low at 0.2–3%, suggesting that this condition is disappearing in Lithuania [Skudutyte et al., 2000], the Czech Republic [Broukal et al., 2006], Finland [Suominen-Taipale et al., 2008], Switzerland [Zitzmann et al., 2008], Norway [Holst, 2008], Hungary [Madléna et al., 2008], the Netherlands [Schuller, 2009], Turkey [Gökalp et al., 2010], Greece [Mamai-Homata et al., 2012], Belgium [Bottenberg et al., 2015], Portugal [Calado et al., 2015], and Germany [Jordan and Micheelis, 2016].

On the other hand, in the age group of 65- to 74-year-olds, the situation is quite dissimilar, according to the data reported from 21 countries (Fig. 3). The percentage of edentulous senior citizens varies considerably between the European countries. The lowest percentage was found in Sweden (2.8%) [Hugoson and Koch, 2008]. In contrast, in Greece, Finland, Turkey, and Bulgaria, more than one-third of the 65- to 74-year-old seniors are edentulous [Suominen-Taipale et al., 2008; Gökalp et al., 2010; Damyantov et al., 2012; Mamai-Homata et al., 2012].

Caries Trends in Cross-Sectional Studies in Adults and Senior Citizens

Repeated cross-sectional studies on caries trends in 35- to 44-year-old adults with a minimum interval of 4 years between the surveys were identified for 13 European countries, as shown in Figure 4. Most of the coun-

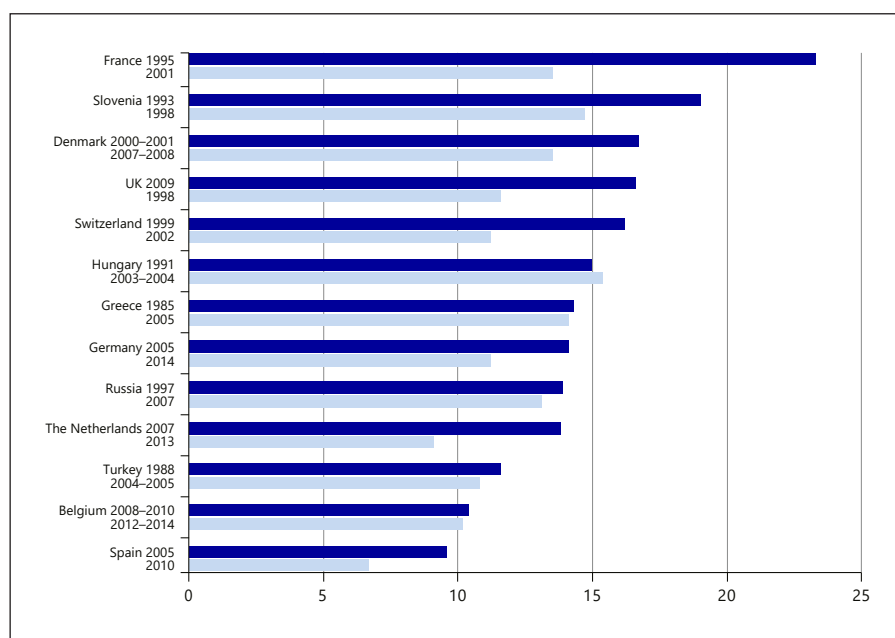


Fig. 4. Repeated cross-sectional studies on caries trends in Europe: mean decayed, missing, and filled teeth (DMFT) scores in 35- to 44-year-old adults.

tries showed a decline in caries, as observed in France [Bourgeois et al., 1998; Tubert-Jeannin et al., 2004], Slovenia [Vrbic, 2000], Spain [Llodra Calvo, 2012], Denmark [Krustrup and Petersen, 2007; Kongstad et al., 2013], Russia [Janushevich et al., 2010], the UK [Bernabé and Sheiham, 2014], Switzerland [Menghini et al., 2002], Germany [Schiffner et al., 2005; Jordan and Micheelis, 2016], Hungary [Madléná et al., 2008], Turkey [Gökalp et al., 2010], and the Netherlands [Schuller et al., 2014]. This decline was remarkable in Spain, with a mean DMFT score of 6.7 [Llodra Calvo, 2012]. However, a decline in caries was observed neither in Greece between 1985 and 2005 [Mamai-Homata et al., 2012] nor in Belgium between 2008 and 2012 [Bottenberg et al., 2015].

In addition, a study on caries trends in 35-year-old Norwegians showed a decline from 14.8 in 1993 to 11.7 in 2003 [Skudutyte-Rysstad and Eriksen, 2007]. Similarly, studies carried out in Gothenburg, Sweden, in 1993 and 2003 among age groups of 30- and 40-year-olds also showed a decline in mean DFT scores from 11.8 to 7.8 and from 16.3 to 11.5, respectively [Hugoson and Koch, 2008].

Publications from 12 countries provided information on caries trends in 65- to 74-year-old senior citizens. Figure 5 illustrates the decline in caries observed in Hungary [Madléná et al., 2008], Slovenia [Vrbic, 2000], Austria [Bourgeois et al., 1998; Städtler et al., 2002], Belarus [Bourgeois et al., 1998; Tserakhava et al., 2011], Germany [Schiffner et al., 2009; Jordan and Micheelis, 2016], and

the Netherlands [Schuller et al., 2014]. The decline was somewhat limited in the Czech Republic [Bourgeois et al., 1998; Broukal et al., 2002], Denmark [Krustrup and Petersen, 2002; Kongstad et al., 2013], Switzerland [Menghini et al., 2002], Spain [Llodra Calvo, 2012], and Belgium [Bottenberg et al., 2015], whereas a slight increase was reported for Russia [Janushevich et al., 2010].

Moreover, studies carried out in Gothenburg, Sweden, among age groups of 60- and 70-year-olds showed mean DFT scores of 14.1 and 15.8 (1993) and of 12.3 and 15.3 (2003), respectively [Hugoson and Koch, 2008].

Longitudinal Studies in Adults and Senior Citizens

In Slovenia, a longitudinal study on caries trends was carried out from 1987 to 1997 in 35- to 44-year-old adults ($n = 100$) and 65- to 74-year-old seniors ($n = 65$). The mean DMFT index in the adults increased from 17.3 ± 5.0 to 19.5 ± 5.0 , whereas in the seniors the increase was from 19.5 ± 4.3 to 24.6 ± 6.5 during the same period [Kovač-Kavčič and Skalerič, 2001]. However, a comparison between the surveys of 1987 and 1997 indicated a marked decline in the mean number of decayed teeth and a slight increase in the mean number of filled teeth in adults. The mean number of missing teeth increased between the surveys in the adults and senior citizens.

More recently, a longitudinal study carried out on Norwegian regular dental service attendees was published. The paper was based on data collected annually

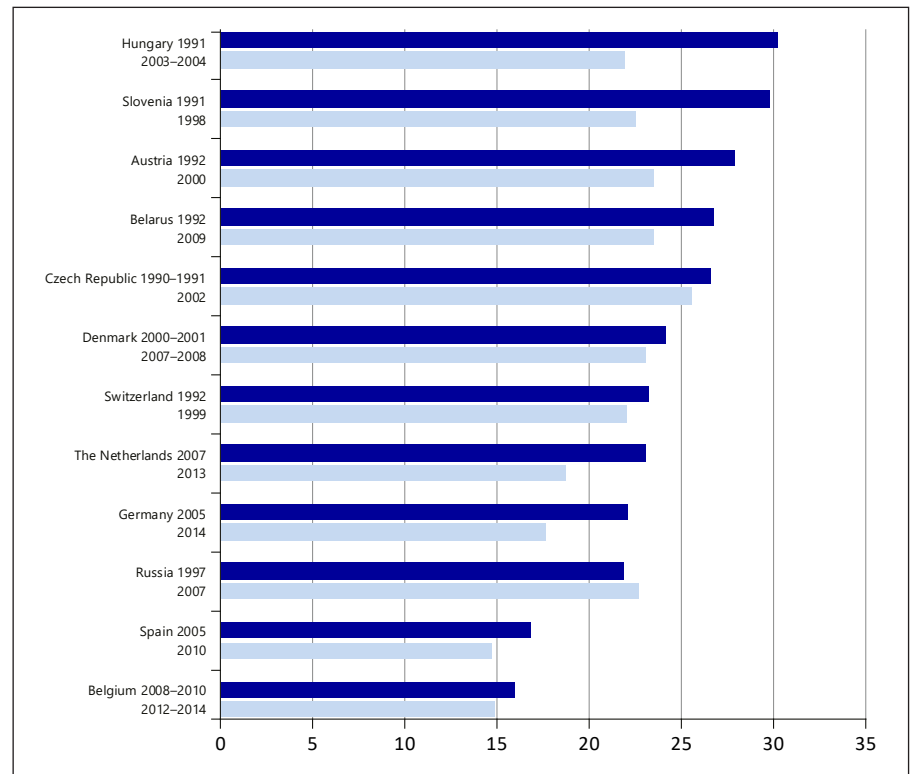


Fig. 5. Repeated cross-sectional studies on caries trends in Europe: mean decayed, missing, and filled teeth (DMFT) scores in 65- to 74-year-old senior citizens.

from 2003 to 2012 in the public dental service [Dobloug and Grytten, 2015]. In 2012, 33- to 42-year-old individuals ($n = 1,453$) and 63- to 72-year-old persons ($n = 888$) had a mean DMFT index of 10.2 ± 0.1 and 20.4 ± 0.2 , respectively. Both cohorts showed a fairly similar pattern concerning caries incidence. Nearly 90% of the individuals had no new caries during the first 5 observation years. After 8 years, 48.5% of the adults had no new caries, in comparison with 46.0% of the seniors. These figures dropped to 12.0 and 10.7%, respectively, by the end of the study.

Commentary on the Impact of Oral Health Conditions on Daily Life Performances

Traditionally, oral health status has been measured through clinical assessments of the absence or presence of diseases as well as by the assessment of short- and long-term treatment outcomes [Locker, 2004]. Currently, this approach is considered limited due to growing recognition that nonclinical assessments such as oral health-related quality of life are important measures of an individual's oral health, daily functioning, and well-being [Sheiham and Steele, 2001; Locker and Allen, 2007].

The appraisal of oral health-related quality of life has increasingly gained attention in observational cross-sectional and longitudinal epidemiological studies [Tsakos et al., 2012; Carvalho et al., 2015]. National oral health surveys such as those carried out in Finland [Suominen-Taipale et al., 2008], Spain [Llodra Calvo, 2012], the Netherlands [Schuller et al., 2014], Belgium [Bottenberg et al., 2015], and Portugal [Calado et al., 2015] assessed the impact of oral health conditions on the oral health-related quality of life of their populations. In these surveys, the instrument used to measure the impact on oral health-related quality of life was the validated abridged Oral Health Impact Profile-14 (OHIP-14) [Slade, 1997]. The OHIP-14 measures the adverse impact of oral health conditions related to the teeth, mouth, or dentures on physical, psychological, and social dimensions [Locker, 2004]. The questions are answered on an ordinal scale as “never,” “hardly ever,” “occasionally,” “fairly often,” or “very often.”

The percentages of adults and senior citizens who reported adverse effects on their oral health-related quality of life occasionally or more often were 36% and 28%, respectively, in Finland [Suominen-Taipale et al., 2008] and 26.1% and 22.6% in Spain [Llodra Calvo, 2012]. In Portu-

gal [Calado et al., 2015], the corresponding figures were 25.2% and 25.7%, respectively, but only seven questions of the OHIP-14 were included in the survey. In Belgium, the median OHIP-14 score was calculated as 0.7 (range 0.0–52.0) for adults and 1.8 (range 0.0–50.0) for senior citizens [Bottenberg et al., 2015]. A larger percentage of edentulous (52%) than of dentate (33%) subjects reported having had at least one adverse effect on their oral health-related quality of life [Suominen-Taipale et al., 2008]. A further inclusion and dissemination of findings on oral health-related quality of life of adults and seniors is desirable.

Commentary on Clinical Caries Diagnosis in Epidemiological Studies

Over the last two decades, in epidemiological studies there has been a growing interest in diagnosing the caries process according to its activity and severity – particularly in clinical stages of development that precede cavitation. The rationale has been to obtain a more accurate estimate of the caries prevalence and treatment needs, in addition to obtaining a scientific basis for treatment decisions and management of the caries process at the population level [Carvalho et al., 2001, 2015; Hugoson and Koch, 2008; Ismail et al., 2009; Machiulskiene and Carvalho, 2018]. This reasoning may equally be applied to oral health care of individuals in clinical practice as well as of populations in public health services.

On the other hand, the implementation and dissemination of the ORCA Cariology Curriculum in Dental Schools and Dental Associations around the world [Schulte et al., 2011] offer an extra opportunity for training dental students in caries diagnosis and its application in epidemiological surveys. In today's scenario, an increasing number of dental schools around the world have been updating the training of their students in caries diagnosis. In the future, the use of clinical caries diagnostic criteria assessing the activity and severity of caries lesions in epidemiological studies will become a natural continuation of the university training. Researchers and policy-makers questioning the appropriateness of applying such caries diagnostic criteria under field conditions, the reliability of these criteria, and the extra time required and their influence on caries outcomes should be informed that these aspects have already been investigated and that they are no cause for concern [Carvalho and Mestrinho, 2014]. Moreover, such caries diagnostic criteria, besides representing our current understanding of the caries process, allow comparisons with previous surveys using the WHO criteria.

Discussion

Reviewing the caries prevalence in adults and senior citizens in Europe has disclosed challenges, as there is much and diverse information available on some countries but only scant information on other countries. The modalities of data acquisition differ between countries, as well as some target variables and the presentation of the results. For these reasons and due to the substantial period covered in data collection, encompassing the period from 1996 to 2016, comparisons of the caries prevalence and its consequences between European countries are not straightforward.

Grouping the data side by side, as shown in Tables 1 and 2 together with Figures 1–3, has only a descriptive purpose and does not aim at direct comparisons between European countries. However, the data presented Figures 4 and 5 are sufficient to outline changes in caries prevalence. Most of these data have been used to provide scientifically based information to support political decisions by health authorities in individual countries.

Some European countries have implemented regular national collections of oral health data which have been published in papers and reports. All national oral health surveys mentioned in this review were well designed and had sound methodologies including representative random sampling and calibration of examiners, leading to good data quality. Although methodological differences between these surveys were observed, the main oral health indicators could easily be retrieved from these reports [Petersen et al., 2000; Skudutyte-Rysstad and Eriksen, 2007; Suominen-Taipale et al., 2008; Chadwick et al., 2009; Tseveenjav et al., 2010; Llodra Calvo, 2012; Bottenberg et al., 2015; Calado et al., 2015; Jordan and Micheelis, 2016]. Nevertheless, a more refined harmonization of data collection at the national level between countries could be set as a goal to be achieved in the future.

With respect to countries with information at the regional or municipal level, efforts were made to present the most representative and recent data [Schuller et al., 2014]. It should be borne in mind that the WHO recommendation from 2013 to implement oral health data collection at the national level may cause difficulties for some countries due to the associated extensive organizational requirements and costs. Data from surveys at the regional or even at the municipal level were included in this review. Taken together, it shows that dental caries still is a common disease in adults.

With regard to home-based oral health care as well as dental caries and its consequences for adults and senior

citizens, there are large differences between the European countries. Extreme values – i.e., outliers – shown in the present review should be interpreted with caution and be confirmed by further studies.

Dental caries is considered as a behavior-dependent disease affected by oral hygiene measures. Since regular brushing with fluoride toothpaste has been shown to be strongly related to lower caries experience [Figuerio et al., 2017], there is support for the rationale behind the collection of this indicator in the context of this review. Given the strong evidence that brushing with fluoride toothpaste twice a day controls the rate of caries progression more effectively than does brushing only once a day [Kumar et al., 2016], there seem to be good opportunities for improving oral health further, as only 33–85% of the adults in some European countries stated that they followed this recommendation (Table 1).

The present review reveals DMFT values for adults ranging from 6.6 to 17.6. In comparison, the review published by Marthaler et al. [1996] exhibited a range of mean DMFT values between 13.4 and 20.8, which clearly indicates a decline in caries. More important information can be derived from intra-country comparisons between repeated cross-sectional studies. Most of these comparisons reveal a distinct decline in caries among adults, with markedly lower caries experiences in the latest comparisons. A closer look at the DMFT changes in countries that have conducted repeated surveys (Fig. 4) shows that the caries experience ranged from 9.6 to 23.3 in the first studies (mean 15.0, median 14.3), while in the follow-up studies a range from 6.7 to 15.4 was observed (mean 11.9, median 11.6). This suggests a reduction of the DMFT value by 20% referring to country-wide data.

An interesting part of this review shows a trend in caries experience in 65- to 74-year-old senior citizens which was less marked than that of 35- to 44-year-old adults. While the mean DMFT scores varied from 15.9 to 30.2 in the first surveys (mean 24.0, median 23.7), they turned out to be between 14.7 and 25.5 (mean 20.9, median 22.3) in the later surveys, corresponding to a reduction by 13%. Probably even more important than the reduction in DMFT is the shift in DMFT components, exhibiting lower MT scores but higher FT scores. This indicates a paradigm shift towards restorative rather than extraction therapy and should have considerable consequences for dental health service research in the future.

Although repeated cross-sectional surveys provide valuable conclusions regarding trends, they are limited with respect to the identification of specific factors associated with improvements in oral health. It is acknowl-

edged that longitudinal studies on caries prevalence and experience are rarely carried out in adult and senior populations [Kovač-Kavčič and Skalerič, 2001; Dobloug and Grytten, 2015]. Major drawbacks of longitudinal studies are the loss of subjects to follow-up and organizational requirements. These limit the feasibility of longitudinal epidemiological studies, which is why cross-sectional studies are the preferred option for national oral health surveys in many countries.

Edentulousness may be seen as a robust indicator for the caries process and its consequences in adult and senior populations. The data showed a substantial gain in oral health also with respect to this indicator. According to our review, edentulousness in the age group of 35- to 44-year-olds started disappearing from the year 2000 [Petersen et al., 2004; Hugoson and Koch, 2008; Llodra Calvo, 2012] and has been diminished in some countries during the last decade, and it might be expected to disappear in more countries in the near future.

However, in the age group of 65- to 74-year-olds, the eradication of edentulousness was not yet reported in any of the countries (Fig. 4). This indicates that the eradication of this condition among seniors in European countries is unlikely to occur in the short term, which is in agreement with findings by Fure [2003] and Müller et al. [2007].

In the present review, all included studies used the WHO criteria for caries diagnosis. Recently, clinical caries diagnostic criteria were revisited to reflect the dynamics of the disease and accordingly to provide a solid basis for subsequent treatment decisions and for further monitoring of dental health of individuals and populations. The use of clinical caries diagnostic criteria in research, in clinical practice, and public health services should be guided by the best available scientific evidence and be universally applicable in all these fields. In this context, the use of caries diagnostic criteria that assess the activity and severity of early caries lesions was recommended, as these favor the best clinical practice directed towards nonoperative interventions [Machiulskiene and Carvalho, 2018]. Epidemiological studies start to report noncavitated active lesions in adults and senior citizens [Jordan and Micheelis, 2016]. However, further epidemiological surveys should also allow for comparisons with previous surveys that used the WHO criteria. Of interest to adults and senior citizens is the diagnosis of coronal as well as root caries in early stages of development. The present review showed that root caries is underreported in the literature.

In conclusion, in the last two decades a decline in caries has been observed in European adults and, to a minor ex-

tent, in senior citizens. It is expected that this decline may contribute to better oral health in both age groups in the future. In addition to these positive consequences for the European populations, important changes to the dental profession as well as the health systems can be expected.

Statement of Ethics

No ethical approval was required for this study, since it was based on the secondary analysis of available data already published in the literature.

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Disclosure Statement

The authors have no conflict of interest to declare.

Author Contributions

J.C.C. designed the review; both authors collected the data and wrote the manuscript.

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