Oral health status and coverage of oral health care: A five-country comparison

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ABSTRACT

Oral health has received increased attention in health services research and policy. This study aims to assess oral health outcomes and public coverage of oral health services in Belgium, Denmark, Germany, the Netherlands, and Spain. Various indicators were used to compare oral health outcomes concerning the most common disorders by age group. Coverage of oral health services was analyzed according to the dimensions of the WHO Universal Coverage Cube. The results showed major differences in the coverage of services for the adult population: coverage was most comprehensive in Germany, followed by Belgium and Denmark. In Spain and the Netherlands, public coverage was limited. Except in Spain, coverage of oral health services for children was high, although with some differences between countries. Regarding oral health outcomes measured by the T-Health index, no country showed outstanding results across all age groups. While Denmark, the Netherlands, and Spain performed above average among 5- to 7-year-olds, Denmark and Germany performed above average among 12- to 14-year-olds, the Netherlands, Spain, and Belgium among 35- to 44-year-olds, and Belgium and the Netherlands among 65- to 74-year-olds. The selection of countries of this study was limited due to the availability and quality of oral health data demonstrating the urgent need for the European member states to establish corresponding databases.

1. Introduction

While oral health care has been isolated from traditional health care and health policy for many decades, in recent years, there has been increased attention on oral health and the global public health burden of oral diseases in public health debates [1]. According to the Global Burden of Disease Study 2017, oral disorders affect approximately 3.5 billion people worldwide, with caries being the most common condition, followed by periodontal diseases. Furthermore, the economic impact of oral diseases should not be underestimated. The consequences of untreated chronic oral diseases are often severe in terms of personal health and quality of life, but they can also lead to missed school days and decreased work productivity while imposing large economic burdens on families and health care systems [2]. In the European Union (EU) alone, spending on treating oral diseases was about EUR 90 billion in 2015,

which is the third-highest amount among noncommunicable diseases, directly ranked after diabetes and cardiovascular diseases [3].

With the rising prevalence of oral health diseases and the corresponding increase in expenditures, effective care, efficient resource allocation, public and private financing models, and access to oral health care are becoming more important for policy-makers, health insurances, and patients [4–9]. Although there is agreement on the objectives of accessibility, quality, and financial protection of health care, the EU member states struggle to provide universal access to high-quality health care. Health services are mostly financed by public sources in almost all EU member states, but some services may still be excluded from statutory health coverage. In particular, oral health care is often not or only partially included in countries' health benefit basket, thus leading to remarkable expense for individuals and society [3]. In fact, cost barriers for oral health care in Europe may be lower than those in

many other countries, such as the USA [2,10]. Nevertheless, although coverage, e.g., in older population groups, is more equally distributed in publicly funded health systems [11], the level of statutory coverage varies widely across European health systems and particularly affect access to oral services [9,10,12]. Despite the introduction of financial health protection, including exemptions for vulnerable population groups, caps on out-of-pocket payments, and complementary voluntary health insurance (VHI) in many countries, private spending remains a barrier to oral health care across the EU. Across 22 European countries, on average, approximately two thirds of total dental spending came from private sources in 2019 [10], and in 2016, on average, one-fifth of household medical spending across OECD countries was attributable to oral care [13]. Oral diseases thus represent a substantial economic burden comprising direct (spending on treatment) and indirect costs (productivity loss).

While out-of-pocket payments for oral health care may ensure that health services are used conscientiously, they may lead to forgone oral health care and, as a result, contribute to poorer oral health. Thus, oral health in different countries may depend on public coverage of oral health care services [3]. Consequently, oral health (care) has received more attention, culminating in the adoption of the WHO Resolution on Oral Health in 2021, which calls on member states to strengthen oral health service delivery as part of the essential health services package to deliver universal health coverage (UHC). Furthermore, member states are called upon to consider a range of measures, including for example, promoting the integration of oral health into national health policies, strengthening prevention strategies, and developing surveillance systems to measure the burden of oral diseases. Based on a draft global strategy for tackling oral diseases, an action plan for public oral health has been set up, including a framework for measuring progress based on indicators to be achieved by 2030 [14]. In 2012 and 2020, the Platform for Better Oral Health in Europe and the WHO had already called for a systematic collection of oral health data, strengthened surveillance of oral disease and data on oral health care systems to finally promote improved data-driven policy-making [3,15]. Nevertheless, a recently published study from the European Observatory on Health Systems and Policies on oral health care coverage in 31 European countries again noted the lack of oral health data, which impedes comparisons between countries [10].

Overall, comparative research regarding coverage and outcomes of oral health care is limited and mostly focuses on subgroups such as elderly people [9,16], children [17], and people with specific diseases [18]. The applied outcome measures of these studies include the Decayed, Missing, Filled Teeth (DMFT) index, which primarily measures caries status by summing the number of decayed, missing, and filled teeth [20]. In addition, the Community Periodontal Index (CPI), which records the conditions of gingivitis, bleeding gums, and calculus and assesses the severity of periodontal diseases [19], has also been used as an outcome measure. Nevertheless, there are more holistic approaches to measuring oral health, such as the Tissue-Health index (T-Health index), which is more sensitive to social and behavioral factors and more efficient than the DMFT index [20,21]. A recent cross-country review of oral health care of the European Observatory compared statutory coverage in terms of services, population and cost coverage [10]. The question of how much is covered by the public system (cost coverage) was not addressed in detail. At the same time the WHO's Global Strategy on Oral Health defines the achievement of the highest attainable standard of oral health as a fundamental right of every human being, thus emphasizing public responsibility for oral health care [22,23]. Evidence on the association between coverage of oral health services and oral health outcomes is mixed with some studies pointing to positive associations [24–26].

Building upon previous studies, we provide more in-depth insights into the oral health coverage and oral health of the populations in five European countries (Belgium, Denmark, Germany, the Netherlands, and Spain). To shed light on public coverage and oral health outcomes, our cross-country study explored variations in and relationships between the following:

(1) public coverage of oral health care for the three dimensions according to the concept of the coverage cube (population coverage, service coverage, and cost coverage) [27], and
(2) outcomes of oral health using a holistic approach of measuring oral health by the T-Health index, which better reflects functional oral health status [28] and other indices.

2. Materials and methods

2.1. Country selection

Countries were included in this study if they were a member state of the European Union (EU), including the United Kingdom, which left the EU on 31 January 2020, and member of the European Free Trade Association (EFTA). A total of 32 countries were screened regarding the availability and comprehensiveness of epidemiological data. According to the uniform methodological standards of oral epidemiological studies recommended by the WHO, data screening of countries' oral health data was based on the criteria of timeliness, representativeness, and connectivity [29]. Specifically, the following criteria were assessed: (i) availability of a population-representative oral health survey in the last decade, (ii) use of relevant measurement concepts, (iii) use of the same age cutoffs, and (iv) completeness of oral epidemiological data. Appendix A shows the country selection process.

2.2. Outcome measures

The available epidemiological data and indices showed several conceptual and practical difficulties. Therefore, we used three indicators to assess oral health.

2.2.1. T-Health index
Based on the individual components of the DMFT index, we calculated the T-Health index [20]. While the DMFT index sums up the respective conditions of the individual teeth, i.e., equal weight is given to a missing tooth, a filled tooth, and a decayed tooth, and no weight is given to a sound tooth [30], the T-Health index rates healthy teeth higher than filled or missing teeth, as these are functionally more important, i.e., a sound tooth contains more healthy dental tissue than a filled tooth. Accordingly, a filled tooth represents more healthy tissue than a decayed tooth because the potential benefits of restorative treatment improve tooth shape and function [19,23]. To calculate the T-Health index, individual components of the DMFT index were extracted from the Country/Area Profile Project (CAPP) database [31] and its respective resources as well as personal correspondence [32–39].

As Bernabe et al. showed empirically, the T-Health index is more strongly associated with perceived oral health when assigning twice the weight of a decayed tooth to a filled tooth but keeping the weight of the latter ≤ 0.50. Therefore, we used the five most appropriate sets of weights for calculating the T-Health index (T-Health-2, T-Health-6, T-Health-10, T-Health-14, T-Health-18) [21], which are presented in Appendix B. As the latter three indices were affected by the extent of restorative care, the best sets of weights for calculating the T-Health index were T-Health-6 and T-Health-2, i.e., the T-Health index should be calculated by assigning twice the weight of a decayed tooth to a filled tooth whilst keeping the weight of a filled tooth ≤ 0.20 [21]. The data used for calculating the T-Health index and the DMFT index, as well as corresponding results, are provided in Appendix C.

The T-Health index (T-Health-6) used in our study assigned a weight of 1 to a sound tooth, 0.2 to a filled tooth, 0.1 to a decayed tooth, and 0 to a missing tooth, corresponding to the following formula:

$$T - Health - 6 = number\ of\ decayed\ teeth * 0.1 + number\ of\ filled\ teeth$$
$$* 0.2 + number\ of\ sound\ teeth * 1$$

The value for sound teeth was calculated as the number of teeth in the permanent set of 28 teeth minus DMFT (number of teeth in the primary dentition minus dmft). Therefore, the maximum value of the T-Health index for permanent dentition is 28, and for deciduous dentition, it is 20. The higher the T-Health index, the better the perceived level of oral health. To ensure that the values are comparable between the countries, the index was calculated for different age groups (5–7, 11–14, 35–44, and 65–74 years).

2.2.2. Periodontal status: community periodontal index (CPI)

In addition to the T-Health index, we used the prevalence of periodontal diseases as a second indicator of oral health. As periodontal screening plays an important role in preventing periodontal diseases, we compared data from the WHO's Community Periodontal Index, which uses three indicators — gingival bleeding, calculus, and periodontal pockets — to assess periodontal status [19]. If available, the prevalence of periodontal diseases among adults and elderly people per age cohort per country was calculated and presented graphically. Data were extracted from the latest available reports from the respective institutions in each country [32,36,38–40].

2.2.3. Replacing missing teeth

Whether and how missing teeth were replaced is important when comparing oral health care between different countries. We thus included the extent of prosthetic care. Again, data were extracted from the latest available reports and publications from the respective institutions in each country [36,39,41,42] and personal correspondence [43].

2.3. Coverage of and expenditures for oral care

To display and compare public coverage of oral health care across the five European countries, we used the framework of the three-dimensional coverage cube developed by Busse and Schlette [27] and adopted by the WHO and many others [44]. Coverage includes the following dimensions:

- Population coverage: who is covered (breadth),
- Service coverage: which benefits are covered (depth), and
- Cost coverage: what proportion is covered (height).

While the dimension of breadth describes the percentage of the population eligible for publicly financed oral health care services, the dimension of depth reflects the range of dental services covered. The height dimension displays the share of total costs covered by public health systems. While differentiating between children and adults, the range of public services was split into three categories, similar to Allin et al. [9]. The first category, 'preventive services', included routine check-ups, X-rays, and prophylactic treatment (e.g., removing plaque, calculus, and stains from the tooth structures). The second category, 'basic services', included tooth-preserving treatments (fillings and periodontal treatment) and extractions, while the third category includes comprehensive services such as dentures and endodontic and orthodontic treatments. Literature databases such as PubMed/Medline, the international health system profile series of the European Observatory on Health Systems and Policies [Health Systems in Transition (HiT)], and country-specific health profiles, as well as gray literature, were used to describe the systems of oral health care including the three coverage dimensions until 2021. Additionally, expenditures for oral care were compared using OECD health expenditure data [source: OECD Health Statistics, 2021].

3. Results

Out of 32 European countries, five remained after applying the selection criteria described above: Belgium, Denmark, Germany, the Netherlands, and Spain. No reliable oral epidemiological data were available for 16 countries. The oral epidemiological data of eleven out of the 16 remaining countries were largely outdated ($\leq$ year 2000) or incomplete (Appendix A).

3.1. Outcomes

The comparison of the T-Health-6 index (Fig. 1) shows that most countries performed close to the average of all five countries. However, oral health in very young children was lower in Belgium and Germany, while it was above the average in Denmark and the Netherlands [range T-Health-6: 17.7 (BE) – 19.5 (DK)]. Adult oral health was best in Spain and the Netherlands, and worst in Denmark [range T-Health-6: 16.5 (DK) – 20.6 (ES)]. The comparatively low scores of the T-Health index among the elderly people in Denmark and the good scores in Belgium were striking [range T-Health-6: 8.0 (DK) – 13.67 (BE)]. Overall, the statistical dispersion around the respective five-country mean in the four age cohorts amounts to a total of 6.8 T-Health points in the case of Denmark, while in Germany, the deviations from the mean are significantly smaller with 1.2 T-Health points. On average, across countries, the percentage deviation from the maximum value of the T-Health-6 — representing full oral health for considered variables — differed between age groups, ranging from 1.8% for 12- to 14-year-olds to 5.6% for 5- to 7-year-olds and 32.0% for 35- to 44-year-olds to 59.5% for 65- to 74-year-olds. However, the percentage deviation from the maximum value of the T-Health-6 also differed between countries, especially for the adults, ranging for 35- to 44-year-olds from 26.3% in Spain to 41.2% in Denmark, worsening with even greater country differences for 65- to 74-year-olds.

Fig. 2 shows the periodontitis prevalence for adults aged 35- to 44 years and 65- to 74 years based on the Community Periodontal Index (CPI). Belgium and Spain performed better in preventing moderate and severe periodontal diseases for both age groups, while the prevalence of more severe forms of periodontal diseases in Germany and the Netherlands was relatively high, as among elderly people in Denmark.

Regarding dentures, a distinction is necessary between removable and fixed dentures. Fixed dentures are usually more expensive, but at the same time, they are considered to be of higher quality as they are associated with a higher oral health-related quality of life [45,46]. As Fig. 3 shows, the proportion of fixed prostheses is significantly higher in Denmark and Germany than in the Netherlands and especially Spain, where only one in six prosthesis wearers had fixed prostheses.

3.2. Coverage of and expenditures for oral care

Table 1 provides an overview of oral health care coverage in the selected countries in terms of the breadth of coverage (who is covered), the depth of coverage (which benefits are covered), and the height of coverage (what proportion of costs is covered) until 2021. In all countries, the coverage of services by public health systems differed between children and adults. Therefore, the two groups were considered separately.

In all five countries, almost the entire population had at least some degree of public coverage for oral health care, whether through national health care systems (Beveridge model) or social insurance systems (Bismarck model) are involved. For Germany, both statutory and private health insurance were included, as health insurance is mandatory. This consequently increased the chances of underestimating the individual benefits or proportions of reimbursement since private insurers usually provide broader coverage of oral health services (depending on the individual contract).

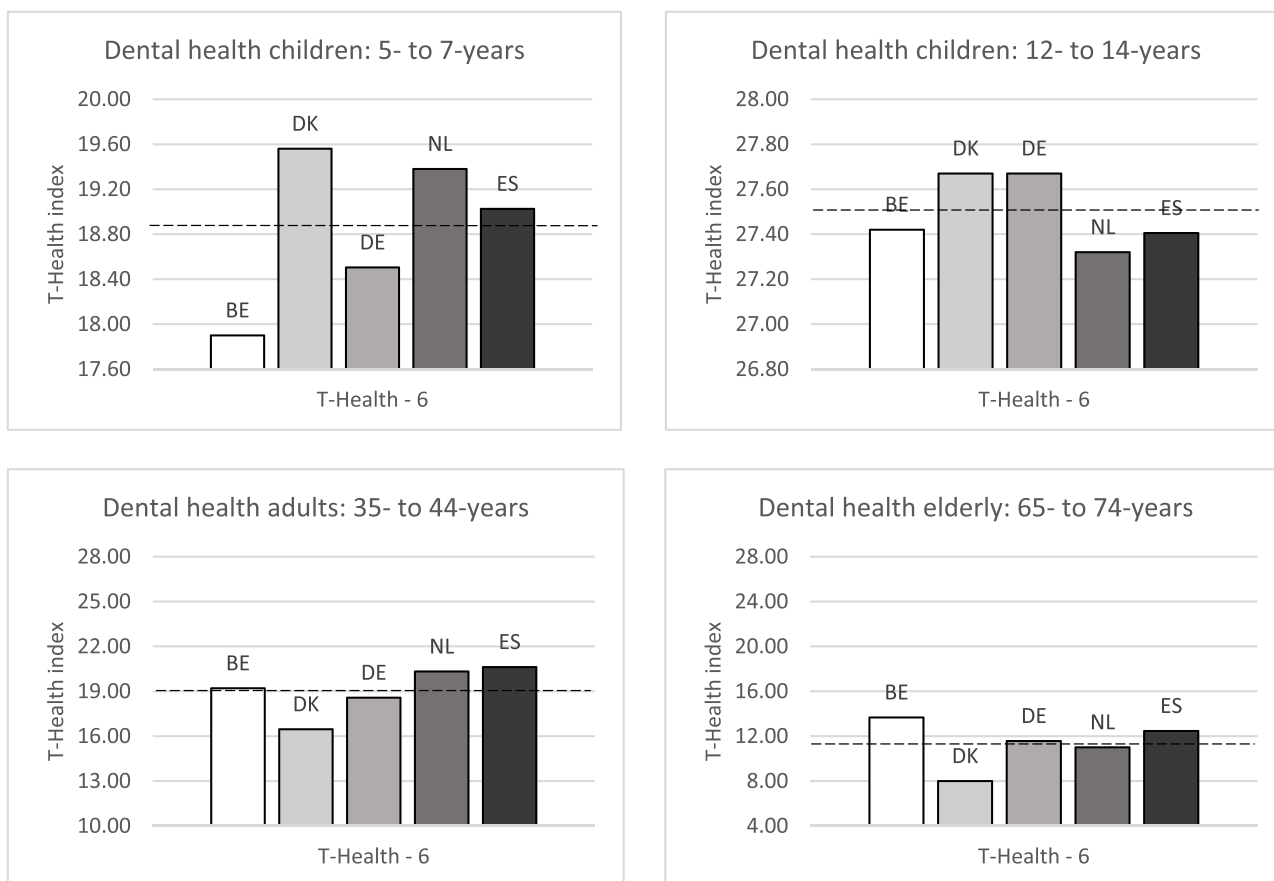A comparison of the benefit baskets for oral health care for children

Fig. 1. T-Health-Index by age group in 2017 or nearest available year Data source: [31–39]. Data refers to year: Belgium (2012–2014), Denmark (2017, children; 2008, adults & elderly population), Germany (2016, Children; 2014, adults & elderly population) Netherlands (2017, children; 2013, adults & elderly population), Spain (2015) Notes: dotted line - average T-Health-lndex of five countries.
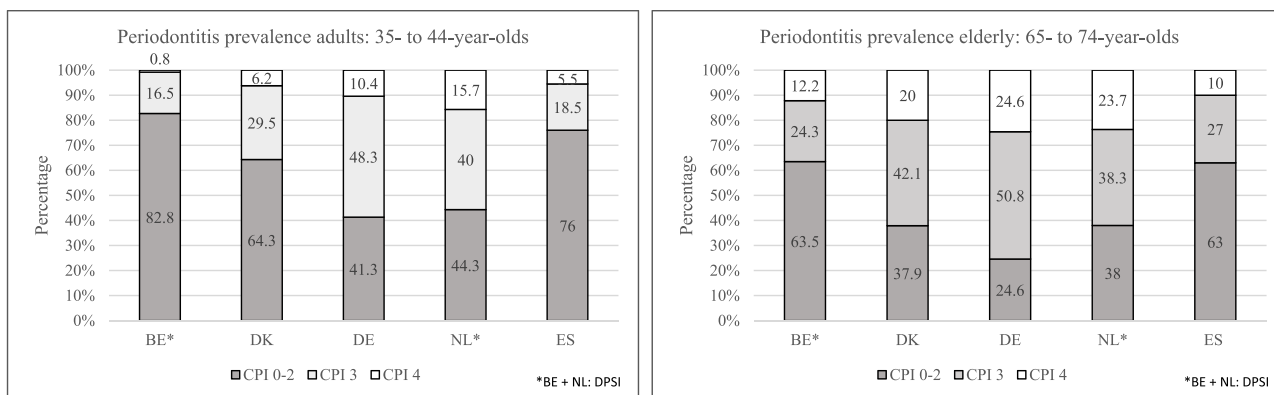

Fig. 2. Periodontitis prevalence of respective age group according to the Community Periodontal Index (CPI) Data Source: [32,36,38-40]. Data refer to the year of data collection: Belgium (2012–2014), Denmark (2001), Germany (2014), Netherlands (2013), and Spain (2015). Notes: Periodontal diseases are classified according to five degrees of severity ranging from 0 (healthy, inflammation-free gingiva and periodontium) to 4 (most severe form of periodontitis with loss of function of the teeth). Periodontal diseases of degree 1 may be cured by an improved domestic oral hygiene, degree 2 and 3 must be checked regularly and treated by a dentist. Degree 4 requires additional periodontal surgery. DPSI: Dutch Periodontal Screening Index.

showed that Denmark, Belgium, and the Netherlands (almost) fully reimburse preventive and curative services. Orthodontic treatments in children are fully reimbursed in Denmark, but only partly or not at all reimbursed in the remaining countries. In Spain, the benefit basket for children provides only partial reimbursement of services, with major differences across the 17 regions. Therefore, no exact proportion of cost coverage could be displayed in Spain.

The differences in oral health services included in the benefit basket for adults are much more pronounced than for children. While in the Netherlands, almost no services are covered by the public health systems, and patients usually pay for preventive and curative services themselves or via VHI, in Germany, standard care of preventive and basic services is fully covered. In Denmark, adults pay for their examination and treatment out-of-pocket, but they can receive a reimbursement from the public system, depending on the type of treatment, health insurance group, and age. For example, adults aged 18–25 can receive a
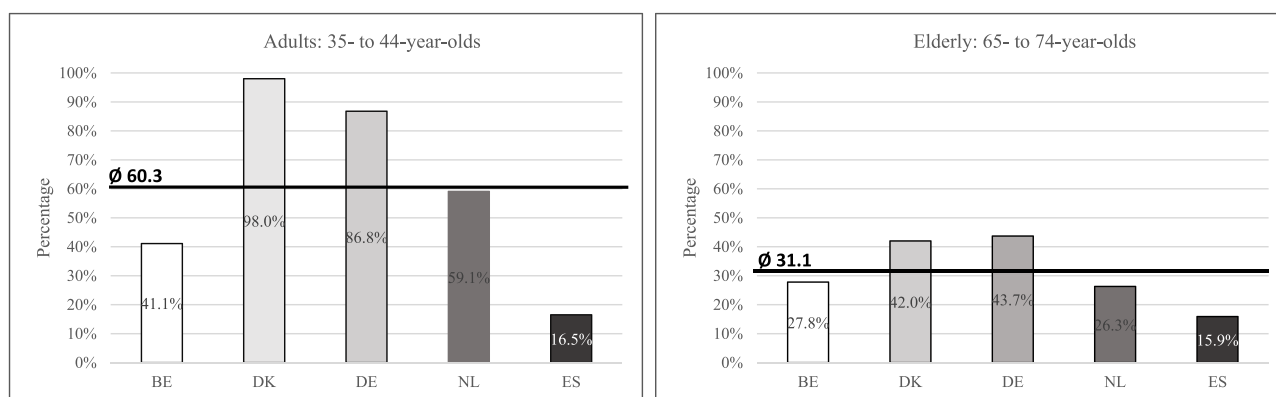
Fig. 3. Share of people with fixed dentures among all prosthesis wearers in respective age cohort Data source: [36,39,41-43]. Data refer to the year: Belgium (2012–2014), Denmark (2001), Germany (2014), Netherlands (2013), and Spain (2015). Notes: black line - an average of people with fixed dentures in five countries.

Table 1
Public coverage of oral health care, 2021.

Population covered	Services covered			Belgium			Denmark			Germany			Netherlands			Spain		
				fully	partly	none	fully	partly	none	fully	partly	none	fully	partly	none	fully	partly	none
<18 years	Preventive services		Routine check-ups															
			X-rays															
			Prophylactic treatment															
	Basic Services	Tooth-preserving treatment	Fillings															
			Periodontal treatments															
			Extractions															
	Comprehensive Services		Tooth-preserving treatment: crowns								60-75%							
		Prosthesis	Fixed prosthesis, bridges								60-75%							
			Removable prosthesis								60-75%							
			Implants					[1]										
			Endodontic treatments															
			Orthodontic treatments		65-78%						80-100%							
≥18 years	Preventive services		Routine check-ups		70-95%			30-62%										
			X-rays		75-89%				[2]									
			Prophylactic treatment		+/-77%			35%										
	Basic Services	Tooth-preserving treatment	Fillings		81-94%			8-22%										
			Periodontal treatments		79-92%[3]			35%										
			Extractions		63-86%[4]			28-100%										
	Comprehensive Services		Tooth-preserving treatment: crowns								60-75%							
		Dentures	Fixed prosthesis, bridges								60-75%							
			Removable prosthesis		73-89%[5]						60-75%			75%				
			Implants		[6]													
			Endodontic treatments		81-94%			35%										
			Orthodontic treatments															

Sources: Fee catalogues, laws, and regulations of respective countries

[1] If implants can only be initiated when growth is completed, decision on case-by-case basis. [2] Only 30% subsidy for bitewings (X-rays) in connection with regular diagnostic examination. Otherwise, no public coverage.
[3] Only periodontal examination and scaling & rootplaning covered; [4] Extractions are covered for persons over the age of 53; [5] ≥ 50 aged: coverage of production/restoration of removable dentures if indicated; [6] maximum two implants covered in the mandible of patients ≥ 70 years, who have been edentulous for at least one year and who have a full lower denture in the mandible for at least one year.

Notes: Several exemptions for vulnerable adult groups exist in countries.

subsidy of 65% for regular diagnostic examinations and status examinations, while the subsidy covers services for adults over 26 years of age up to 40%. The Belgian social security system has a relatively broad coverage of benefits with a comprehensive share of reimbursements. Preventive and basic services are covered to a high percentage. Although in Spain half of the benefits considered are partially covered, there is large variation across the 17 regions. Across all countries, only costs of predefined services, which correspond to standard care, are included in the benefit basket, i.e., not every material for fillings and crowns may be fully reimbursed.

Table 1 does not list the extended depth or height of coverage for subgroups of the population. However, all countries include those exceptions to protect certain subgroups in terms of unmet needs due to financial barriers. In Belgium, for instance, people with granted social benefits or under specific conditions (e.g., disability) are automatically entitled to preferential reimbursement and reduced copayments. In contrast, others are entitled on demand (e.g., based on their income) [47]. Germany provides extended coverage to lower-income adults (e.g., those receiving income support or social assistance) [48]. In Denmark,

there are several oral health care schemes for certain defined groups, including people over 18 with reduced mobility or profound physical or mental disability and people with a mental or intellectual illness and certain general disorders. They can receive oral health care for free or for an annual copayment. Socially vulnerable citizens can apply for free oral health care. Cash benefit recipients, students, and other low-income groups can apply for a subsidy for oral treatment. In the Netherlands, oral health care for people with congenital dental defects or severe disabilities is covered [49]. In Spain, preventive measures are covered as part of the protocol for a healthy pregnancy. In general, the level of benefits strongly depends on the autonomous communities, some having established basic coverage for the permanent dentition of children (6- to 15-year-olds) with public financing. Further exemptions exist for patients suffering from congenital diseases and oral cancer [50].

Appendix D additionally illustrates the three dimensions of the coverage cube for the countries, including coverage of benefits for preventive services, basic services, and comprehensive services, aggregated across the twelve benefit areas considered in Table 1. The cubes clearly indicate differences in the systems of oral health care. Due to the

major differences in partial coverage across the 17 Spanish regions, a graphical representation for the country was not possible.

Regarding sources for financing oral health care, there were again differences across the five countries. According to OECD health statistics, the share of funding for oral outpatient curative care is shown for public financing schemes (government/compulsory schemes), household out-of-pocket payments, and voluntary health care payment schemes. The share of public and thus solidarity-based funding was by far the highest in Germany (2020: 67.2%) and lowest in Spain (2020: 1.6%), where oral health care is primarily financed privately by households. In 2020, Belgium ranked in the middle (38.6%), followed by Denmark (36.3%), and the Netherlands (16.9%). In the Netherlands, financing is dominated by VHI (2020: 64.2%), which in the other countries ranges between 0.1% (Belgium) and 11.1% (Denmark). In Spain, funding of oral health care is dominated by out-of-pocket payments. Some changes from 2010 to 2020 need to be mentioned. The share of public funding decreased by 8% in Belgium, while the share of out-of-pocket payments increased by approximately the same proportion. In contrast, in the Netherlands, the share of public funding increased by 7.7%, but from a substantially lower level in 2010 (9.2%) compared to Belgium (2010: 35.1%). In Germany and Denmark, the proportion of expenditures by VHI schemes decreased, while the share of out-of-pocket payments increased. Overall, the comparison for 2010 and 2020 shows a similar picture in terms of country ranking regarding the proportion of funding schemes (Fig. 4).

In summary, the results showed major differences in the benefit packages and/or the level of reimbursement for oral health care among the five countries. While the Netherlands and Spain include the fewest services in the public benefit basket, Germany provides larger benefit packages, followed by Belgium and Denmark. In the Netherlands, a large part of the population (84% in 2018) purchased VHI to cover expenditures on oral health care [10]. When analyzing outcomes, a slightly different picture arises. While oral health measured by the T-Health index seemed similar concerning children, the differences were more pronounced for the ≥ 18 age group. While the Netherlands and Spain performed well for the 35–44 age group, Denmark performed poorly. Regarding the prevalence of periodontitis among adults and elderly individuals, Germany and the Netherlands performed worse than other countries. Regarding the share of people with fixed dentures among all prosthesis wearers in respective age cohorts, Germany and Denmark performed well compared to the other countries, with both having coverage to some extent for these services.

4. Discussion

This study aimed to compare variations in oral health outcomes and coverage of oral health care across European countries. Coverage dimensions of health care systems and various oral epidemiological outcomes were included, such as indices focusing on caries, periodontitis, and the share of people with fixed dental prostheses. Our analysis showed limited data availability on oral health. Sufficient and up-to-date oral epidemiological data were available only for five out of 32 considered countries.

The level of public coverage of oral health care, namely the benefit packages and/or the level of reimbursement for adults varied clearly between the five countries, which is reflected by the outcomes of dental health to some extent. Germany and Belgium, which both have social health insurance systems, show comparatively strong public coverage of oral health care services, although there are limitations in terms of partial coverage of benefits for adults [47,51]. Nevertheless, an important remark must be made for Belgium. Although dentists are publicly financed through compulsory health insurance on a fixed fee-for-service basis, dentists can choose whether to apply the 'fee schedule' [47], e.g., in 2020/2021 39.56% of dentists refused to accept the fee schedule, which constituted an additional barrier for many patients. Contrary to Belgium and Germany, the Netherlands directly excluded most services for adults from the public dental benefit basket, while Denmark directly excluded comprehensive services such as dentures and restricted the share of coverage for preventive and basic services. However, in the Netherlands, nearly the entire adult population– compared to those in the other four investigated countries, purchased VHI to cover expenditures on oral health care. In addition, an important remark must be made regarding the development of public expenditures for oral health. Belgium is the only one of the compared countries where public dental care expenditure as a share of total dental spending fell between 2008 and 2019 [41]. This shows gaps in universal oral health coverage (UHC) for all countries considered, but especially for the adult population in the Netherlands, Spain, and Belgium. According to the 74th World Health Assembly Resolution (2021), it is recommended that UHC be strengthened, which should indeed not be underlined by the possibility of dentists rejecting the fee schedule as in Belgium. In addition, the recommended shift away from curative toward preventive approaches might be difficult to implement without including strengthened cost coverage for respective services, what concerns the adult population in the Netherlands, Spain, and Denmark in particular.

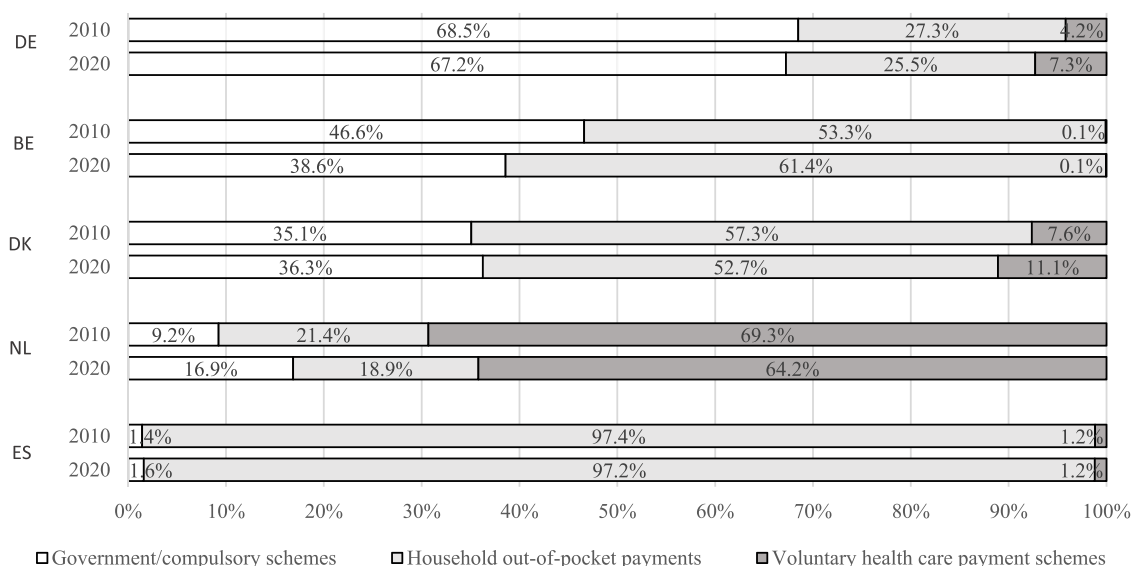Regarding oral health outcomes, the deviations in the respective age

Fig. 4. Proportion of oral expenditures on oral outpatient curative care per funding source, 2010 and 2020. Source: OECD health statistics, 2022.

groups from the cohort-specific mean were lowest in Germany, which can presumably be attributed to the fact that the benefit basket for children and adults does not show any considerable differences. In contrast, Danish adults and seniors face significant benefit exclusions, while children receive exemplary care through the Danish Public Dental Health Service [52]. Here, the close linkage of oral health care to schools may be noticeable. The public health care system for children under 18 is free and organized by municipalities. Almost every one of the 98 municipalities employs its own dentists in its own facilities to examine and treat children and adolescents [53]. In Germany, for instance, group prophylaxis generally exists, however respective treatments must be initiated by an appointment with the dentist. Nevertheless, based on the results of the T-Health index, Germany and Denmark were in the lead for oral health among 12-year-olds but showed only average results for the other age cohorts. Despite coverage limitations, Spain showed good oral health, at least among younger children. Denmark performed well regarding children oral health but lagged behind the average of the five countries for adults and the elderly individuals, although trends in self-reported dentate status between 1987 and 2017 among Danish adults decreased remarkably for the prevalence of complete tooth loss [54].

Even though all European health care systems face similar epidemiological and financial challenges, the analysis showed that coverage of oral health care is organized differently in the five countries compared. A link between coverage and oral health may be suspected but cannot be derived directly from the results due to different data points regarding health outcomes. System-dependent strengths and weaknesses of coverage could be identified. Nevertheless, no clear "winner" could be chosen since such a winner could not be determined due to specific national coverage system designs and the lack of a general "accounting algorithm" for the results [55]. However, income dependency on demand can also play an important role, which has already been demonstrated, especially in the costly prosthesis sector [56]. For instance, residents in Denmark have the highest proportion of adults with fixed dentures compared to the other four countries. However, while the high copayments for Danish households do not prevent patients from choosing more complex/expensive prostheses, in Spain, patients tend to forego dental care because of limited coverage. As a result, the country has the highest level of unmet needs for dental care due to financial reasons. Denmark and Belgium showed a sharp increase in individuals with unmet needs for oral services due to financial barriers between 2008 and 2018 [10,57]. Particularly in Spain and Belgium, a high proportion of low-income households forgo oral health care, which might be attributed to the limited coverage of oral health services in Spain and the possibility of dentists in Belgium not applying the 'fee schedule'. This, in turn, should be of concern given the links between oral health and systemic disease [58]. Although the financial factor is one of the most important barriers to accessing dental care, which might be partially addressed by special protection schemes for low-income households and vulnerable groups, the distance from the place of residence to the dentist, waiting times, fear of dental treatment or lack of time constitute further reasons for the unmet need for dental care [10].

Overall, we found large gaps in data availability on oral health, despite the WHO's calls for improving oral health surveillance, data collection, and monitoring [3]. However, recently, the member states of the WHO agreed to adopt a global strategy for oral health. The strategy aims to inform the development of a new global action plan, including a framework for tracking progress with targets to be achieved by 2030 [59]. Once data collection on oral health is ensured, the T-Health index may be used as an extra composite measure of the population's oral health status, as it can be calculated easily from published data necessary to calculate the DMFT index. The index the allows comparison of dental health among populations, as it is more sensitive in detecting differences in oral health between population groups. In addition, the T-Health index is more strongly associated with perceived oral health than the DMFT index [21,60].

The results must be interpreted in light of several limitations. First, although the best available data on outcomes were collected, different outcome years may have biased the analysis. Second, while information on coverage was collected for 2021, data on outcomes were available for 2001–2017 and differed between countries. Although statutory coverage did not undergo profound changes between 2001 and 2021, some changes must be considered. The total fee of some procedures to be paid by patients to dentists in Belgium rose more sharply than the reimbursements by public health insurance, leading to increased out-of-pocket payments by patients. In addition, some new procedures were introduced for adults covered by public health insurance, while for others, the age limit was lowered to broaden the group of beneficiaries. Third, we could not rule out that data collection methods may have differed between countries. Fourth, we used the T-Health index as it more rationally analyses the oral health status because it is associated with oral health-related behavior and sociodemographic factors. However, although validation studies exist [21,60], further country-studies are needed to confirm most appropriate sets of weights and to assess the applicability to different populations. For our study, we therefore used the five most appropriate sets of weights, which showed the same rankings of oral health when comparing the countries. Fifth, the comparison of coverage and oral health outcomes was limited by the cross-sectional design of our study. Long-term trends are needed to gain insights into associations between coverage and oral health outcomes, which requires regular updates of the databases on oral health outcomes as described in the action plan for public oral health, including its framework for measuring progress based on respective indicators [14]. In the long term, trends between the DMFT and T-Health indices may develop differently, as filling a decayed tooth and extracting a tooth would change the T-Health score but not affect the DMFT index. Therefore, longitudinal studies should be used to measure population dental health instead of cross-sectional studies [21].

5. Conclusion

Based on the data available at the national level, only five countries out of 32 European countries could be considered for analysis. These countries clearly show variations in oral health outcomes and public coverage and may require different policy measures to improve oral health. In Germany and Belgium, strategies to avoid caries in younger children should be improved. In Denmark, success in oral health should be ensured by lifelong oral prophylactic care concepts if the health gains of the early years of life are not to be lost later in life. In Germany, the awareness of periodontitis as a silent disease should be increased, both among the population and dentists. This also applies to the reduction of the high periodontitis prevalence in the Dutch population. Overall, the fact that many European countries do not regularly report population-based data on the oral health of their citizens limited the present review to five countries. There was a lack of specific data on outcomes, especially regarding the prevalence of periodontal disease, prosthodontic care for missing teeth, and disaggregated costs of oral health (cost-of-illness accounting). Without these detailed data, health policy-makers are "flying blind". An evaluation of the performance of oral health care systems would be limited but is urgently needed. To enable a comprehensive comparison and assessment of the overall performance of oral health care systems, considerable efforts are necessary in the coming years to improve and methodologically standardize the databases for recording and monitoring the prevalence of caries and periodontitis within the framework of national and international health reporting. Corresponding WHO databases thrive on the flow of data "from below". National professional organizations, but above all, health policy-makers, need population-wide oral health surveys and corresponding databases to enable assessments regarding oral health and establish evidence-based health care planning and efficient resource allocation.

Submission declaration and verification

All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

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Cornelia Henschke: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Visualization, Funding acquisition, Writing – original draft, Validation. **Juliane Winkelmann:** Validation, Writing – review & editing. **Astrid Eriksen:** Validation, Writing – review & editing. **Eugenia Orejas Pérez:** Validation, Writing – review & editing. **David Klingenberger:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Visualization, Validation, Writing – review & editing.

Declaration of Competing Interest

Cornelia Henschke, Juliane Winkelmann, Astrid Eriksen, Eugenia Orejas Pérez, David Klingenberger declare no conflict of interests. Cornelia Henschke reports a grant from Institut der Deutschen Zahnärzte (IDZ) (see funding). David Klingenberger is employed at the IDZ, Germany. Eugenia Orejas Pérez is employed at the Ministerio de Sanidad, Spain.

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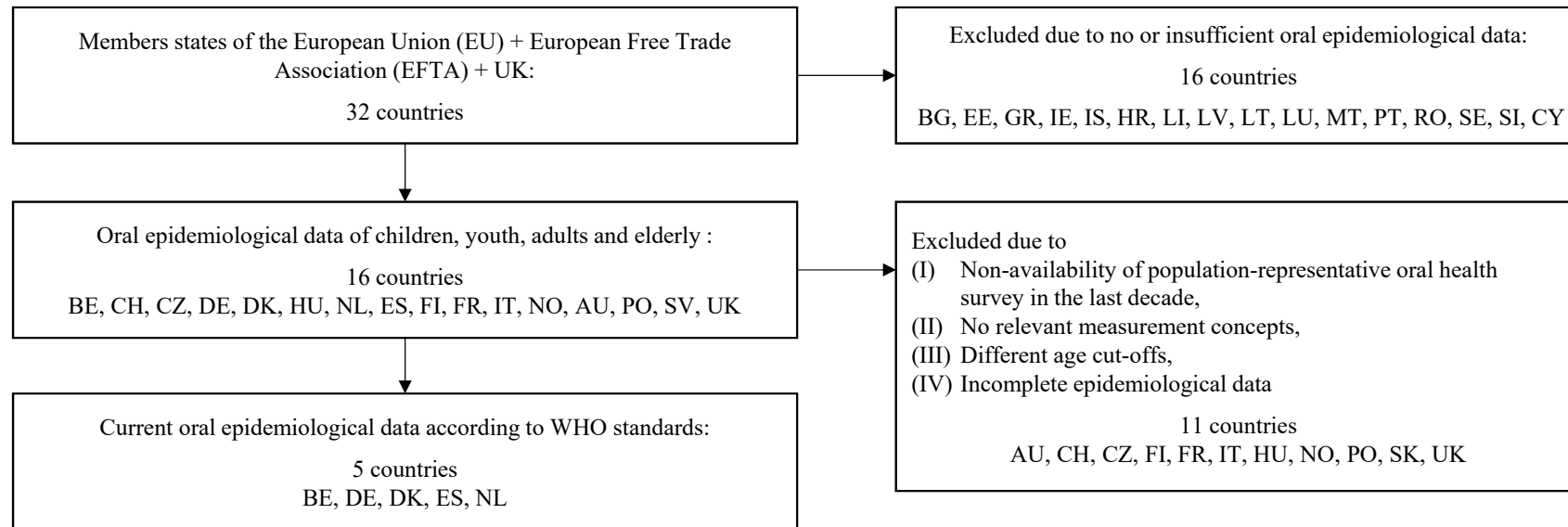## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2023.104913.

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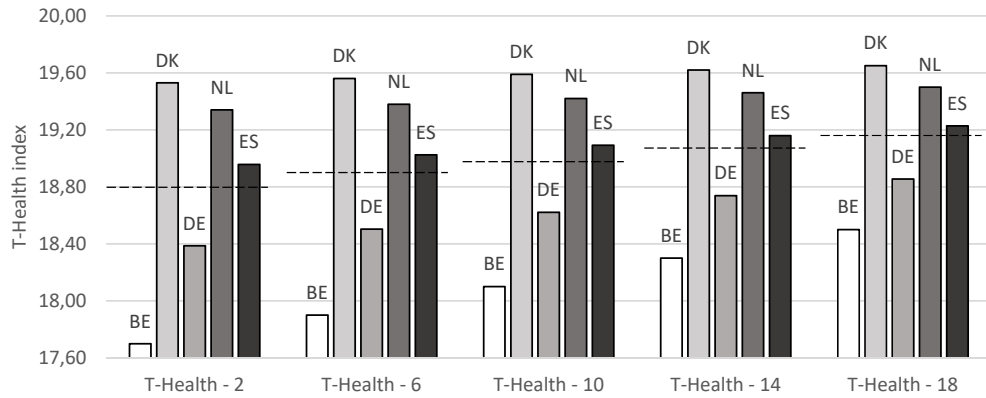
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| Members states of the European Union (EU) + European Free Trade Association (EFTA) + UK:

32 countries | → | Excluded due to no or insufficient oral epidemiological data:

16 countries

BG, EE, GR, IE, IS, HR, LI, LV, LT, LU, MT, PT, RO, SE, SI, CY |

↓

| Oral epidemiological data of children, youth, adults and elderly :

16 countries
BE, CH, CZ, DE, DK, HU, NL, ES, FI, FR, IT, NO, AU, PO, SV, UK | → | Excluded due to
(I)   Non-availability of population-representative oral health survey in the last decade,
(II) No relevant measurement concepts,
(III) Different age cut-offs,
(IV) Incomplete epidemiological data

11 countries
AU, CH, CZ, FI, FR, IT, HU, NO, PO, SK, UK |

↓

Current oral epidemiological data according to WHO standards:

5 countries
BE, DE, DK, ES, NL

Appendix A: Country selection process

Country abbreviations: AU: Austria, BE: Belgium, BG: Bulgaria, CH: Switzerland, CY: Cyprus, CZ: Czech Republic, DE: Germany, DK: Denmark, EE: Estonia, ES: Spain, FI: Finland, FR: France, IT: Italy, GR: Greece, HU: Hungary; HR: Croatia, IE: Ireland; IS: Iceland, LI: Liechtenstein, LT: Lithuania, LU: Luxembourg, LV: Latvia, MT: Malta, NL: Netherlands, NO: Norway, PO: Poland, PT: Portugal, RO: Romania; SE: Sweden, SI: Slovenia, SK: Slovakia, UK: United Kingdom

Dental health children: 5- to 7-years according to T-Health index

T-Health index

20,00
19,60
19,20
18,80
18,40
18,00
17,60

DK NL ES DE BE (repeated labels across groups)

T-Health - 2   T-Health - 6   T-Health - 10   T-Health - 14   T-Health - 18

Dental health children: 12- to 14-years according to T-Health index

T-Health index

28,00
27,80
27,60
27,40
27,20
27,00
26,80

DK DE BE ES NL (repeated labels across groups)

T-Health - 2   T-Health - 6   T-Health - 10   T-Health - 14   T-Health - 18
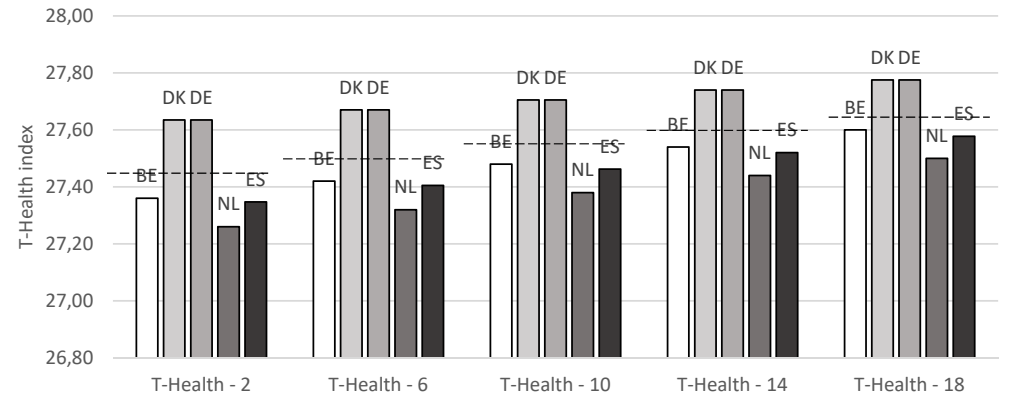
Dental health adults: 35- to 44-years according to T-Health index

T-Health index

28,00
25,00
22,00
19,00
16,00
13,00
10,00

BE DK DE NL ES (repeated labels across groups)

T-Health - 2   T-Health - 6   T-Health - 10   T-Health - 14   T-Health - 18

Dental health elderly population: 65- to 74-years according to T-Health index
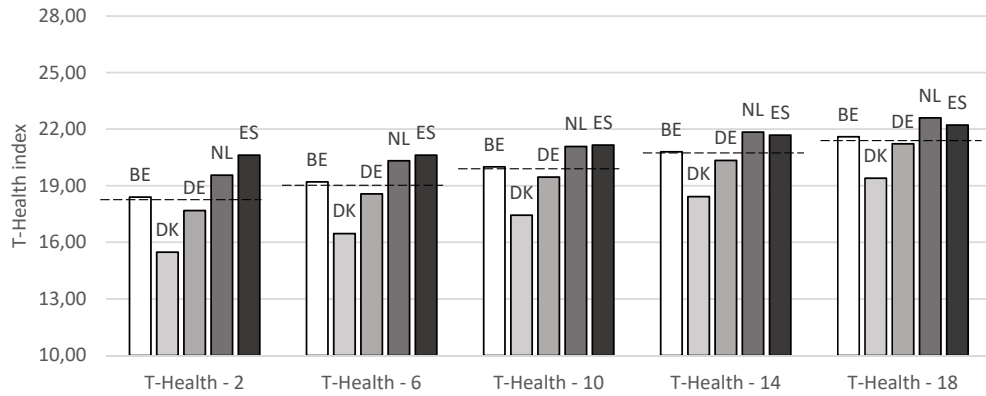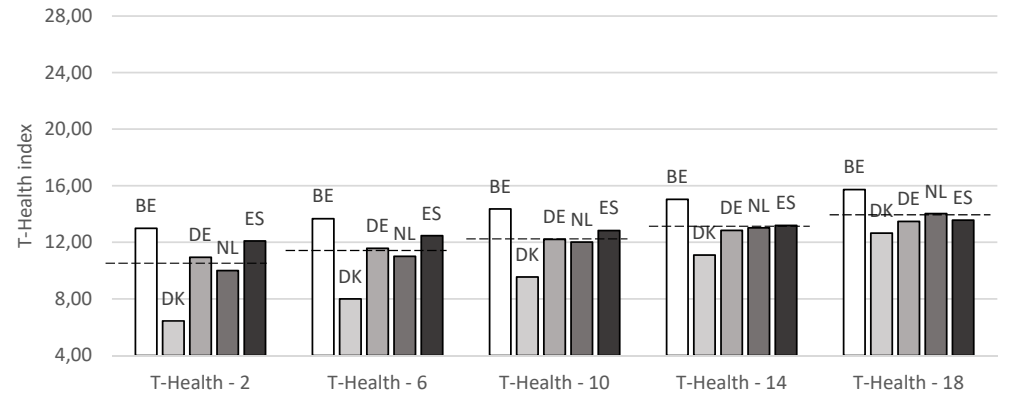
T-Health index

28,00
24,00
20,00
16,00
12,00
8,00
4,00

BE DK DE NL ES (repeated labels across groups)

T-Health - 2   T-Health - 6   T-Health - 10   T-Health - 14   T-Health - 18

Appendix B: T-Health index by age group in 2017 or nearest available year for different set of weights

Data source: [31-39]. Data refers to year: Belgium (2012-2014), Denmark (2017, children; 2008, adults & elderly population), Germany (2016, children, 2014, adults & elderly population), Netherlands (2017, children; 2013, adults & elderly population), Spain (2015)

Notes: dashed line – average T-Health indices of five countries

Formula: T-Health 2 = no. of decayed teeth*0.05 + no. of filled teeth*0.1 + number of sound teeth; T-Health 6 = no. of decayed teeth*0.1 + no. of filled teeth*0.2 + number of sound teeth;
T-Health 10 = no. of decayed teeth*0.15 + no. of filled teeth*0.3 + number of sound teeth; T-Health 14 = no. of decayed teeth*0.2 + no. of filled teeth*0.4 + number of sound teeth;
T-Health 18 = no. of decayed teeth*0.25 + no. of filled teeth*0.5 + number of sound teeth

Country	Country code		Dental health children: 5- to 7-year-olds								
		data year	decayed teeth	missing teeth	filled teeth	dmft	T-Health index-2	T-Health index-6	T-Health index-10	T-Health index-14	T-Health index-18
Belgium	BE	2012-2014	1.0	0.0	1.5	2.5	17.7	17.9	18.1	18.3	18.5
Denmark	DK	2017	0.4	0.0	0.1	0.5	19.5	19.6	19.6	19.6	19.7
Germany	DE	2016	0.7	0.2	0.8	1.7	18.4	18.5	18.6	18.7	18.9
Netherlands	NL	2017	0.4	0.1	0.2	0.7	19.3	19.4	19.4	19.5	19.5
Spain	ES	2015	0.9	0.0	0.2	1.1	19.0	19.0	19.1	19.2	19.2
Mean			0.7	0.1	0.6	1.3	18.8	18.9	19.0	19.1	19.1

Country	Country code		Dental health children: 12- to 14-year-olds								
		data year	decayed teeth	missing teeth	filled teeth	DMFT	T-Health index-2	T-Health index-6	T-Health index-10	T-Health index-14	T-Health index-18
Belgium	BE	2012-2014	0.2	0.0	0.5	0.7	27.4	27.4	27.5	27.5	27.6
Denmark	DK	2017	0.1	0.0	0.3	0.4	27.6	27.7	27.7	27.7	27.8
Germany	DE	2016	0.1	0.0	0.3	0.4	27.6	27.7	27.7	27.7	27.8
Netherlands	NL	2017	0.4	0.0	0.4	0.8	27.3	27.3	27.4	27.4	27.5
Spain	ES	2015	0.3	0.0	0.4	0.7	27.3	27.4	27.5	27.5	27.6
Mean			0.2	0.0	0.4	0.6	27.4	27.5	27.5	27.6	27.6

Country	Country code		Dental health adults: 35- to 44-year-olds								
		data year	decayed teeth	missing teeth	filled teeth	DMFT	T-Health index-2	T-Health index-6	T-Health index-10	T-Health index-14	T-Health index-18
Belgium	BE	2012-2014	1.2	1.8	7.4	10.4	18.4	19.2	20.0	20.8	21.6
Denmark	DK	2008	0.6	3.4	9.5	13.5	15.5	16.5	17.4	18.4	19.4
Germany	DE	2014	0.5	2.1	8.6	11.2	17.7	18.6	19.5	20.3	21.2
Netherlands	NL	2013	1.0	1.1	7.1	9.2	19.6	20.3	21.1	21.8	22.6
Spain	ES	2015	1.1	2.6	4.7	8.4	20.1	20.6	21.2	21.7	22.2
Mean			0.9	2.2	7.5	10.5	18.2	19.0	19.8	20.6	21.4

Country	Country code		Dental health elderly: 65- to 74-year-olds								
		data year	decayed teeth	missing teeth	filled teeth	DMFT	T-Health index-2	T-Health index-6	T-Health index-10	T-Health index-14	T-Health index 18
Belgium	BE	2012-2014	0.9	8.4	6.4	15.7	13.0	13.7	14.4	15.0	15.7
Denmark	DK	2008	0.4	7.4	15.3	23.1	6.5	8.0	9.6	11.1	12.7
Germany	DE	2014	0.5	11.1	6.1	17.7	10.9	11.6	12.2	12.8	13.5
Netherlands	NL	2013	0.9	8.5	9.6	19.0	10.0	11.0	12.0	13.0	14.0
Spain	ES	2015	1.3	11.9	3.0	16.3	12.1	12.5	12.8	13.2	13.6
Mean			0.8	9.5	8.1	18.4	10.5	11.3	12.2	13.0	13.9

Appendix C: Data and calculation of the DMFT and the T-Health index by age group in 2017 or nearest available year for different set of weights

Data source: [31-39].
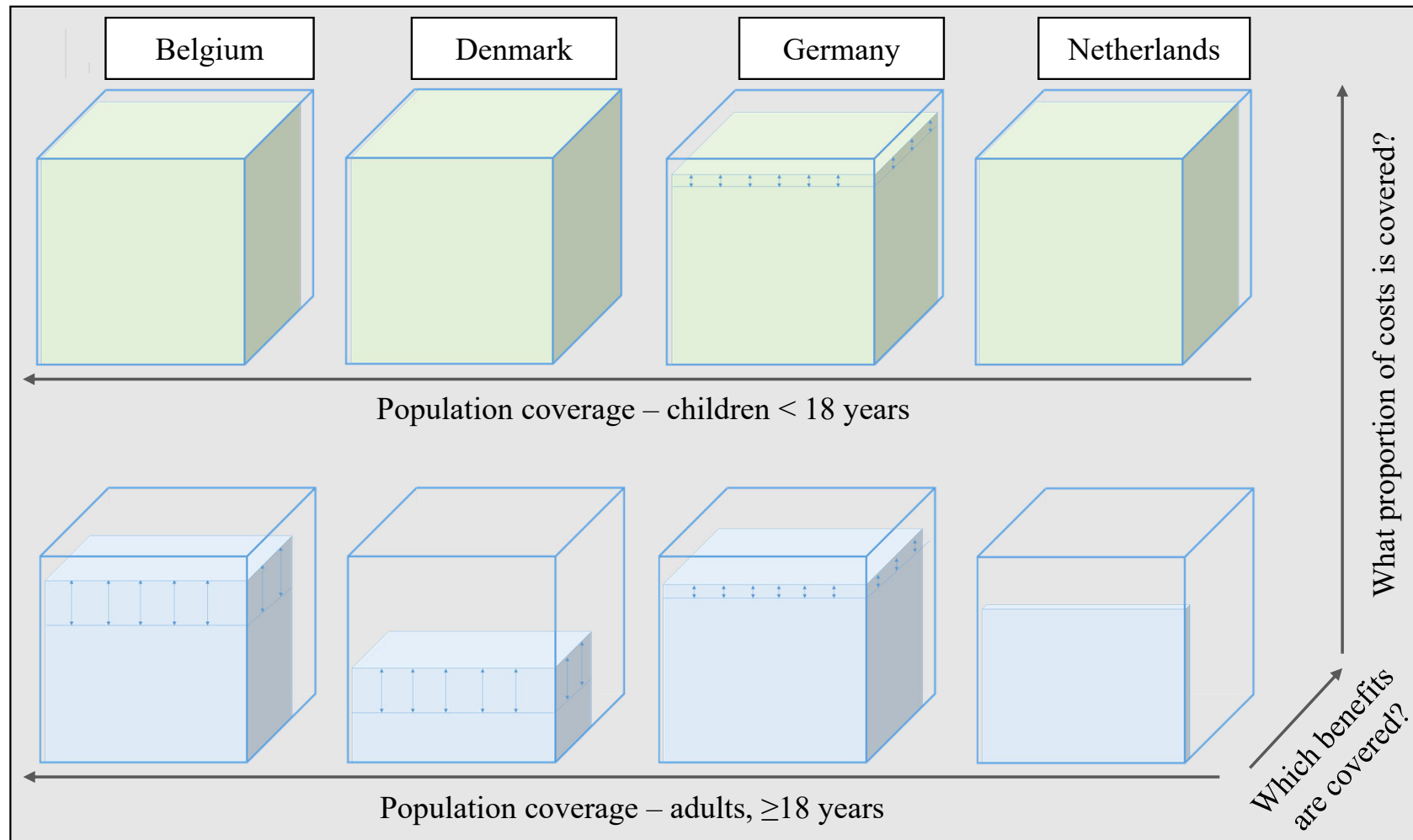
Appendix D: Comparison of oral health care coverage between countries

Note: Population coverage is represented by the breadth of the cube. The benefits covered are based on table 1 and represented by the depth of the cube. The proportion of costs covered (height) is calculated as the average of the corresponding proportion of costs of benefits covered (see table 1). Benefits without cost-coverage were not part of the calculation, as those are represented by the depth of the cube. If arrows are integrated, the average minimum and maximum for cost coverage of corresponding covered benefits is shown. This may be the case if the proportion of costs covered depends, for example, on the use of check-ups or the age of patients.