New Analytical Tools for Evaluating Dental Care Systems – Results for Germany and Selected Highly Developed Countries

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Objective: *To propose new analytical tools that facilitate the obtention of quantifiable results for evaluating different dental care systems.*
Methods: *The paper describes the construction of a composite indicator that measures dental health on a population basis in one overall indicator, the Dental Health Index (DHI). If the DHI is combined with a Dental Care Cost Index, an efficiency index (EI) can be created.*
Results: *The use of these new instruments for analysing different dental care systems reveals that the Swedish and Danish populations enjoy the best dental health status, followed by US, Japanese, Australian and Canadian citizens. Germany ranks in the middle, while the Dutch and Finnish populations enjoy a lesser degree of dental health. Advanced dental health can be achieved in any oral healthcare system, irrespective of the underlying cost-sharing and funding structures. As a benchmark for industrialised countries, cost levels for dental care between 0.5% and 0.7% of GDP, seem to be the international norm. A population's dental status is determined by the degree to which preventive and tooth-preserving treatment approaches are practised, also amongst adults.*
Conclusion: *The new instruments broaden the diagnostic possibilities for investigating different dental care systems. The greater the degree to which preventive and tooth-preserving treatment methods for the entire population are incorporated in daily clinical practice, the faster and better such systems progress and perform in terms of efficacy and efficiency.*
Key words: *benefit/cost analysis of the dental sector, overall dental health indicator, performance of dental care systems, efficiency of oral care*
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Kohn's thesis[1], that cross-national research as an analytical strategy is of pivotal importance for generating, testing and further developing sociology, is equally valid for oral health science. Consequently, in 1969, the World Health Organisation (WHO) created a Global Oral Data Bank (GODB), followed by the Oral Health Surveys Manual (1971), now in its fifth edition[2]. Subsequently, the Organisation for Economic Cooperation and Development (OECD) also developed its own manual, "A System of Health Accounts 2000"[3]. As a result, cross-national research on oral healthcare is able to rely on robust, standardised outcome data from the GODB and on oral health spending data from OECD statistics.

Although there are numerous cross-national studies focusing on partial aspects of dental status or on certain system characteristics[4-8], the results of all of these studies are only valid for the analysed subgroups or objects of investigation and cannot be generalised for the whole population or the entire dental care system. Moreover, Kravitz and Treasure[9], presenting an actual and comprehensive overview of European oral healthcare systems, measured dental health only by 'Decayed, Missing, Filled, Teeth (DMF-T) at age 12' and 'edentulism at age 65', which does not sufficiently monitor a population's dental status.

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An example of the rare residual international comparisons with a genuine population perspective is the work of Crocombe et al[10]. Here, the findings for the numerous clinical indicators used differ according to the index employed and the reference group, making it difficult to draw a clear, final conclusion. Another example that aspires to depict the dental status of European populations is the work of Patel[11], where prevalence and trends regarding dental caries are measured solely by means of the DMFT for 12-year-olds. A further study amongst European countries, using interview techniques for measuring the oral health status of adults and oral health attitudes, communicates insights into differing oral health behaviours and attitudes[12], but neglects the importance of dental health in childhood.

If a dental health comparison of different countries is based only on data from the younger generation, a country's ranking does not mean that the outcome also applies to adult generations. In the past, quite a few countries with low dental experience in 12-year-olds exhibited relatively high numbers of missing teeth in middle-aged adults and/or extremely high rates of edentulousness (between 30% and 65%), in seniors aged 65 to 74[13,14]. This means that the development of caries experience over a lifetime is often not constant, and thus a single dental indicator for a certain age group is unable to capture this phenomenon.

In previous studies, researchers focusing on the adult population proposed the use of two dentate status categories, 'edentulousness' and the presence of '20 or more teeth', as an expression of functional dentition[15]. This approach neglects oral health in childhood and overlooks the fact that dental health in the young strongly influences adult dental health. The same consideration applies to proposing the use of the FST (F = filled, S = sound and T = teeth) indicator[16].

In the present work, the explicit focus is on the dental status of the entire population and on total spending – the purpose being to carry out a benefit/cost analysis. For both aims, suitable instruments are required. These are partially lacking at the current time. While reliable overall indicators for analysing the cost side, e.g. dental health costs, in relation to Gross Domestic Product (GDP) exist, a comparable overall indicator for measuring the benefit side of a population's oral health status is non-existent. However, in medicine, the overall indicator 'life expectancy' provides information on the population's health status; in dentistry, no such equivalent exists. This is why, in this study, the author introduces a newly created composite indicator, which allows quantifiable results.

The aim of this paper is to broaden the range of analytical tools to facilitate international comparisons of different oral healthcare systems, by measuring the efficacy and efficiency of a country's dental care system. The objective is to test a two-pronged hypothesis by applying these new tools to a relatively homogeneous group of affluent Western countries. The first aspect of the hypothesis is that the proposed composite indices are appropriate and useful in practice and allow deeper analyses of dental care systems. Secondly, care systems that put preventive care and tooth-preservation first, perform better than other systems.

Materials and methods

The first proposal for measuring the efficacy and efficiency of dental care systems was made by Bauer et al[17]. This paper introduces an updated version to the international community. At first, the construction of a dental health index, measuring the overall oral health status of a population, is described. From a population perspective, dental decay and its complications (tooth loss) traditionally form the greatest threat to natural teeth[18] and account for about 95% of the oral disease burden across the world[19]; the measurement of oral health status in this study focuses on dental decay and its indicators. At a later stage, an efficiency index, linking a dental care system's benefit with its cost side, will be introduced.

The new analytical tools are then applied to the relevant empirical data from the countries under study. The inclusion criteria for the countries selected are:

- countries must be at a similar stage of development;
- there should be some difference in the way in which the healthcare systems are organised, regulated and funded (national health, social insurance and private insurance models);
- countries must have a well-established oral healthcare system;
- countries must regularly monitor their population's outcome data.

These criteria are fulfilled by Germany (DE), France (FR), the Netherlands (NL), Japan (JP), Switzerland (CH) (social insurance model), the United Kingdom (UK), Sweden (SE), Denmark (DK), Finland (FI) (national health model), the USA (US) (private insurance model) and Australia (AU) (a mix of the public and private models). Additionally, Canada (CA), with its publicly financed social health system, has been selected, because – like Switzerland – the health legislator explicitly decided not to include dental care (except

Table 1 Point system to convert the proportion of caries-free children aged 5 to 6 years old and the proportion of edentulousness in seniors aged 65 to 74 years old into corresponding indices.

Caries-free Index[1] (caries-free 5/6-year-olds as a %)		Edentulousness Index[2] (total tooth loss in 65/74-year-olds as a %)	
100 - > 90%	0 – u. 1 point	0 - < 10%	0 – u. 1 point
90 - > 80%	1 – u. 2 points	10 - < 20%	1 – u. 2 points
80 - > 70%	2 – u. 3 points	20 - < 30%	2 – u. 3 points
70 - > 60%	3 – u. 4 points	30 - < 40%	3 – u. 4 points
60 - > 50%	4 – u. 5 points	40 - < 50%	4 – u. 5 points
50 - > 40%	5 – u. 6 points	50 - < 60%	5 – u. 6 points
40 - > 30%	6 – u. 7 points	60 - < 70%	6 – u. 7 points
30 - > 20%	7 – u. 8 points	70 - < 80%	7 – u. 8 points
20 - > 10%	8 – u. 9 points	80 - < 90%	8 – u. 9 points
10 - 0%	9 – 10 points	90 – 100%	9 – 10 points

1) Example - proportion of 66%: 3.4 points. 2) Example - proportion of 66%: 6.6 points.
Reference: 21

when it relates to children, expectant mothers and public assistance recipients) into the healthcare system[20].

The study is descriptive and observational in nature and the material used is derived from existing databases. Although it is a cross-sectional investigation, it involves additional longitudinal findings from regular surveys and furnishes evidence of relationships and influencing factors.

Construction of a dental health index

A meaningful composite indicator for the dental health of the entire population must fulfill the following conditions:

- record the main dental disease – caries – and its consequences;
- be easy to handle;
- be sensitive to dental health concerns;
- allow a quantitative measurement of dental health;
- include all important age groups/generations;
- be founded on internationally accepted indices for which comparable data exist.

The well-established indicators 'proportion of caries-free teeth in 5 to 6-year-olds', the DMFT index for 12-year-olds and for 35 to 44-year-olds, as well as 'edentulism in 65 to 74-year-olds', all comply with these preconditions. Moreover, the last indicator (edentulism in seniors) is additionally, an indirect measurement of whether periodontal breakdown is widespread amongst the elderly population, because tooth loss in higher age groups may also be caused by severe periodontitis.

In order to depict the dental health of children, adolescents, middle-aged adults and seniors, the above-mentioned single indicators are combined into an overall indicator, the Dental Health Index (DHI), as a single figure. Owing to the fact that improvements in the indices 'proportion of caries-free teeth in 5 to 6-year-olds' and 'edentulousness in 65 to 74-year-olds' are not rectified – a higher proportion of caries-free teeth indicates a positive change, while a higher proportion of total tooth loss in seniors indicates a deterioration – these two indicators first have to be rendered compatible before they are combined with the absolute values of DMFT for 12 and 35 to 44-year-olds. The indicators 'share of caries-free teeth in 5 to 6-year-olds' and the 'proportion of edentulous seniors aged 65 to 74' are therefore converted to a point system based on the following method (Table 1). The method of conversion ensures that changes in both indicators affect the population-related DHI – both rectified and balanced.

The foundation for a healthy dentition is laid out in childhood. A high proportion of caries-free deciduous teeth in children aged 5 to 6 years old and favourable DMFT values for 12-year-olds, form the indispensable basis for long-lasting healthy permanent teeth. Indeed, individuals have good prospects for continuous oral health and for retaining all of their teeth for a lifetime.

Table 2 Dental Health Index for populations of highly industrialised countries in 2009 to 2013[1].

Country	Caries-free at age 5/6		DMFT 12 (2)	DMFT 35/44 (3)	Edentulousness 65/74		DHI[10] (5)	Rank
	in %	Index (1)			in %	Index (4)		
SE	78	2.2	0.8	9.7[5]	9.9	1.0	3.425	1
DK	< 83	1.7	0.6	13.5	8.7	0.9	4.175	2
US	53	4.7	1.19	10.91	15.0	1.5	4.575	3
JP	58	4.2	1.4	12.3	6.9	0.7	4.650	4
AU	50	5.0	1.05	10.7	21.1[7]	2.1	4.713	5
CA	57	4.3	1.0	12.3[9]	21.7	2.2	4.950	6
FR	63	3.7	1.23	14.6[3]	15.5[8]	1.6	5.283	7
DE	≈60	4.0	0.7	14.5	22.6	2.3	5.380	8
CH	≈ 50	5.0	0.8[4]	14.5[4]	13.8	1.4	5.425	9
UK	< 58	4.2	0.7[2]	16.6[2]	15.0[2]	1.5	5.750	10
NL	< 55	4.5	0.8[6]	17.4	41.0	4.1	6.700	11
FI	39	6.1	0.7	16.5	36.0	3.6	6.725	12

1) Or most recent available value; 2) Except Scotland; 3) Rhone/Alpes; 4) Canton Zurich; 5) Jönköping; 6) Den Haag; 7) 65+; 8) 65 years; 9) 40-59 years; 10) DHI (5)= [(1)+(2)+(3)+(4)]:4.
Source: 22-28

Consequently, the dental health of children (5 to 6 years old) and adolescents (12 years old) should be weighted more heavily in the overall indicator than the DMFT values for middle-aged adults (35 to 44 years old) and edentulousness in seniors (65 to 74 years old). As the single indicators for children and adolescents, both of which relate only to a 1-year age group, are easier to improve than the indicators for adults and seniors, which relate to 10-year age-groups, this is achieved by adding the points for the proportion of caries-free teeth, the absolute DMFT values for 12 and 35 to 44-year-olds to the points for the proportion of edentulousness among seniors aged 65 to 74, and then dividing the sum by the number of included indicators (four in this case)[21]. The lower the DHI, the better the overall dental health status of the population. Expressed as a formula, the DHI reads like this:

$$DHI = \frac{\textit{Caries-free index 5/6} + \textit{DMFT 12} + \textit{DMFT 35/44} + \textit{Edentulousness Index 65/74}}{4}$$

Construction of an efficiency index

The link between the DHI and the Dental Care Cost Index, defined as a proportion of total oral healthcare costs in relation to GDP, forms the efficiency index (EI). To ensure that both indices indicate improvements in the same manner and direction, the practical link is achieved by adding the two indices (DHI and EI) together[21]. Thus, better dental health amongst a country's population, as well as diminishing macroeconomic resources for oral healthcare, are indicated by decreasing indices. In mathematical terms, the formula reads:

$$\textit{Efficiency Index} = \textit{Dental Health Index} + \textit{Dental Care Cost Index}$$

The lower the EI, the better the benefit/cost ratio of a country's oral healthcare sector. The new EI allows a simple but meaningful measurement and analysis of the benefit/cost level of a country's dental healthcare system. As a result, the evaluation spectrum for optimising oral healthcare systems is broadened.

Table 3 Efficiency Index of the dental care sector in a selection of highly developed countries in 2009 to 2013.

Countries	Dental Health Index of the population[1]		Dental Care Cost index: (Total oral health care costs in % of GDP)		Efficiency Index[2]	Rank
	Value	Index Germany = 100 (1)	Value	Index Germany = 100 (2)	Index Germany = 100 (3)	
DK	4.175	78	0.50	60	138	1
SE	3.425	64	0.67	80	144	2
US	4.575	85	0.70	83	168	7
JP	4.650	86	0.53	63	149	3
AU	4.713	88	0.56	67	155	4
CA	4.950	92	0.77	92	184	10
FR	5.283	98	0.52	62	160	5
DE	5.380	100	0.84	100	200	12
CH	5.425	101	0.66	79	180	9
UK	5.750	107	0.45	54	161	6
NL	6.700	125	0.40	48	173	8
FI	6.725	125	0.54	64	189	11
For information:						
DE 1980	8.730	162	1.15	137	299	-
DE 1990	7.700	143	0.83	99	242	-
DE 2000	6.330	118	0.89	106	224	-

1) Data from Table 2; 2) (1) + (2) = (3).
References: 21, 31 and 32.

Results

The new indices (DHI and EI) for the benefit and cost side of an oral healthcare system will now be used to describe the empirical situation in selected industrialised countries. Table 2 shows the values of the relevant single indicators, which comprise the DHI for the various countries. With a DHI of 3.425 the Swedish population enjoys the best dental health. Its dental status is over 50% higher than that of the German and almost 100% higher than that of the Finnish population. The dental status of the populations of Denmark, the USA, Japan, Australia and Canada are also rather good. Countries like France, Germany, Switzerland and the UK, with DHI values over 5 but below 6, form the middle group, followed by the Netherlands and Finland (DHIs > 6). By looking at this ranking, one has to keep in mind that the populations of the countries compared are amongst those exhibiting the best oral health status amongst the highly developed countries.

Eleven countries show 'very low' (DMFT < 1.2) caries prevalence levels in 12-year-olds according to the WHO classification[29]. Only 12-year-old Japanese children (DMFT 1.4) fall into the 'low' level category (DMFT 1.2-2.6). Less favorable are the DMFT values for middle-aged adults. Here, no country reaches a 'very low' caries prevalence level (DMFT < 5.0). Only the levels achieved by Sweden, Australia, the US, Canada, Japan, and Denmark can be classified as 'low' MFT 5.0 to 13.9). Germany, Switzerland and France just miss the 'low' level category. The values for edentulism amongst the elderly fall into a wide range of categories. While the Japanese, Danish and Swedish populations enjoy a low prevalence of edentulism in seniors (6.9%, 8.7% and 9.9%, respectively) with the prognosis for Sweden, by 2015, showing 95% dentate subjects aged 65 to 74 years old with 90% of 75 to 84-year-olds being dentate[30], the rate of edentulism in the elderly in Switzerland, France, the US and the UK is moderate. With just over 20% edentate elderly, total

tooth loss in Australia, Canada and Germany is more widespread. Some countries still face relatively high edentulism rates in the 65 to 74-year-old age-bracket (Netherlands and Finland).

However, further progress is possible if the trends remain stable. This is true for all of the single indicators used in this study. Only Denmark and Sweden, with a level of about 80% caries-free children aged 5 to 6, have largely exploited their potential in this field. In contrast, the indicator 'caries prevalence in adolescents' (DMFT = 12) leaves room for only minor progress in France, Japan, the US and Canada. The other countries have already achieved very low caries prevalence rates (DMFT = 0.6 to 0.8). Most of the reserves exist amongst adults. Here, caries prevalence in the middle-age group (35 to 44 years old) has the potential to decrease considerably in most of the countries except for Sweden, Australia, the US and Canada, where only minor improvements are possible. Especially in countries like the Netherlands and Finland, greater advances in reducing edentulism in seniors aged 65 to 74 years old can be expected. However, the remaining countries – and to a minor degree Japan and Sweden – can also strengthen efforts to lower the prevalence of full denture wearers. In general, it is possible to predict a further decline in caries prevalence and edentulism in adults. This trend will persist until 'very low' or 'low' levels of caries prevalence and edentulousness in the elderly are achieved[5].

Table 3 demonstrates the link between the outcome data (DHI) and the total cost of dental care in relation to GDP, using DE (2010 = 100) as a benchmark.

The most efficient systems are those of Denmark and Sweden. Slightly less efficient are Australia, France and the UK. Although, since 1980, the German dental care system has made significant progress in both efficacy and efficiency – the EI improved by one third (Table 3) – all countries still perform more efficiently than Germany. Also comparatively low in efficiency are the Finnish and Canadian systems.

Regarding the cost side of the dental sector, the comparison shows that - independent to the level of dental health achieved - all of the countries spend much less in terms of financial resources than Germany. The second highest level of expenditure is to be found in Canada. Even countries with a considerably better dental health status than Germany operate their dental care system with 20% to 40% less resources (Table 3). Switzerland, a country with a very high per capita income and a comparable dental health level, spends 20% less than Germany. The least expensive dental systems are found in the Netherlands and the UK.

With reference to dental status, Figure 1 shows the outstanding position enjoyed by Sweden and Denmark, followed at a certain distance, by the US, Japan and Australia. Significantly lower is the dental status of the Finnish and Dutch population. In terms of costs the majority of countries spend between 0.5% and 0.7% of GDP financing the dental sector.

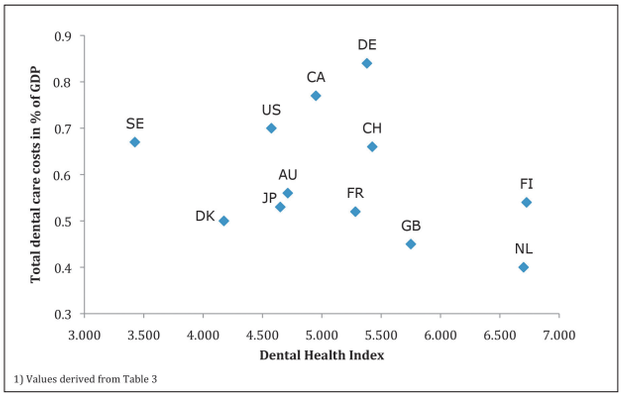

Fig 1 Efficiency chart of the dental care sector in a selection of highly developed countries between 2009 and 2013.[1]
1) Values derived from Table 3.

Discussion

The validity of cross-national research depends on the accuracy of health outcome and cost data as well as on the comparability of survey time points. For most of the data, up-to-date figures were available. Where this was not possible, the nearest available data were selected. These data all lie within a time span of less than 10 years, except for the data on middle-aged adults in France and the Netherlands, where no regular monitoring of adult dental health is conducted. A further imprecision lies in the fact that, for a few countries, data for middle-aged adults were not available in national representative surveys. In these cases, representative regional data, which authors considered to be of nationwide validity, were chosen (e.g. France, Switzerland and Sweden). The aforementioned limitations exist but can hardly be avoided in transnational, cross-sectional analysis. A further weakness is due to the observational character of this study, because it is problematic to control biases inherent in such a study type. In general, the data sets are reliable and draw a realistic picture of the current performance of a country's dental care system.

A previous investigation, with 2005 as its study period, also used DHI as the indicator for dental health in the whole population, and involved the same countries, including Finland. In this comparison, Sweden and Australia performed best with DHIs of 4.38. Oral

Table 4 Changes in adult dental status in a selection of highly developed countries in 1972 to 2011.

Country	Age class	Time span	Indicator	Results			Change in % points
SE	65/74	1980 – 2002	Edentulism	44.0%	↘	10.0%	-34.0
DK	35+	1975 – 2005	Edentulism	36.4%	↘	5.0%	- 31.4
	65/74	1987 – 2000	Edentulism	51.0%	↘	27.0%	-24.0
	65/74		Functional dentition	16.0%	↗	40.0%	24.0
	65/74	1995 - 2005	Edentulism	37.4%	↘	8.7%	- 28.7
JP	45-54	1987 - 2011	Functual dentition	76.0%	↗	95.0%	19.0
	55-64			40.0%	↗	81.0%	41.0
	65-74			22.0%	↗	60.0%	38.0
	65/74		Edentulism	30.0%	↘	6.9%	-23.1
CH	65/74	1992 - 2002	Missing teeth (MT)	15.4%	↘	10.4%	-5 MT
	65/74		Edentulism	26.8%	↘	13.8%	-13.0
DE	65/74	1997 - 2005	Functual dentition	22.0%	↗	40.0%	18.0
	65/74		Edentulism	24.8%	↘	22.6%	-2.2
UK	20-65+	1978 - 2009	Edentulism	28.0%	↘	6.0%	-22.0
	65/74		Edentulism	78.0%	↘	15.0%	-63.0
	20-65+		Prevalence of dental decay	46.0%	↘	28.0%	-18.0
CA	20-79	1972 - 2010	Edentulism	23.6%	↘	6.4%	-17.2

References:15,18,24-26,33-36

health status was slightly lower in the US (5.58), France (5.60), Germany (5.63), Denmark (5.78) and Switzerland (5.85) and considerably lower in Japan (6.45), the UK (6.53), the Netherlands (7.3) and Canada (8.05)[21]. All countries, except Australia, which had some minor deterioration in the DMFT for 12-year-olds, and in edentulism amongst the elderly (owing to the use of a dissimilar age bracket: 65+ instead of 65 to 74 years old in 2005), had improved their dental status within the previous 5 years. The range of DHI values between high and low performers diminished between 2005 (3.7) and 2009 to 2013. Obviously, some countries still do better than others. Before trying to determine the reasons for this, we will check whether the existing, periodically repeated surveys on adult dental health, which use indicators like missing teeth, the existence of a functional dentition and the prevalence of edentulism, confirm or contradict our results based on the composite DHI indicator.

Available survey data over time indicate substantial decreases in dental decay, tooth loss and edentulism in adults in all of the countries shown (Table 4). Especially distinct were the declines in edentulism amongst elderly Danes, Britons and Japanese. In the UK, the reduction is reflected in all adult age groups and shows how strongly dental care is built around a preventive philosophy[18]. Significantly slower, and starting later, were the advances amongst German adults. Summarising the survey findings, their trends match the results based on the composite DHI indicator. Thus, it was possible to achieve the first aim of this study i.e. to prove the practicability and reliability of composed indices for measuring dental health on a population basis.

Furthermore, the findings of the 2009 Eurobarometer (a random sample from the member countries of the EU), on oral health in the age groups 15 to 55 years old, using the self-reported indicator "how many of your natural teeth do you have"[12], tend to support the

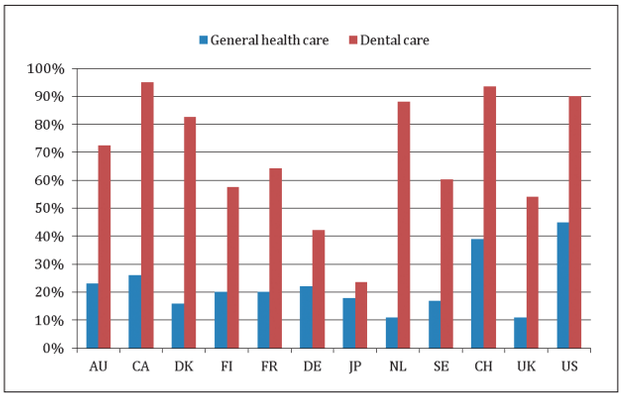

Fig 2 Total private payment for general health and dental care (%) in a selection of highly developed countries in 2010. References: 31,37,38.

observations of our study, which confirm the leading position of the Scandinavian countries with respect to dental status. The majority of the survey respondents, who stated that they still have all of their natural teeth, lived in Denmark (57%) and Sweden (55%).

Possible reasons for diverging performance levels

Independent of the healthcare system and its provider (public, private or public/private) or the differences in regulating and funding structures, good dental health can be achieved in any system. Consequently, diverging healthcare systems cannot explain variations in the efficacy of dental care systems. However, this conclusion is not surprising. Despite substantial differences in the general healthcare systems, a similar pattern can be found in all of the countries under study: dental care is regulated and funded separately from general healthcare owing to higher demand elasticity and lower intrinsic risk. While, in general healthcare, only a low degree of private financing is required, in dental care, so as to avoid a moral hazard, much higher proportions of private funding are evident (Fig 2).

In most of the countries under study, minors and the less fortunate are entitled to free or subsidised dental care, but normal adult patients usually have to pay high patient excesses per treatment (Table 5). With the exception of Germany and France, where tooth-preserving treatments are free or the excess is rather low, dental care and in particular prosthetic treatments have largely been removed from universal insurance coverage. Additionally, many countries offering universal health coverage changed their dental treatment coverage from a benefit-in-kind coverage to a predetermined reimbursement amount for standardised benefits[39]. This happened in the Netherlands, Germany, the UK and Sweden. All in all, we are left with the surprising finding that the funding structure of a dental care system does not predetermine oral health outcomes. Even if all treatments have to be financed privately, it is possible for the entire population to achieve a high dental health status, as can be seen for countries like Canada and Switzerland.

Nevertheless, apart from this outcome, the design of a dental care system does matter as far as patient satisfaction with access to care, affordability, a safety net for low-income patients and quality of care are concerned. In this regard, patients in the US and Australia express a remarkably high level of discontent, since almost one third or one quarter of the population, respectively, believe that their health system should be completely overhauled. These levels of discontent are three to four times higher than in European insurance-based systems[8,40]. Considerable dissatisfaction is also found with the Canadian dental system[41].

Another influencing factor regarding outcome performance could be oral health behaviour and attitude. 'Regular dental attendance' is chosen as the key indicator for this area because many studies show a correlation between the regular use of dental services and improved dental health[15, 42,43]. Using this indicator, findings show that regular dental attendance rates in adulthood have been well established for decades and reach 85% of the population in Sweden, where 70% to 80% are enrolled in a recall system, based on the clinician's initiative[23]. In Denmark, dental attendance rates steadily increased to over 90% amongst the 35 to 75+ age group[24]. Although the regular dental visiting habits of German adults aged 35 to 74 have also improved, from 60% in 1997 to 74% in 2005[35], the rate is still clearly below that of the two Scandinavian countries.

In Canada, the US, Australia and Japan, countries that exhibit a better level of dental health than Germany, the dental attendance rates are even lower (68%, 65%, 45% and about 40%, respectively)[36,42, 44,45]. For the US, Australia and Canada, this might be compensated for by the fact that, in these countries, large parts of the population benefit from water fluoridation (90% of Australians, 62% of Americans and 45% of Canadians)[46-48].

Another factor is presumably more relevant in explaining differences in dental health levels: the predominance of preventive and tooth-preserving treatment philosophies, the existence of an active oral health policy that sets goals and reviews them and the availability of accompanying scientific dental services research. All of these factors are present in countries that rank better than Germany, such as Denmark,

Table 5 Adult patient excesses (%) for selected dental services in European countries in 2013.

Treatment	DK	DE	FR	UK	NL	CH	CA
Extensive examination and consultation of a new patient	60	0	30	90	100	100	100
Two-surface direct filling of tooth 45	90	0/25[1]	30	82	100	100	100
Subgingival curettage	60	0	30	82	100	100	100
Root canal filling in tooth 46	20	0	30	82	100	100	100
Extraction of tooth 31	60	0	30	82	100	100	100
Bonded crown on tooth 21	100	72	82	89	100	100	100
Insertion of an implant in region 11	100	100	100	100	100	100	100
Fully veneered bridge from tooth 45 to tooth 47	100	82[2]	84	89	100	100	100
Model cast denture	100	56[2]	78	89	100	100	100
Full dentures in the maxilla and mandible	100	53[2]	92	89	25	100	100

1)Depending on technique (single layer or multiple layer); 2) without bonus.
References: 20 and 32

Sweden, the US, Japan and Australia. For example, in the case of Japan, the exceptional achievements in the dental status of adults, despite low dental attendance rates, are due to effective preventive and tooth- preserving efforts by dental services[25,45, 49]. These efforts were supported by the creation of the '80-20 Campaign' (1989), aimed at encouraging the preservation of 20 or more teeth up to the age of 80. The campaign was jointly initiated by Japanese health policy and the Japan Dental Association. A further extension of this development can be expected from the nationwide introduction (2009) of a new oral health program for adults created by the Japan Dental Association. It aims to change dental health examination programs from the traditional disease-finding type into a risk-finding and health-guidance type, which will also raise the unsatisfactory low rate of regular dental check-ups amongst adults[50]. An obstacle to the ultimate breakthrough for prevention amongst Japanese adults lies in the fact that the current social insurance system does not provide for preventive dental health maintenance[45].

In Germany, the above-mentioned factors are largely lacking, although the preventive orientation of German clinicians has improved over the last decade[51]. There is neither a noteworthy nationwide preventive and tooth-preserving treatment philosophy for adults (mainly due to imbalances in the clinicians' fee structure which favours invasive procedures and does not provide for remuneration, by the social insurance, of preventive treatments for adults). Also there is no goal-oriented oral health policy in existence since the paradigm shift in dental care that started in 1978 and ended in 2000, with the legislative anchoring of the preventive approach in dental care. Since that time, dental care has ceased to be a subject of consideration in health policy. The diverging treatment philosophies that characterise Swedish and German clinicans can best be demonstrated by the fact that, in Sweden, crowns and endodontically treated teeth have diminished dramatically, whereas these treatments are on the rise in Germany[21,23]. While, in German dental care, preventive treatment for minors is well established and practised nationwide, this approach has not been adopted in adult dental care – except in the case of a few general practitioners. Moreover, in contrast to Germany, Denmark introduced preventive dental care for adults in the social insurance system in 1988, forming the basis for risk-oriented intervention and individual instruction in oral self-care[15]. As far as remuneration for preventive treatments is concerned, dental systems, which are predominantly privately financed (the US, Australia, Canada and Switzerland), find it easier to reform their fee system in favour of preventive methods than self-administered systems, that operate on the basis of unanimous joint action on the part of the sickness funds and the dental professions (as in Germany). Also, in contrast to most other countries, scientific oral health service research is still in its infancy in Germany[21] and official nationwide oral health goals are not defined. Thus, adult dental care

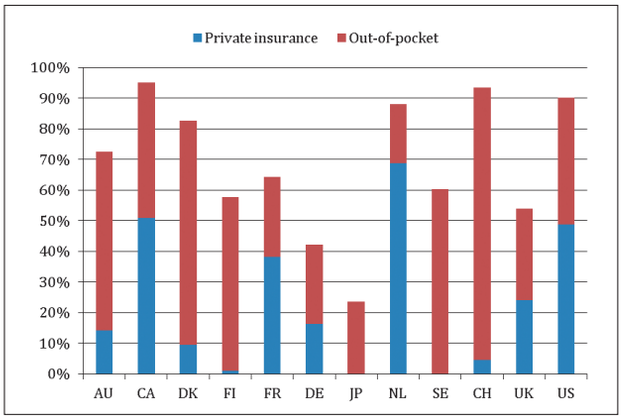

Fig 3 Private payments (out-of-pocket, private insurance) for dental care (%) in a selection of highly developed countries in 2010. References: 31,36–39.

in Germany develops in an uncoordinated and erratic manner and is hardly subject to evaluation by dental science. All of these shortcomings go a long way toward explaining why Sweden and Denmark and, to a lesser extent, the US, Japan, Australia and Canada perform better and are able to reduce the number of missing teeth in adults and edentulism in the elderly, faster than Germany. Although the relationship between preventive and tooth-preserving action and the performance of a dental care system does not necessarily prove to be cause and effect, this relationship is striking and noteworthy.

According to health economics literature, the amount of dental care expenditure depends, inter alia, on the form and size of the copayment and on patients' income level[52,53]. The most influential effect results from out-of-pocket payment. In this regard, Switzerland ranks first, while the lowest out-of-pocket rates are found in the Netherlands, Japan, Germany and France (Fig 3). At first glance, the low out-of-pocket contributions in the latter countries seem to be in contradiction to high excesses for adult dental treatments, as shown in Table 4. The explanation for this assumed contradiction lies in the fact that, in some of these countries, where dental care for adults has largely been privatised, patients feel compelled to take out private insurance, which attenuates the effect of a patients' excess. This is particularly relevant for the Netherlands, the US, France and Canada. Therefore, out-of-pocket and private insurance contributions must be considered together, in order to capture the real effect of private expenditure on cost levels for dental care. Total private payments are highest in Canada, Switzerland, the US, the Netherlands and Denmark and lowest in Japan and Germany. Interestingly, the Japanese example shows that good dental health can be achieved at a reasonable cost level without high patient excess.

Analysing the values in Figure 3, the macroeconomic cost levels of dental care should be relatively low in Canada, Switzerland, the US, the Netherlands and Denmark. Obviously, this is true for the Netherlands and Denmark and, to a lesser degree, for Switzerland and the US, where – owing to substantially higher levels of income per capita – the cost level is above average, when compared with the countries included here. On the other hand, in the two countries with the lowest share of private payments, the cost levels should be the most elevated. This is indeed the case in Germany, where the macroeconomic burden for dental care is excessive (Table 3), but it is not so in Japan (0.53%). A possible explanation for this discrepancy might be found in the fact that, in Japan, other factors effectively limit the trend towards rising dental costs. These factors could be seen as Japan's below-average income level and the strong tooth-preserving treatment approaches that are favoured by oral health policy and practised by the dental services. A similar relationship might explain why the UK manages its dental care system so efficiently, with just over half of the resources expended by Germany. The only country that does not fit into our explanatory model is Canada, a country with an average per capita income and a population with a favourable dental status, where dental care is almost completely financed privately and the cost level is nevertheless disproportionately high (0.77%). The cause of this discrepancy calls for a separate investigation. However, this would go beyond the scope of the present study.

After careful consideration, the assumption that sensible copayments for adults reduce overall dental expenditure and the costs of a dental system cannot be confuted by the international comparison. Germany had proven this assumption to be valid in the decade 1980 to 1990, when the country first introduced a 20% copayment for prosthetic treatments (1978), which it later doubled in 1989, with the consequence that total dental care costs, in terms of % of GDP, dropped from 1.16% in 1980 to 0.84% in 1990[21] and since then remained at that level. However, the relatively low copayment level that currently exists in Germany seems to be a cause for poorer performance in financial terms. These assessments are in line with the perception that, excluding the clinician's efforts, good oral health is strongly promoted by motivated and cooperative patients practising individual self care. On the other hand, because of low copayment levels and income-related out-of-pocket ceilings limiting annual costs for patients and families to 1% to 2% of income, barriers to dental attendance are

almost non-existent in German dental care, in contrast to countries such as the US, Australia, the UK, Finland and Canada. However, the Swiss example shows that even high levels of cost sharing, combined with annual limits and exemptions, as well as transparent pricing and billing, regardless of a patient's income, assures equity and allows for the budgeting of dental care costs[8]. Taking these experiences into account, an effective safety net can hardly justify the excessively high cost of Germany's oral health system. Strong evidence seems to indicate further potential for improving both efficacy and efficiency in German dental care persists.

On balance, the findings of the international comparison can be summarised as follows:

- good dental status on a population basis can be achieved in any health system, irrespective of the structures used for funding dental care;
- however, the cost of a dental care system is influenced by the extent and the design of patient cost sharing;
- if the share of total private payment is substantially below 50%, cost levels tend to be rather high unless other factors compensate for this effect. Depending on a country's income level, a cost level in the range of 0.5% to 0.7% of GDP seems to be the norm, when taken as a benchmark for an effective dental care system;
- a population's dental status is predominantly determined by the degree to which a preventive and tooth-preserving treatment approach – also for adults – is implemented in the dental service and supported by health policy and dental science.

Conclusion

The author hopes it was possible to prove that the proposed overall indicators and their interactions are useful and practical in application, reflect the oral health reality of a population as a whole, the changes a population undergoes and opens new horizons for optimising dental care systems. Additionally, the analysis conducted by means of the new composite indicators revealed that oral healthcare systems, which adopt a preventive and tooth-preserving approach, not only for the young generation but equally for adults, progress faster and perform better in terms of efficacy and efficiency. The combination of absence of preventive efforts aimed at adults and low incentives for patient collaboration seem to explain why Germany still has great potential for achieving a more efficacious and efficient dental care system. The findings of this study might also be helpful for developing countries like China, that is currently improving its healthcare system.

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