

Oral health in emerging countries and suggestions for adjusted care strategies

Abstract

Objective: Investigation into the oral health status of selected emerging countries from different regions of the world, so as to capture a broad spectrum of oral health reality prevailing in fast-growing middle-income countries, the aim being to present helpful steps towards adjusted strategies that improve the dental health of the entire population.

Method: Using a composite indicator, the Dental Health Index, the oral health of entire populations is measured and compared with the aid of these quantifiable results. The study relies on existing data, where possible, from national representative surveys.

Results: The best performer is the upper middle-income country of China. It is followed by India and Vietnam, two lower middle-income states, which placed second and third, although the two latter populations are largely untouched by professional dental activities. This finding is scientifically challenging to explain and needs further investigation. The relative wealthiest country, Malaysia, ranks in the sixth place while Brazil, with one of the highest dentist per capita ratios in the world, places only eighth, just ahead of the Philippines which ranks last in the study.

Conclusion: Over the last decade, the awareness and the willingness shown by all countries to improve their precarious oral care situations resulted in the successful implementation of dental care strategies. However, the main obstacles - the widespread shortage of dentists and the poor oral health awareness among the population, particularly those living in poor and/or rural areas - can only be overcome by development-stage adjusted strategies. The broad use of teledentistry (TD) and priority education and training of mid-level dental professionals could be promising instruments for solving these shortcomings in a manageable period of time and under limited financial resources. To attract additional financial and technical resources and expertise, public/private partnerships should also be encouraged.

Keywords: status of oral health in emerging countries, measurement of population's oral health status, oral care problems in emerging countries, macro-level comparisons of oral health, teledentistry in oral care

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Introduction

While abundant literature exists on oral health care in industrialised countries, the opposite is true for developing nations. Even in economically fast progressing middle-income countries, epidemiological data is scarce and – apart from general reflections^{1,2} - proposals for specifically designed oral health policies in those countries are rare. The World Health Organization (WHO) and the World Dental Federation (FDI) endeavoured to bridge this gap by creating the basic package of oral care (BPOC) and advocate this framework for the delivery of dental care in less developed countries.³

In this study, we focus on emerging countries that are characterised by a fast-growing middle-class and with large portions of the population living in remote or rural areas. Apart from epidemiological findings, such investigations into populations' oral health might also bring new insights into the natural course of dental decay, periodontal diseases and their interaction among populations that are hardly affected by professional activities.⁴ Against the background of a comprehensive analysis of the existing epidemiological data in these countries, we intend to put forward helpful proposals for appropriate and realistic long-term oral health strategies. Our reflections are founded on detailed studies bearing on achievements in the well-advanced oral care systems of high-income countries and their specific experiences over decades, as well as on the knowledge that emerging countries face quite different problems in oral health care compared with industrialised societies.^{5,6}

There is a complete divergence in the prevalence of dental decay in permanent teeth, measured by the DMFT (Decayed, Missing, Filled Teeth) index, between industrialised and developing countries. Whereas caries prevalence among the elderly in high-income societies, generally, ranges from around 25% (Australia) to 30% (Germany, Finland) the corresponding figures for emerging countries are more than 90% (e.g. Vietnam, China, South Africa)^{7,8} and the great majority of caries cases in the latter countries remains untreated. If any treatment takes place at all, it is mostly extraction and prescription.⁹ Moreover, caries prevalence and severity in the deciduous teeth of 5/6-year-olds are much higher in developing countries than in industrialised nations. This is similarly true for missing teeth in adults, most of which are not replaced, unlike in affluent societies.¹⁰

Especially worrisome is the fact that, in general, oral disorders are on the rise in many low and upper middle-income countries¹¹. Considering the huge treatment needs in developing nations, it is utopian to expect the acute dental care situation in emerging middle-income countries to be solved with an individual treatment concept that fosters restorative dental strategies and thereby neglects broad-based primary care, health promotion, prevention and early intervention/pain relief independently of traditional dental clinics. Tu et al., therefore, urgently advocate in favour of new population-based models for providing oral health according to the necessities of the low and upper middle-income countries.¹¹ As in the well-advanced dental care systems of the industrialised countries, between 5% and 6% of

the Gross Domestic Product (GDP) are earmarked for dental care,¹² this would mean that the entire health budget of developing countries would have to be directed towards the dental sector. For example, in 2020 lower middle-income countries and upper middle-income countries spent an average of 3.9% and 6.1% of GDP respectively on total health care.¹³ Whether genetic and/or dietary factors play a role in explaining the good ranking of India and Vietnam could not be clarified within the scope of this article.

Country comparisons of oral health status and its development over time are very limited in developing countries. This article seeks to close this gap and compares emerging countries from three continents, Asia, Africa and South America, to capture a broad spectrum of the oral health reality of advancing lower and upper middle-income states. The aim of this paper is to present an overview of oral health in these countries which, while progressing economically, are currently in the phase of building their social health systems. Based on robust experiences from high-income countries and on the findings of this evolutionary study, we attempt to outline a new, detailed approach to improved oral care provision in these emerging countries which have to overcome great obstacles during the transformation process to higher development stages.

Materials and methods

The empirical data were taken from the WHO/Malmö University global oral database. Systematic internet research for the latest scientific material on the investigated topics, served to supplement outdated or lacking data on certain indicators or age groups from specific countries. The research was conducted only in English-language publishing journals. In collecting the data, we used the WHO standard reference age classes for 5/6-, 12-, 35/44-, and 65/74-year-olds and added the value for missing teeth in seniors (65/74-year-olds) as this single indicator measures the cumulated defects across the course of life, and is therefore particularly informative for evaluation purposes.

The population’s oral health status is measured by the following composite overall indicator, the Dental Health Index:

$$DHI = (Caries-free Index 5/6 + DMFT 12 + DMFT 35/44 + MT Index 65/74 + Edentulism Index 65/74) : 5.$$

Table 2 Characteristics of the selected emerging countries around 2020^{16-19,21,23,37}

Country	GDP/capita PPP (current international \$) 2022	Δ GDP ¹ (in %) 2018/22	Population (in bn) 2022	Yearly change in %	Urbanisation rate (%) 2022	Access to fluoridated water in % 2012	Sugar consumption kg/cap./year 2021	Middle-class ⁴ (%) 2018
BR	17,823	1.5	0,215	0.52	88	41	46.9	51
CN	21,483	5.3	1,412	- 0.02	64	0	10.9	51
IN	8,400	4.1	1,417	0.81	36	0	18.6	6
ID	14,658	3.4	0,276	0.74	58	Common ³	24.3 ⁵	17
PH	10,137	3.2	0,116	1.54	48	0	24.0 ⁵	17
MY	33,525	3.1	0,34	1.09	78	72.8 ²	55.1	73
ZA	15,920	0.5	0,60	0.87	68	0	40.4 ⁵	22
TH	20,679	0.9	0,72	0.15	53	0	39.4	58
VN	13,461	5.7	0,98	0.68	39	4	15.2 ⁵	39

1.The percentages are biased by the corona epidemic; 2. 2020; 3. Mostly in the form of bottled water, but below the optimum level; 4. Definition: spending between 10-50 \$/day; 5. Data from 2012.

The current study is a descriptive and cross-national investigation using, where possible, existing empirical data from national representative surveys or broader data pools that allow generalising conclusions. If necessary, longitudinal data are used to consolidate

This means, the lower the DHI, the better the oral health status of the entire population. The calculation of the DHI is described in detail elsewhere.^{12,14}

The primary criterion in selecting the countries for this study was their status as economically fast-growing middle-income countries. They were subsequently disaggregated into lower and upper middle-income states from different regions of the world to explore the similarities of what is a large spectrum of countries in their individual stages of development. It was important that countries comprise populous nations and smaller ones in different geographic conditions. It was also imperative that a certain amount of national survey material on the age groups to be investigated and scientific studies on oral health matters connected to our topic, be available. Based on these criteria the densely populated China and India, the most populous nations of the world, and the large South American country of Brazil were selected, along with the very heterogeneous Indonesia, the world’s largest archipelago with 17,500 scattered islands and more than 300 ethnic groups. The comparatively less densely populated states of the Philippines and Vietnam and the smaller countries of Thailand, Malaysia and South Africa were also added. As one of the richest African states, South Africa was chosen because of its highly developed industrial and service sector, its well-established infrastructure and large, skilled workforce. The different development stages are shown in Table 1.

Table 1 Development levels of selected emerging countries, 2022¹⁵

Region	Lower middle-income	Upper middle-income
South America	-	Brazil (BR)
Africa	-	South Africa (ZA)
	India (IN)	China (CN)
	-	Indonesia (ID)
Asia	Philippines (PH)	Malaysia (MY)
	Vietnam (VN)	Thailand (TH)

Additionally, important country characteristics are shown in Table 2.

time-point related results. Owing to the cross-national study design, conclusions on cause and effect are limited, but it is possible to present evidence of relationships and influencing factors.

Results

To get the full picture of the oral health status of an entire population, we have to choose a meaningful overall indicator that includes all relevant age classes. This is why, the DHI was developed

and used in several studies relating to high-income countries.¹² It is now to be applied to a comparative study of emerging countries. Table 3 gives an overview of the single indicators and how they relate to the DHI.

Table 3 Population's Dental Health Index (DHI) in selected emerging countries around 2020 or nearest^{9,20,22-47}

Country	Survey year	Caries-free 5/6		DMFT 12 (2)	DMFT 35/44 (3)	M-T 65/74		Edentulism 65/74		DHI ² (6)	Rank
		%	Index (1)			abs.	Index (4)	%	Index (5)		
BR	2005/10/15/19	47	5.3	1.9	15.8	20.5	10	36.8 ¹	3.7	7.3	8
CN	2010/15	28	7.2	0.9	4.5	5.5 ⁵	3	9.0 ³	0.9	3.3	1
IN	2000/07/10/12	31	6.9	1.6	3.5	8.9 ⁵	5	18.5	1.9	3.8	2
ID	1995/07/14/18	10	9.0	3.2 ¹¹	4.5	16.3 ¹⁰	9	17.6	1.8	5.5	5
PH	2006/11/18	3	9.7	3.3	12.9	17	9	21.4 ³	2.1	7.4	9
MY	2010/17	38	6.2	0.8	10.7	22	10	32.2	3.2	6.2	6
ZA	89/00/02/10/16	31	6.9	1.1	12.3	25.2 ⁹	10	34.2 ³	3.4	6.7	7
TH	2017	24	7.6	1.4	6.6	10 ⁴	6	8.7 ⁴	0.9	4.5	4
VN	2001/09	27 ⁸	7.3	1.9	4.7	8 ⁶	5	5.9 ⁷	0.6	3.9	3

1. ≥ 60; 2. DHI = [(1) + (2) + (3) + (4) + (5)] : 5; 3. 60-69; 4. 60-74; 5. Ref. to 28 teeth; 6. South Vietnam; 7. ≥ 50y; 8. 5y, rural areas; 9. Cape Town; 10. 65y, 11. Jakarta and Satellite Cities (representative for Indonesia).⁷²

When analysing the findings, it is necessary to realise, that qualitative assessments of the results (e.g. good/less good, favourable/unfavourable) may only be interpreted as relative evaluations within the group of emerging countries studied, unless the findings fall within internationally defined categories (e.g. *very low/low/moderate*). A look at the caries-free 5/6-year-olds reveals that, with nearly 40% to 50%, Brazil and Malaysia show better results than the other countries. Almost no children in the Philippines are caries-free. If these findings are compared with results from highly developed countries, where the percentages lie between 40% and 79%,¹² the values in the emerging countries are on average half as good, with the exception of the Philippines.

As deciduous teeth may influence the health of permanent teeth in 12-year-olds, it is helpful to get a more detailed insight into the status of the deciduous teeth of 5/6-year-olds by additionally using the dmft index (decayed, missing, filled milk-teeth) in these countries (Table 4).

Table 4 Trend of prevalence of deciduous teeth (dmft) among 5/6-year-old preschoolers in emerging countries^{23,24}

Country ¹	Period	Period	Δ absolute
BR	1990: 3.0	2015: 1.9	- 1.1
CN	1997: 5.9	2015: 4.2	- 1.7
PH	1999: 9.8	2011: 5.6	- 4.2
MY	1997: 4.1	2007: 3.9	- 0.2
ZA	1998: 3.2	2013: 2.5	- 0.7
TH	2006: 5.4	2017: 4.5	- 0.9
VN	2001: 6.2	2015: 10.4 ²	+ 4.2

1. For IN and ID comparable data are missing; 2. Hue region.

In most of the countries under study, the prevalence of carious deciduous teeth diminished slightly over the last 10 to 20 years. Greater progress was achieved in the Philippines (-4.2 percentage points) and in China (-1.7 percentage points), whereby the improvement in the Philippines is striking as almost no preschoolers are found to be caries-free (Table 3). On the other hand, the values for Vietnam reveal that caries in deciduous teeth is rampant and treated in less than 5% of cases.²⁴ Nguyen et al. see the reason for this grave deterioration in the fact that children in public kindergartens are fed sweet snacks, such as

pudding or yogurt as well as milk containing sugar, on a daily basis²⁴. With regard to the treatment of deciduous teeth by means of filling, even in high-income countries (e.g. Germany) only 43% of carious milk teeth in 6/7-year-olds are treated by filling or extraction.²⁵

The DMFT values of 0.8, 0.9, and 1.1 for 12-year-old Malaysian, Chinese and South African adolescents, respectively, are indeed remarkable. These results fall within the WHO category of *very low* (<1.2)⁴⁸ and correspond to values known from highly developed countries. Three countries (TH, BR, IN) and even Vietnam belong to the category *low* (<1.2-2.6). The example of Vietnam shows that the dependence between caries prevalence in deciduous and permanent teeth is not as close as theory often suggests. Only Indonesia (3.2) and the Philippines (3.3) exhibit *moderate* caries affection (<2.7-4.4). As the basis for life-long good oral health is laid in the young generations (5/6- and 12-year-olds), young people in most of the emerging countries have a comparatively favourable starting point, whereas the youth of Indonesia and the Philippines are off to a worse start in terms of their oral health future.

In Malaysia for example, the prevalence of caries-free 6-, 12- and 16-year-olds increased steadily between 1996 and 2018/19 to values of 37.9, 71.4 and 56.9 respectively. The projection up to 2030 for these three age groups predicts caries-freedom figures of 50.9%, 85.7%, and 56.9%.²⁰ The observation that caries-freedom in 6-year-olds is lower than in the higher school ages can be explained by the fact that only 32 % of preschool children and 18% of toddlers received primary dental services in 2019, while 95% of primary and secondary pupils participated in comprehensive incremental dental care, including school-based fissure sealants, introduced in 1985.²⁰ The high caries-free prevalence of 12-year-olds can also be attributed to broad access to water fluoridation (72.8%).^{49,50} The fact, that prevalence of caries-freedom has been used as an indicator here, illustrates the prioritisation of prevention and early intervention in the young generation by Malaysian oral health policy. Policy is oriented towards a 'caries-free' future rather than caries treatment.⁵¹

As the DMFT values for adolescents are time-point related, it is useful to know whether these data are reliable in the long term. This is true for Malaysia and Brazil, where the DMFT values have experienced a substantial and steady decrease over the last fifteen years. Also in the Philippines, which started from a much higher

level, the DMFT improved slightly over the same period. In China, South Africa, India, Thailand and Vietnam, the values remained stable at their *very low* or *low* levels throughout the last one and a half decades.²³ Only in Indonesia has the DMFT value oscillated around 2 to 3 over the last twenty years.^{23,47}

A sharp increase in caries prevalence takes place between 12-year-olds and middle-aged adults. The increase in caries burden is particularly distinct in Malaysia and South Africa (\approx tenfold) and Brazil (\approx eightfold), whereas the rising caries prevalence in Indonesia, India and Vietnam is extremely moderate (Table 3). It is highly noteworthy that the drastic increase in caries prevalence between adolescents and middle-aged adults is alike in both emerging and high-income countries.¹² However, there is a decisive difference between the two country types. This difference lies in the composition of the DMFT values, which are similar in 35-44-year-olds. In emerging countries, the DT-component is very high while the FT component is near zero whereas in high-income countries it is precisely the contrary with DT <1 and FT very high, meaning that virtually every cavity is filled.

A more precise look at the DMFT values in middle-aged adults reveals differences ranging from 3.5 (IN) to 15.8 (BR). The majority of middle-aged people exhibit a low caries burden, between 3.5 (IN) and 6.6 (TH). Only South Africa, the Philippines and Brazil, in particular, show higher values of 12.3, 12.9 and 15.8 respectively. The relatively high values among the middle-aged Brazilians are striking because the caries burden in 6- and 12-year-olds is not distinct, and the dental health of young adults increased substantially between 1986 and 2010.⁵² On the other hand, considering that caries prevalence peaks in the age classes 6, 20-24 and 60-64,⁵³ the very low DMFT levels in middle-aged adults in India, Indonesia and Vietnam are surprising, all the more because manifest caries is usually not treated.

Against the background of predominantly moderate DMFT values in 35/44-year-olds, combined with the widespread paucity of filling treatment, it is exciting to observe the oral health development as the population grows older. First, the figures for missing teeth in seniors (65-74) are insightful. A dichotomy is obvious among the countries. Countries like China, Vietnam, India and Thailand exhibit rather low MT values (5.5-10), whereas the rest of the countries (ID, PH, BR, MY, ZA) present much higher figures (16-25) in the area of missing teeth. The low MT in seniors corresponds to the DMFT values of middle-aged Chinese, Vietnamese, Indian and Thai citizens. Also, the high DMFT figures in 35/44-year-old Brazilians and Filipinos (15.8, 12.9 respectively) are on par with the high number of missing teeth in seniors (20.5, 17 respectively). Severe tooth loss defined by <10 remaining teeth occurs in almost half of 60-79-year-old Brazilians,⁵⁴ indicating the somewhat low effectiveness of the comparatively advanced Brazilian dental system. However, what is hard to explain is the huge difference among Indonesian citizens, with a low DMFT in adults aged 35/44 (4.5) followed by a high MT value in seniors of 16.3 (Table 3) later in life. Worthy of note as well, are the figures for missing teeth among Malaysian and South African seniors who present values of 22 and 25.2 respectively.

There should be a strong dependence between figures for missing teeth and edentulism in seniors. This is particularly so in Brazil (36.8%), South Africa (34.2%) and Malaysia (32.2%). Again, the percentage of edentulous seniors is comparatively low in Vietnam (5.9%), Thailand (8.7%) and China (9%). Indonesian and Indian seniors exhibit edentulism rates of 17.6 and 18.5% respectively (Table 3). When comparing the range and level of average figures for missing teeth and edentulism in seniors of emerging countries (MT: 5.5-25; edentulism: 5.9% -36.8% respectively) with those of the ten

best-performing high-income countries (MT: 4-12; edentulism: 2.7%-21.7% respectively),¹² it is obvious that the degree of restoration largely explains the difference in oral disorders at high age where the effects of the absence of treatment cumulate in the majority of the emerging countries. However, the low figures pertaining to missing teeth and edentulism in seniors in Vietnam, Thailand and China are not worse than the comparable average values for seniors from high-income countries. This remains a mystery which can hardly be explained solely by the lack of oral therapy.

To illustrate the different oral health realities in emerging and industrialised countries, we contrast the outcomes of the leading emerging country (China) with the foremost among the high-income countries (Sweden, SE) and a country (Germany, DE) that also shows good oral health but in a less elevated form (Table 5).

Table 5 Oral health outcomes in the leading emerging (CN) and the leading high-income country (SE) and a less well performing high-income country (DE) 2015-2020¹²

Country	Caries-free 5/6 (%)	DMFT 12	DMFT 35/44	MT 65/74	Edentulism 65/74 (%)
CN	28	0.9	4.5	5.5	9.0
SE	79	0.8	9.7	4	2.7
DE	>62	0.44	11.2	11.1	12.4

Data from Table 3.

It must be pointed out that the filling rates in China (12y: 47.5%; 35/44y: 26.6% and 65/74y: 12.8%)⁵⁵ are slightly better than in most of the other emerging countries and that in Sweden - the benchmark for all highly developed countries - nearly 100% of adults up to the age of 60 enjoy full dentition.⁵⁶ The pure results of these two differently developed countries are not as far away from each other as one would have expected. First, they show what a well-designed dental system can achieve by providing prevention-oriented oral care from the beginning of a child's life along with consistent tooth-retaining practices up into old age. The comparison between China and Germany unveils a retention of natural teeth in Chinese seniors, measured by MT values and edentulism rates, that is much higher than in Germany, which appears confusing (Table 5). Certainly, more seniors are still more dentate in Germany than in China; however, this is only because their cavities are replaced by artificial teeth, which is not regularly the case in the emerging country of China. Now, how is this finding to be explained? The prevailing treatment philosophy and the scale of dental fees could have a role to play. Dentists in affluent societies might more often assess teeth as not worthy of preservation and instead recommend a denture. However, the Swedish example proves that it is possible to save even strongly damaged teeth and retain largely complete dentition up to a high age without extracting restored teeth earlier than necessary. In emerging countries, the opposite is the case: there, teeth are predominantly extracted due to pain and are usually not replaced because of high treatment costs and a general reluctance to seeking care. As dental treatment in these countries is largely financed out-of-pocket, oral care is only sought in acute situations. Under those circumstances, citizens from emerging countries may retain more teeth, including tooth remnants, because they cannot afford to have bad teeth extracted.⁵⁷

In the case of the Vietnamese people, who on average have a low level of caries, it is surprising to find that subjects living in urban areas show a higher prevalence and severity of caries than rural people, although urban citizens are better educated and enjoy healthier living conditions.⁴ Based on the assumption that the process of the economic and social transformation of society leads to a rapid growth

of the urban population, particularly among the young generation, dietary patterns are likely to be changing to more cariogenic foods, which could cause more dental diseases. This is why Do et al. fear a deterioration in the oral health of the adult Vietnamese population in the future if health policy does not implement protective measures to combat this trend.⁴ However, other and more recent studies do not confirm the finding of a higher prevalence of oral disorders in urban citizens.^{39,40}

The documented single indicators produce the following overall indicator for a population’s dental health, the DHI (Table 3). The best oral health status is achieved by the upper middle-income country of China with a DHI of 3.3. This result is validated by long-term longitudinal nationally-representative survey data whereby, over the last twenty years, the

- a) DMFT rate for 12-year-olds remained stable at a *very low* level,²³
- b) the preventive inspection and counselling rate increased to about 40%,
- c) caries prevalence reduced strongly in 35 to 74-year-olds,
- d) caries filling rates improved considerably in all age groups,
- e) tooth loss, on a low level, was concentrated only among seniors and
- f) the repair rate of dentures rose significantly from 40.1% (2005) to 61.5% (2015).⁵⁵

In other words, the oral health status of Chinese people improved substantially and there was a notable increase in the utilisation of dental services. Two lower middle-income countries, India and Vietnam,

ranked in second and third place. The lowest DHI was measured for the Philippines (DHI: 7.4), another lower middle-income country. What is striking is the fact that the wealthiest upper middle-income country, Malaysia, ranks only in sixth place with a DHI of 6.2. This means that the dental health of the Malaysian people is about half as good as that of the best-ranked country, China. Despite it being the world’s most populous country with challenging living conditions and major remote areas, China’s top ranking comes as no surprise because it leads in most of the single indicators. This is impressive, as in such large-scale countries with extreme climate zones the oral health facilities are difficult to establish and maintain. Since these conditions also exist in India, another large country, with a much lower level of wealth compared with all the other investigated countries (Table 2), the fact that it takes second place is quite unexpected.

The results of population’s dental health ranking in the emerging countries studied, harbours surprises and requires interpretation. Consequently, it would be helpful to construct an overview of the characteristics of these emerging countries’ dental systems (Table 6). What immediately stands out is the fact that countries with a comprehensive benefit catalogue and broad government coverage of oral health care costs, such as Malaysia and Brazil, neither lead the ranking, nor do they achieve the best oral health outcomes by comparison. On the contrary, they rank sixth and eighth, far behind China, India and Vietnam (Table 3), all countries with currently rudimentary or practically non-existent (VN) dental systems, although in the field of medical care, the Vietnamese social health insurance covers 87% of the population and the premiums for socially vulnerable people are fully subsidised.⁵⁸ Detailed proposals for a primary oral health care system in Vietnam were recommended by international and Vietnamese experts in 2000.⁵⁹

Table 6 Dental care system characteristics in selected emerging countries, 2021^{24,60,61}

Available procedures for detecting, managing and treating oral diseases in the primary care facilities in the public sector:	BR	CN	IN	ID	PH	MY	ZA	TH	VN
-Oral health screening for early detection of diseases	yes	yes	yes	yes	yes	yes	yes	yes	no
-Urgent treatment for emergency care and pain relief	yes	no	yes	yes	yes	yes	yes	yes	no
-Basic restorative procedures to treat manifest dental decay	yes	no	yes	yes	no	yes	yes	yes	no
Oral health interventions as part of health benefit packages:									
-Coverage of the largest government health financing scheme (% of population)	80	95	30	84	92	100	85	80	87 ¹
-Routine and preventive dental care	yes	yes	yes	yes	no	yes	yes	yes	no
-Essential curative dental care	yes	no	yes	yes	no	yes	yes	yes	no
-Advanced curative dental care	yes	no	no	yes	no	yes	yes	yes	no
-Rehabilitation dental care	yes	no	no	no	no	yes	yes	no	no

Dental services are not covered by the social health insurance, except for children under six

However, these have not been fully implemented to date. Nevertheless, an important step was taken by incorporating BPOC into the curricula of all three Vietnamese dental schools and by obligating dental graduates to work for at least up to three years in government postings³ in order to foster community-based primary oral care.

The oral care systems of China and the Philippines are also in the process of development. Nevertheless, China reveals more favourable oral health conditions compared with the other countries. This astonishing fact leads us to conclude that existing health care systems in emerging countries are an important but not sufficient condition for achieving satisfactory oral health in the population. We will now move on to evaluate other influences that might play a decisive role. To this end, we need to take a look at the dental infrastructure and the oral care habits obtaining in the countries observed. Table 7 offers an overview, whereby the results of fluoride exposure in the countries studied should also be kept in mind (Table 2).

As dental decay primarily can be prevented by low sugar intake, sufficient fluoride exposure, regular tooth brushing with fluoridated toothpaste and - in countries with advanced oral awareness and accessibility to dental services - regular preventive dental check-ups, Table 7 shows the current reality of dental behaviour and existing dental infrastructure. The dental workforce, measured by dentists per 10,000 people, is highest in Brazil, with a dentist/population rate which is five times higher than in South Africa, Indonesia and India and more than sixteen-fold that of Vietnam. However, the oral status of the current Brazilian population (rank 8), measured by DHI, reveals that more dentists obviously does not inevitably mean better oral health. Brazilians predominantly brush their teeth almost three times per day, a majority uses dental floss, they have a high rate of access to water fluoridation (41%) and a low smoking rate, but they have an extraordinarily high daily sugar intake (108 g/day).

Table 7 Dental infrastructure and oral care habits in emerging countries around 2020⁶²⁻⁷⁵

Country	Dentists /10,000 people	Dental visits/year (%)	Tooth brushing ≥ twice/day (%)	Dental floss/toothpick (%)	Sugar consume/capita (g/day)	Smokers (%)	Existing oral health policy and goals
BR	6.68	42 ¹	mostly 3 times	67.5	107.7	13.2	yes
CN	4.52	40	88	29	19.1	25.7	yes
IN	1.6	28	45	-	53.8	28.1	yes
ID	1.24	≈ 4	49.2 ⁴	-	66.1	37.2	developing
PH	2.49	33 ²	76	-	57.8	23.4	yes
MY	3.0	51	34.4	8.4	116.1	22.8	yes
ZA	1.11	<10 ⁵	63 ⁵	34 ⁵	82.1	20.4	yes
TH	2.55	19	76.1 ⁶	-	117.3	22.5	yes
VN	0.4	24 ³	56.6	-	27.6	25.0	no

1. Thereof, 19% treatment; 2. Every two years; 3. Within more than two years; 4. Thereof, 37.2% only once; 5. Students 18-24 years; 6. Thereof: 35.8% only once.

China, on the other hand, ranks first despite having no water fluoridation. This circumstance illustrates that more dentists can most certainly help to achieve satisfactory oral health, if other factors are also fairly favourable. Such factors would include: their high frequency of tooth brushing combined with some dental flossing, a dental attendance rate of 40%, which is very favourable for emerging countries, and the lowest daily sugar intake of all the countries studied (Table 7). A source of surprise is the good ranking (ranks two and three) of India and Vietnam, two lower middle-income countries with rudimentary oral care facilities. They both reveal a very low dentist/population rate (1.6, 0.4 respectively), and a low dental attendance rate (≈ 25%). Only half of their population brush their teeth twice a day. However, their citizens have a relatively moderate to low daily sugar intake (IN: 53.8g; VN:27.6g) while their smoking rates are comparable elevated (Table 7). In both countries, access to water fluoridation is either non-existent or insignificant (Table 2). However, these countries perform better than countries such as Brazil, South Africa and Malaysia, which - for emerging countries - possess relatively advanced oral care systems (Table 6). Maybe, genetic and/or diet factors play a role in explaining the good ranking of India and Vietnam. Though, the clarification of this possible connection goes beyond the scope of this article.

The remaining countries (MY, TH, PH) have significantly better dentist/population rates (3.0-2.5) than India and Vietnam, but perform less well. Although the relatively well-off Malaysia boasts a high level of water fluoridation (73%) and exhibits comparatively elevated dental attendance rates, tooth brushing habits in both Malaysia and Thailand are highly insufficient and the daily sugar consume is quite extreme.

The countries of Indonesia and South Africa share a similar low dentist/population rate, a negligible dental attendance ratio, and comparable tooth brushing habits, although South Africans seem to practise some dental flossing (note: although, the interviewed subjects were technology students, which might render the values unrepresentative, no other empirical data were available). Moreover, the daily sugar intake is fairly high in both countries (Table 7), whereby Indonesia has the advantage of having high fluoride exposure in the form of fluoridated bottled drinking water (Table 2). Otherwise, at 37%, Indonesian’s smoking rate is the most elevated of all societies observed.

The last rank in our comparison falls to the Philippines. This population has no water fluoridation, nearly the same dentist/population rate (2.49) and a comparable dental attendance rate as Thailand, but better tooth brushing habits (76%, twice/day) and moderate sugar consumption compared with the other countries.

Nevertheless, the Philippines perform worse than the other countries as far as general oral health status is concerned.

When comparing the population’s oral health status of high-income countries, it is sufficient to measure only dental decay values, because periodontal destruction (CPI 4) is indirectly captured in the DMFT figures. If the periodontally damaged tooth is successfully treated, the DMFT remains unchanged, otherwise the untreated tooth will – in the long run - be lost and the MT component will rise. This relationship does not exist in emerging countries where most periodontal diseases are not treated. Therefore, additional indicators are needed to measure the periodontal burden in order to demonstrate the whole morbidity structure surrounding oral health. In WHO’s database on periodontal health profiles, scores are based on the Community Periodontal Index (CPI). As CPI grades 1 and 2 are easily reversible, only grades 3 (shallow pockets) and 4 (deep pockets), indicating periodontitis, are documented as they are in special need of treatment.

The highest prevalence of periodontitis (Figure 1) exists in Malaysian adults (60%), followed by Chinese adult citizens (50%). India and Brazil are less affected, whereby findings from a newer study reveal increased figures of over 50% for the Brazilian population.⁷⁶ The average distribution of periodontitis in lower middle-income (10%) and upper middle-income countries (42.5%) differs significantly,⁷⁷ whereas between high-income (43.7%) and upper middle-income countries the prevalence levels are almost equal. The highest prevalence rates of periodontitis in high-income states are partly explained by the fact, that, in these countries 25% of the population are over 60 years old, while in many emerging African and Asian countries this part of the population comprises only 5%.⁷⁸ Thus, measured against these benchmarks, Malaysia, China and presumably Brazil are affected above average by the burden of periodontitis.

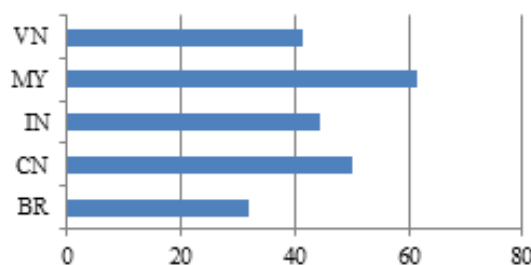


Figure 1 Occurrence of periodontitis (CPI 3 + 4) among adults aged 35-74¹ in selected emerging countries 2010-2012² or nearest (in %).^{4,23,76}

1. Mean of 35/44 + 65/74; 2. Countries with obsolete figures from the 1980’s are not documented; 3. Vietnam: Mean of 35/44 + 45+.

In the case of China, this is surprising considering its good DHI value (3.3). A lower periodontal burden would have been expected. On the other hand, as periodontal diseases are rarely treated and the oral habits of Chinese citizens are far from perfect, the high occurrence of gum diseases might be plausible. It is then all the more striking that on average Chinese seniors loose only few teeth (Table 3). As these relationships between dental decay and periodontal disease are not quite clear, Nazir et al. assert that the prevalence of periodontal diseases in different groups and differently developed countries is not 'fully understood'.⁷⁷ In this connection, a great large-scale review of 75 studies found that the prevalence of severe periodontitis rises with age but peaks in 40-year-olds and then stabilises.⁷⁸ However, other studies emphasise that the severity of periodontal disease advances with growing age.⁷⁷ Noteworthy, too, are the high periodontal affection rates of India and Vietnam compared with the average distribution of periodontitis in lower middle-income countries. The newest figures for Vietnamese seniors even show excessively high periodontitis prevalence rates of 83.3%.³⁹

Discussion

In the following passage we discuss suggestions for improving oral health provision in the emerging countries under study, whereby it is clear that although all of these countries have similarly difficult starting conditions, there is no one-system-fits-all solution. The existing dental realities in the countries are too complex for that. To begin with, we will focus on solutions for overarching problems and then concentrate on country-specifics. Despite divergencies between the emerging countries studied with regard to geography, topography, a variety of ethnicities and development stage, there are many commonalities concerning the field of dental care in terms of morbidity structures, oral health literacy and behaviours, demand for oral care and dental service utilisation. For example, in most of these countries.

- a) caries prevalence in deciduous teeth is very high (71%-88%),^{55,79}
- b) caries prevalence in the adult population is often rampant (77%-94%),^{9,55,79}
- c) most decayed teeth remain untreated (68%-89%),^{9,6,32,36}
- d) if there is treatment, it is mostly extraction and prescription,^{5,9}
- e) dental service utilisation is rudimentary (10%-31%),^{34,80-82}
- f) oral health literacy is at best 40% (MY)⁸¹, mostly lower (BR: 28.5%),⁸³
- g) oral health awareness is hardly existent across large parts of the population,
- h) correct tooth brushing is extremely seldom (ID: 8.5%),⁷³
- i) adequate nationwide dental facilities and workforces are widely lacking⁸⁴ everywhere, except in Brazil, where, on average, the dentists/population ratio is sufficiently high, but distribution is very uneven (mostly in urban areas)⁸⁵ and
- j) most people in rural and remote areas cannot afford or are unwilling to pay for dental services.

Furthermore, all emerging countries are characterised by a fast-growing middle-class. In Malaysia, Thailand, Brazil and China this part comprises already more than half of the population. However, in the remaining countries (Table 2) this sector accounts for a substantially lower proportion of the population (6% to 39%), which means that the majority or relevant parts of the populace live in poor

urban regions or in the countryside/remote areas. The care needs of these two distinct sectors of the population are necessarily different. The better-off members of the urban population expect individually-oriented dental concepts, while the majority needs community-based primary care focusing on oral health awareness, education and promotion, on self-care oral hygiene and simple treatments, such as pain relief, simple fillings and/or extractions. Against this background, with the currently existing structures and health-policy frameworks, it will hardly be possible to solve the dental problems of underserved people in the emerging countries. However, times of transition when oral health policies are still in the designing and experimental phase in most of the emerging countries, might present promising opportunities for new approaches towards completing existing schemes or strategies from which the broad population could benefit. In addition, openness towards new solutions in oral care systems is much higher if structures are not already firmly established and there is no resistance from professional groups to be overcome.

Another similarity existing in all of the emerging countries studied, is decisive, namely the fact that they all have easy access to electricity (apart from occasionally problems in South Africa) and to the internet, as well as a high rate of mobile phone usage (Table 8). This enables full use of digital technologies by health professionals and potential patients in nearly all parts of these countries. This new tool is essential for all emerging countries, irrespective of how advanced their dental care system is (e.g. Brazil, Malaysia) and even for Brazil where the more than sufficient number of dentists is, unfortunately, unevenly distributed. In this context, we need to remember that a sufficiently large dental workforce in emerging countries means having limited numbers of dentists and large numbers of dental auxiliaries.⁵⁹

Table 8 Telecommunication infrastructure in selected emerging countries 2021/2022⁸⁶

Country	Access to electricity (%)	Mobile cellular subscriptions (per 100 people)	Internet user (%)
BR	99.5	99	81
CN	100	125	76
IN	99.6	81	46
ID	99.2	115	66
PH	97.5	144	53
MY	100	141	97
ZA	89.3	167	72
TH	100	176	88
VN	100	140	79

Thus, the great opportunity to overcome the crucial shortages of dentists and other dental professionals in rural and remote areas of emerging countries upon which everything in oral care depends, lies in information and communication technology (ICT) and more precisely in teledentistry (TD). In the long run, the use of this technology might even help to close the gap in oral health status between these nations and the high-income countries and opens up the possibility of skipping an entire stage of development. If emerging countries succeed in creating frameworks that foster prevention and tooth retention in early childhood, instead of establishing concepts that rely on restorative and rehabilitation procedures for their well-educated urban adult citizens, they could avoid higher caries prevalence rates in the middle-aged and much of the tooth loss in seniors, thereby saving substantial financial resources. Germany, a high-income country, was able to successfully implement this paradigm shift at the end of the last century, in the face of great resistance on the part of professional groups.⁸⁷ Since that time, the oral health of German citizens has steadily improved.¹²

To overcome the key shortfall in the provision of dental care in emerging countries – the widely lacking oral services in rural and remote areas, where major parts of the population live – we propose the integration of TD into the public health service's primary oral care activities. According to Tella et al. TD offers vast potential for oral health care in emerging countries.⁸⁸ This modern tool is capable of overcoming the hitherto limiting factors of time, distance and trained manpower, which would otherwise prove unsurmountable. TD can enhance system-efficacy (oral health outcome) and -efficiency (relation between benefits and costs), provide access to the underserved population, offer diagnoses and recommend treatments over long distances, improve quality of care and enforce dental education and training for dental nurses and dental auxiliaries.⁸⁸ The latter point is particularly important because training dentists requires at least six years and is extremely cost-intensive while the use of TD calls for only a few dentists and/or well-trained dental hygienists to superwise a pool of dental nurses, dental auxiliaries and dental health workers. Thus, local dental ancillary personnels trained in BPOC-procedures could constitute the primary resource for training and promoting oral health knowledge and practices at rural primary oral care facilities, preferably in combination with the appropriate medical staff.³

This would be a low-cost model to enable dental examinations in remote areas where no oral medicine ward is available.⁸⁹ The applicability of TD has been demonstrated in industrialised countries (e.g. Australia, Sweden, Italy, USA) and in emerging countries such as Brazil, India, China and some Latin American states as well as in various dental patient groups.⁸⁹ The feasibility of managing oral lesions via images sent through emails has been proved by a Brazilian study, which concluded that the use of email and digital cameras for TD is beneficial in rural and remote parts of the country where medical specialists are absent.⁹⁰ To overcome the shortage of mid-level dental care providers in underserved areas of Arizona/USA, health legislation in 2004 allowed dental hygienists to provide dental care in underserved populations by permitting them to send digital diagnostic data from rural/remote settings to a distant dental professional team. This model places one or several dental hygienists in the role of mid-level practitioners by digitally linking them to a dental care team at a clinic or a dental practice from where their primary care activities are managed and guided.⁹¹ This initiative is a role model for emerging countries to enable them to provide oral hygiene, oral health knowledge, correct tooth brushing instruction, and simple treatments (e.g. atraumatic restorative treatment, ART).⁸⁸ Studies show that dentists are quite open-minded towards serving patients in remote areas by means of TD⁹² and the resistance to mid-level professionals might be low, as dentists do not compete with them in these underserved areas. In their study, Tantawi et al. provide some insight into how TD is currently practised worldwide, showing that TD is mostly practised at local level and as informal project.⁹³ In summary, they concluded:

- a) TD policies and laws at national level facilitate its implementation, as the countries of Finland (TD programme at intermediate level) and Saudi Arabia (piloting a national strategy) demonstrate.
- b) The second generation of TD (robotics) may enable indirect interventions in remote areas using the internet, as is being tested by China,⁹³ although currently only 52% of dentists are supportive of TD.⁹⁴
- c) Although high mobile use and great internet coverage (>90%) are essential in implementing TD, Zimbabwe, a lower middle-income country with very low internet coverage, is still able to maintain a local remote patient monitoring system providing TD services.⁹³

d) Different stakeholders drive TD programmes. In Canada and Finland, provincial health centres initiated TD, in Saudi Arabia and the United Kingdom national governments took the lead, while in Egypt and Zimbabwe private companies operate TD. In China, several university clinics were the first movers in the practice of TD.⁹³

e) As initial costs are high and knowledge in the field of TD is limited in emerging countries, seeking technological expertise to implement TD and pursuing public/private collaborations between governments and ICT or other multinational companies such as IBM, Philips, Apple, Unilever, Colgate/Palmolive, Wrigley's Orbit etc., hold considerable promise.

In 2021, the World Dental Federation (FDI) published a fact sheet on evidence-based TD showing how dentists can use this tool in their practice, to improve patient care. They emphasized particularly the societal benefits of TD for underserved parts of the population.⁹⁵ The current knowledge on TD, summarised by Goffin et al. concludes similarly that the advantage of TD 'lies in expanding the reach of care.'⁹⁶

Some surveys on dentists' attitudes against TD have shown these to be based on poor knowledge and scant practice of TD among general dental practitioners. In this case, the majority of the study participants expressed positive attitudes and openness towards practising TD in the future.⁹⁷ When questioned as to the preferred field of application for TD, over 80% of dental professionals favoured community dentistry.⁹² That choice recognises the lack of dental services in the rural areas of emerging countries. Under these circumstances, the task of finding, educating and training limited groups of especially motivated dentists to serve in oral public health, as oral health managers supervising teams of mid-level dental professionals in remote areas, should be achievable within a manageable period of time.

Evidence exists that, like dental hygienists, mid-level dental professionals are just as able to identify dental decay in children from photographs as dentists can in a clinical setting.⁹⁸ It is also proven that mobile phone TD is reliable enough to establish an initial diagnosis of caries in children.⁹⁹ Furthermore, a large-scale, systematic review of patient satisfaction with TD in rural and remote settings revealed high patient satisfaction. The method was seen as so reliable and effective for patients in these areas that the authors recommend encouraging TD in similar parts of the country.¹⁰⁰ The same is true for dental therapists, who get a two to three year academic education in dental hygiene and dental therapy, and deliver quality care comparable to dentists.¹⁰¹⁻¹⁰⁴ Patient acceptance and satisfaction is evidenced in countries like New Zealand, Australia, the Netherlands, Malaysia, Thailand and Vietnam.¹⁰¹

In the light of scarce resources allocated to health and particularly oral health, it is vital to set priorities for certain parts of the population, the goal being, to obtain the best oral outcomes with the least expenditures, whereby the perspective should be a long-term one. For countries with a complete benefit catalogue and high insurance coverage (BR, MY), our suggestion would be, to maintain the present provision for the urban population while prioritising service to the poorer urban and rural population, beginning with programmes for mothers and their children, school-based tooth brushing training supervised by specially trained teachers, trained mothers (known as 'school dental care aids' in Switzerland) and dental nurses.

Alongside this range of primary dental care for mothers and children, community-wide oral health awareness programmes

combined with tooth brushing education using fluoridated toothpaste for grown-ups, should be implemented by community dental auxiliaries. With the help of TD and mobile clinics staffed by mid-level oral professionals, regular school-screenings should be introduced, so that schoolchildren are trained to keep their teeth clean and cavity-free. If fillings in permanent teeth are necessary, mid-level professionals should treat them by means of ART procedures, an approach which has proven effective in China, South Africa, the Philippines, Malawi and Zimbabwe.³ More complex treatments could be done with the help of TD by the same mid-level experts supervised by a dentist or dental hygienist/dental therapist at a central oral care facility.

To facilitate patients' use of dental care services, the primary oral health benefits catalogue should include tooth-retaining procedures and, ideally, an incentive for regular use of dental care in the form of a bonus or a voucher. These forms of incentives were a great success in Germany and Sweden and served to keep dental usage high. Providing the greatest possible incentives for keeping a person's own teeth healthy should take precedence over the need to broaden the benefits catalogue to include certain simple prosthetic procedures.

Whenever possible, public/private partnerships should be encouraged to mobilise additional resources and expertise to improve dental infrastructure and training programmes, as well as implement or ameliorate community-based preventive projects.¹⁰⁵ As the oral health industry is dominated by multinational companies, often allied to prevention/oral hygiene and emphasizing corporate social responsibility (CSR), good opportunities should exist for such partnerships.¹⁰⁶ Quite a few partnerships have been successfully implemented in emerging countries.¹⁰⁷ Indeed, Aggarwal even considers them a panacea in oral health for developing countries.¹⁰⁸

Country-specific reflections

Brazil and Malaysia

While Brazil's young generation is relatively well served and up to middle-aged adults, oral health has improved in the last decades, it deteriorates in older age groups, leading to extreme tooth loss and edentulism in seniors. Forecasts until 2040 even predict alarmingly high edentulism rates in seniors (87%).¹⁰⁹ This signals that, despite substantial progress over the last decade, the Brazilian oral care system, still faces serious shortcomings in adult dental care provision. At first glance, this might seem astonishing as Brazil has one of the highest dentist/population ratios in the world. On the other hand, at around 112,000, the number of licensed dental assistants and dental hygienists is very low.¹¹⁰ Of this oversupply of dentists, only 25% are linked to the public oral care service,¹¹¹ although it is these dentists who serve 75% of the population.¹¹⁰ In most cases, oral health is privately financed (64% out-of-pocket, 26% private insurance) and predominantly delivered by private providers¹¹⁰. As a result, there are still major regions where people are unserved by primary oral health care,¹¹² the declared backbone of Brazil's new oral health policy.¹¹¹ These might be the crucial facts underlying the structural problem that plagues Brazilian oral care. The imbalance between the oversupplied better-off urban regions and the large percentage of underserved poor and remote areas, might be the cause of the observed substandard oral outcomes among the elderly. In urban areas, a supply-induced demand, which often accrues in dentally oversupplied societies, possibly combined with a private fee-structure, that does not prioritise prevention and tooth-retaining procedures, as well as a pain-driven utilising of oral services by patients, seeking only restorative treatment, could lead to high rates of missing teeth and edentulism in advanced

age. If this context really exists, it needs to be tackled urgently for this deterioration in older adults to be stopped and resources saved. Indeed, two facts seem to support that hypothesis. First, of Brazil's five geographic regions, the one with the greatest dental need (North) exhibits the lowest number of dental procedures.¹¹² Second, private health plans that serve about a quarter of the population consume about half of Brazil's health budget.¹¹³

Based on these facts, Pucca et al. recommend a plan for further improvements:

- a) building a unified and integrated system to offset the strong influence of private providers and their special marketing interests,
- b) reforming university training, which is too highly dominated by the requirements of private dental clinics and centred on diseases rather than prevention and tooth retention, and
- c) strengthening the education and training of dental mid-level personnel to meet the demand for dental health teams and solve the problem of the latter's distribution.¹¹¹

In Malaysia, where almost 80% of the population live in urban areas (Table 2) and where oral health policy has made a shift from a provider-focused to a people-focused system,¹¹⁴ the oral health of seniors is particularly poor. While most of the schoolchildren are reached by school dental services, only 6% of adults use government oral health care facilities.¹¹⁴ Although Malaysia already has a notable dental attendance rate among its urban inhabitants, the high level of tooth loss, starting already in middle age,¹¹⁴ is probably the result of excessive sugar consumption combined with insufficient oral hygiene (Table 7), leading perforce to very pronounced rates of periodontitis and eventually to tooth loss.^{23,115} To stop this progression, sugar consumption must be brought down (e.g. by means of advertising restrictions) and tooth brushing habits intensified. The fact that ethnic Chinese and Indians living in Malaysia, have lower tooth loss rates than Malays,¹¹⁶ proves that this is definitely achievable. Interestingly, this finding is in line with our study results, where the DHI's of China and India are significantly better than Malaysia's. Furthermore, the dental utilisation rate in rural areas should be strengthened (e.g. by means of a yearly bonus or voucher scheme) and it should be ensured that preventive and tooth-retaining treatments have priority (e.g. by favouring such treatments within the dental fee-structure).

China and Vietnam

China seems to have a particularly pronounced political will to improve the oral health of its population. In 2016, it published a blueprint for Healthy China 2030 wherein oral health plays a relevant role. Concerning dental care, its central idea is a paradigm-shift from a treatment-centred practice to a prevention-oriented management of oral diseases. By 2030, China aims to attain the main health levels of developed countries.¹¹⁷ Consequently, China has developed a Chronic Diseases Program in which the following requirements for oral care are defined:

- a) oral health education in preschool, primary and middle school,
- b) training techniques to practice correct oral hygiene,
- c) the promotion of early intervention among urban and rural citizens through community health service centres and township hospitals,
- d) oral health examinations as a regular part of physical examinations, and

- e) implementation of topical fluoridation and pit and fissure sealing to lower the caries prevalence rate of 12-year-olds to below 30% by 2025.^{36,118}

If the above-mentioned activities and aims are to be implemented successfully, the currently existing basic medical insurance system will have to be expanded. At present, Chinese insurance covers only 15% of dental care expenditure and the vast majority has to be paid out-of-pocket.¹¹⁷ Thus, either health insurance will have to be extended to cover preventive and tooth-retaining procedures or the government will have to allow the introduction of private dental insurance as a complementary part of general health insurance. In any case, it is decisive to ensure that the fee-structure places priority on tooth-retaining and preventive measures in order to set the right incentives for the dentists/dental professionals. To hold costs down and provide incentives for potential patients to practise proper oral hygiene and make regular use of dental check-ups, general health insurance should not include prosthetic treatments. In the light of the favourable outcome values for China shown above (Table 3), it seems justified to put every emphasis on prevention and tooth-retention. The goal of reaching the oral health standards of industrialised countries by 2030 could then be a realistic one.

Similar to China, the Vietnamese population's oral health status, except in the case of preschoolers, looks comparatively favourable, although dental care provision is widely lacking, oral health behaviour is substandard and an oral care system is hardly existent. Under these circumstances health policy should undertake to cover a basic oral health care package (BOHCP) within the social health insurance system, whereby emergency care and primary prevention should always have priority over secondary prevention in the form of simple fillings such as atraumatic restorative treatment (ART).⁵⁹ In the presence of constraints caused by a paucity of financial resources, priority should also be given to the young generation, especially to toddlers and preschoolers, before gradually including older generations.

The measures that Vietnam could undertake to improve workforce requirements for implementing a functional primary oral health care system were described in detail by van Palenstein Helderma et al. two decades ago,⁵⁹ but these have been only partially implemented. As these recommendations are still valid, the need to fully implement them is greater than ever.

To protect teeth against sugar, a sugar tax has proven helpful to keep the consumption of sugar-containing foods and drinks as well as health care costs low.^{119,120} That is why Vietnam, the only country under study which does not have a sugar tax, is urgently recommended to introduce one. A fortiori, because the consumption of sugary products, although still on a low level, has been shown, since 2009,^{23,39} to increase in children and adults thereby endangering oral health.

Indonesia and India

Over the last ten years, Indonesia, a country where dental pain is the only need factor associated with dental utilisation in rural areas,¹²¹ has taken steps towards improving its population's oral care provision. In the past, government spending on oral care was very low and dental provision was generally financed through out-of-pocket payments by households.¹²² In 2014, National Health Insurance (NHI) was launched with the aim of covering the whole population. The NHI scheme includes oral health services for all ages. Primary care includes counselling, fillings and minor surgery, as well as emergency therapy and fissure sealants for children. The Ministry

of Health developed The Grand Design for 2015-2030, with the goal of achieving an Indonesia free of caries by 2030.⁴⁵ The roadmap for this programme is revised every 5 years. The first steps are targets for caries control in 12-year-olds, and the standardization of oral health programmes at Community Health Centres (CHCs), which increased from 9,655 in 2013 to 9,993⁴⁵ in 2018. Furthermore, school-based dental programmes and community-based health efforts were strengthened. For example, dental services for infants aim to maintain the oral cavity healthy before teething (for up to 12 months).⁴⁵ However, the dental workforce hardly increased in line with these health policy regulations and the number of dentists has remained stable at its very low level since 2013.

To improve this unfavourable situation, the government-mandated programme for dentists to work in CHCs should be expanded. In 2018, only half of CHCs had a dentist on their team.⁴⁵ The insufficient number of dental personnel in rural areas presents a major obstacle to achieving the country's oral health goals for 2030. Therefore, it is vital to educate and train mid-level dental personnel using the possibilities of TD as described above. In addition, the great potential offered by mothers trained in oral hygiene needs to be emphasised. By deploying *school dental care aids*, mostly housewives and mothers who receive a prior two-day training, Switzerland has been achieving very good oral health results in preschoolers and schoolchildren since the 1970s.¹²³

As the oral health of preschoolers in Indonesia is already rather poor owing to the lack of a national programme for that age group⁴⁵, oral health policy should close this gap and give priority to the entire young generation as it is they who will determine the population's future oral health status.

Indonesian adults exhibit remarkably high smoking rates (37.2%), the highest of all the countries compared (Table 7). These rates explain a certain proportion of the oral morbidity.⁷⁴ To prevent and reduce smoking habits, especially among males, up to 70% of whom are smokers, health policy could emphasise evidence-based strategies such as smoking-free zones (e.g. in restaurants, public buildings, public transport), price increases, and health education campaigns targeting large audiences. Counselling by doctor's and dentist's combined with medication are further instruments to stop smoking.¹²⁴

The oral status of the Indian population, which ranked second in our study, is astonishing because the high prevalence of caries and the low level of treatment in all age groups (24% across all adult classes)⁸⁰ obviously do not inevitably produce the expected poor oral health results that dentistry would predict for such conditions. The explanation for this mystery is still unclear. Genetic or dietary factors might also play a role. To protect the population from deteriorating oral health in the future, the Indian Government published its National Oral Health Policy¹²⁵ in 2021. This policy is a great step forward and illustrates the drive of India's decision makers.

Oral health care in India is currently rendered through the private sector. Public health only plays a minor part.¹²⁵ The national health policy sets the following goals for 2030:

- establish country-wide baseline data by 2025 (current data is not sufficient),
- reduce morbidity from dental diseases by 15%,
- raise the utilization rate of public dental care by 50% per district,
- increase the coverage of community based oral education and procedures for oral health through health care facilities by 70%,

- e) make available appropriate preventive dental services and promotion at each health & wellness and primary health centre by 2025,
- f) make available curative dental services at each Primary Health Centre,
- g) ensure district-level electronic databases containing information on health system components by 2025, and
- h) establish integrated oral health information infrastructure to connect districts to primary health care centres.¹²⁵

Policy is aiming for comprehensive oral care, including promotive, preventive, curative and rehabilitative therapy. These plans are all very ambitious and risk overburdening the system unless further priorities are set. Prioritising is possible as these goals and plans still have to be transformed into concrete oral health programmes of national scope but tailored to meet different regional circumstances and needs.¹²⁶

The Philippines, South Africa, Thailand

The prevalence of dental caries among Filipinos across all age groups is 87.4%.⁷⁹ This is in line with other South-East Asian states. As the Philippines is a transitional economy, decay is more rampant than in upper-middle-income countries. The DHI of 7.4 is the lowest ranking in our comparison. Until recently, the oral health system was only rudimentary, but the newly introduced Universal Health Care (UHC) Act aims to provide comprehensive quality health services, including oral care to all Filipino citizens.⁷⁹ Based on this new legislation, a network of health policy stakeholders discussed the future of oral health and recommended the following activities:

- a) reducing caries prevalence by 30% from the 87.4% baseline within three years,
- b) prioritising public health intervention through local preventive programmes,
- c) engaging the academic training institutions to expand the dental workforce, including dental health ancillaries,
- d) including the crucial roles of midwives, mothers and schoolteachers in prevention and health education,
- e) starting prevention at the prenatal stage,
- f) improving fluoride exposure,
- g) extending the engagement of dental professionals from individual- to population-based services so as to strengthen primary care and
- h) engaging dental professionals by integrating oral preventive programmes into medical prevention and control strategies.⁷⁹

Complementing these proposals, the UHC Act contains a regulation under which graduates who are granted government-funded scholarships are required to serve in the public sector for at least three years.⁷⁹

In South Africa, the oral health of the 5/6- and 12-year-olds is relatively good, compared with the other countries studied, which signals that the dental care system for schoolchildren is functioning. However, it could be made more effective and cost-efficient.¹²⁷ At the same time, the oral health of middle-aged adults and particularly of seniors is rather poor. This indicates that emphasis must be placed on improving adult oral care. The main causes for the widespread prevalence of oral diseases in adults are the high intake of sugared drinks and the hidden sugar in South Africa's popular fast food dishes,

as well as the lack of protective fluoride exposure.^{22,127} Thus, these are the urgent areas for population-wide oral health policy activities. Since a sugar tax (Health Promotion Levy) was already introduced in 2018 to reduce excess sugar intake - against great resistance of the influential sugar industry - it would be unrealistic at the present time to propose expanding the tax on all added sugar sources as recommended by Boachie et al.¹²⁷ Instead, advertising restrictions on sugary products, which are not included in the tax legislation,¹²⁸ could be introduced to reinforce the effect of the current sugar tax.

Furthermore, to protect teeth against cariogenic attacks, fluoride exposure must be strengthened by controlled water fluoridation combined with the regular use of fluoridated toothpaste.²² As in India, fluorosis is a problem because groundwater is frequently flooded with fluoride and the reason behind the natural release of fluoride into the groundwater is unknown. This makes it impossible to precisely control water fluoridation, which would be essential.^{129,130} In this case, the fluoridation of bottled drinking water, as in Indonesia, or salt fluoridation (as in Switzerland and Germany) could bring the required dental protection. In addition to these measures, there is a need to develop the mid-level dental workforce in the public sector, on which 85% of the population rely,¹²⁷ particularly in the countryside. How this could be improved by using TD has been described above. The fact that South Africa already has a comprehensive oral care benefit catalogue should facilitate this task. All in all, South African oral health policy is committed and has sound theoretical approaches; however, implementation is sluggish and financial backing is often unclear.²²

The Thai population enjoys a comparatively good oral health status (rank 4 in our study), which can be seen as the consequence of a very dedicated oral health policy, that prioritises oral health as a public health issue. Thailand integrated oral health care (routine and preventive, basic and advanced curative treatments) as part of its medical health benefit packages (UHC). Eighty per cent of Thai citizens are therefore covered by the largest government health financing scheme.¹³¹ The rest of the population is insured by two other national insurance systems. The Dental Association of Thailand takes part in school dental programmes,¹³² which is exemplary for an emerging country. As beneficiaries of UHC may currently only obtain treatment at the hospitals or clinics where they are registered, a proposal by the National Health Security Office is in the pipeline, to allow beneficiaries access to primary oral health services at any health care access points.¹³³

The newest development in Thai oral health policy is the announcement by the public health ministry of its decision to establish a new dental department to promote dental care throughout the nation.¹³⁴ The ministry also announced its plan to improve the dental workforce by opening a dental hospital in each of the nation's 77 provinces for its upcountry residents by the end of 2024.¹³⁵ Furthermore, the public higher education institute, which educates mid-level health workers, launched a new medical degree to reduce the country's health worker shortage.

Finally, the following experience of high-income countries might be interesting: dental systems perform better in terms of outcome, costs and system efficiency if the performance of dental provision is regularly monitored, if systematic scientific research accompanies the development of treatment and provision quality and if there is legal intervention when necessary.¹³⁶ This observation could be particularly important for dental systems that are in their experimental and designing phase, seeking to create systems that are compatible with the conditions specific to their country.

Conclusion

Unlike in the past, particularly over the last decade, the governments of the emerging countries under study have been showing a greater awareness and willingness to improve the precarious oral health situation of their populations. The majority realises that full emphasis must be placed on improving the oral health of people living in poor and rural regions, where the dental workforce is small or non-existent, the greatest demand for dental care consists of pain relief and oral health awareness is undeveloped. Consequently, our study yielded that the key task, when seeking to improve oral health in emerging countries, lies in the need to expand the mid-level dental workforce to tackle the two priority challenges of: igniting oral health awareness and training oral health behaviour, enabling the poor and rural population to self-care, and of offering secondary prevention along with basic atraumatic restorative treatment (ART). In underserved and rural communities, these services can be provided by trained dental mid-level personnel and both tasks would require the use of TD. To facilitate the implementation of resource-intensive projects, financial and technical expertise should be sought by forming partnerships with socially engaged multinational companies.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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