The Ageless DMFT Index (A-DMFT): a proposal for a unified DMFT index for all ages and dentitions.

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Abstract

Objectives

To propose a dental caries index that can be calculated regardless of age, even in situations of mixed dentitions.

Methods

The A-DMFT is defined simply from weighted means of the DMFT and dmft indices, with weights given by the number of natural teeth present (or that should be present) in the mouth (permanent and primary, respectively), and relativized according to the square root of the individual's age.

Results

The highest value for the A-DMFT in our simulations was 14.1, in a two-year-old child with dmft = 20; in the permanent dentition it was 8.1 in a 12-year-old child with DMFT = 28. A five-year-old child with dmft = 4 has A-DMFT = 1.8 while a 12-year-old with DMFT = 4 has A-DMFT = 1.2; and a 50-year-old with DMFT = 4 has A-DMFT = 0.6. A 10-year-old with dmft = 2 and DMFT = 2 has A-DMFT = 0.6 while a same age child with dmft = 0 and DMFT = 4 has A-DMFT = 1.0.

Conclusions

The A-DMFT index is particularly useful for describing the severity of caries in children with mixed dentition. A-DMFT can be described for the entire study population, even if it consists of people of various ages and even if individuals with primary, mixed or permanent dentitions are combined. This could be useful in some studies, as it may increase efficiency and reflects the severity of caries in the population as a whole, not only in one age group in the population.

Introduction

The index most used for describing the prevalence or severity of dental caries consists of counting the numbers of teeth that are decayed (D), missing (M) and filled (F). It is abbreviated as DMFT, or as dmft, in the case of primary teeth. It was first proposed over 80 years ago by Klein and Palmer in 1937 (1), or perhaps even earlier than this by Munblatt in 1933 and Gafafer and Messner in 1936; as reported by Mario Chaves in 1959 and 1986 [2].

The DMFT index for individuals aged 12 years and over and the dmft index for children aged between two and five years share practically the same characteristics, except for the number of teeth in the mouth and, obviously, the types of teeth and exposure time. However, use and interpretation of the DMFT and

dmft indices is particularly problematic in situations of mixed dentition, i.e. in children between six and 12 years of age. Calculation of both indices within this age group, as a strategy for taking into account the presence of both primary and permanent teeth, is clearly unsatisfactory. This is not only because instead of only one index, two of them are calculated, but also because both of them are potentially unrepresentative and non-comparable because of the different numbers and types of teeth, which characterize large heterogeneity of children's mouths.

Therefore, comparison of the severity of caries in situations of mixed dentition may be difficult and invalid. For instance, how could one say that a ten-year-old child with DMFT = 3 and dmft = 1 is in a worse or a better condition than an eight-year-old with DMFT = 3 and dmft = 0? Or how much better or worse is the ten-year-old than the eight-year-old in this case? Or likewise, comparing two ten-year-old children, one with DMFT = 4 and dmft = 0 and the other with DMFT = 2 and dmft = 2: which of them presents higher severity of caries? In this situation, the sum between DMFT and dmft is the same (i.e. 4), but does this mean that caries severity should be recorded as equivalent in these two ten-year-old children?

The DMFT index is usually described according to age or age group. The importance that researchers give to the length of time for which teeth are exposed to the risk of caries and to the risk of being restored or extracted, is implicit in this practice of linking the DMFT index to age. It does not make sense to compare the DMFT indices of older individuals and younger individuals because this exposure time differs between the two groups. For instance, the mean value for the DMFT index at 12 years of age has frequently been used by international researchers, organizations and associations (such as the World Health Organization and the World Dental Federation). This has enabled comparisons of dental caries between different populations and the time trends recorded in the same population. In addition, researchers assess DMFT by different ages in order to investigate dental treatment needs and therefore being able to plan services for different age groups.

The restriction of this indicator to individuals who are 12 years old, the age that characterizes the emergence of the exclusive permanent teeth, explains the obvious dependence of the DMFT index on age. This dependence is a limitation and makes immediate collective generalizations unfeasible.

It might, for example, be asked whether the same DMFT = 3 for two individuals with complete permanent dentitions, but different ages between 13 and 18 years old, would indicate that they present similar caries severity. The answer would probably be that they do not. Having three teeth affected by caries at 13 years of age is more severe and represents a dental caries situation that is worse than having three teeth affected by caries at the age of 18. This is because of the shorter time for which the dentition of the younger individual has been exposed to caries, while it is already just as damaged as that of the older individual. The first and second molars of the 13-year-old may have been exposed in the mouth for approximately seven years and one year, respectively. However, in the 18-year-old, these teeth will have been exposed for 12 years and six years, respectively. This probably shows that the caries severity has been stronger in the younger individual than in the older one because, over a shorter period of time, the

dentition of the younger person was damaged by caries to the same extent. Analogous reasoning can be used in comparing populations based on the mean DMFT index.

In summary, the DMFT index is calculated by counting the number of teeth affected by caries and it only makes sense when correlated with age. This gives the index some advantages, but also some disadvantages. The count of decayed, missing and filled teeth is recognized to be a good indicator of caries severity. Moreover, age needs to be taken into account as a proxy for the length of exposure of teeth to caries risk, i.e. a proxy for the length of time for which the teeth have been exposed in the oral cavity.

Therefore, the objective of the present study was to propose a unified dental caries index that can be calculated regardless of age, even in situations of mixed dentitions, by combining the DMFT index, dmft index, number of natural teeth present in the mouth and age. This unified index is named the Ageless DMFT index, or, A-DMFT.

Methods

The index proposed is defined simply from weighted means of the DMFT and dmft indices, with weights given by the number of natural teeth present (or that should be present) in the mouth (permanent and primary, respectively), and relativized according to the square root of the individual's age. This index can be calculated for any individual who is at least two years old. The reason for use the square root of age rather than the age itself is to "lessen" the impact of this parameter on the index, through relativizing its importance in a more appropriate way. Similar logic is commonly seen in some economic indices that use the idea of equivalence scales, with the square root being often recommended (OECD, 2011)

Symbolically, taking advantage of notations already established for decayed, missing or filled teeth, the new index proposed can be expressedas:

$$A-DMFT = \frac{DMFT.\,N_p + dmft.\,N_d}{N_p + N_d} / \sqrt{Age}$$

Where:

$DMFT$ = Numbers of permanent teeth that are decayed, missing due to caries or filled;

$dmft$ = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old;

N_p = Number of permanent teeth in the mouth or that should be present in the mouth at this age;

N_d = Number of primary teeth in the mouth or that should be present in the mouth at this age.

It can be seen that, for children who only have primary teeth, the Ageless DMFT (A-DMFT) index is simply the dmft index divided by the square root of the child's age because N_p = 0. Analogously, for individuals who only have permanent dentition, the A-DMFT index is the DMFT index divided by the square root of the age.

Results

The tables show the values of the A-DMFT for various situations. These hypothetical situations show A-DMFT values for individuals of different ages, but with the same dmft and DMFT values, and for individuals of the same age, but with different dfmt and DMFT values in primary, mixed and permanent dentitions.

The highest possible value for the A-DMFT in these simulations was 14.1, in a two-year-old child with dmft = 20. The highest value for the A-DMFT in permanent dentition was 8.1 in a 12-year-old child with DMFT = 28. A five-year-old child with dmft = 4 has A-DMFT = 1.8; a 12-year-old with DMFT = 4 has A-DMFT = 1.2; and a 50-year-old adult with DMFT = 4 has A-DMFT = 0.6 (Table 1).

Table 1

Individuals with **different ages**, but equal dmft + DMFT. Primary (2 to 5 years), mixed (6 to 11 years) and permanent (12, 13, 14, 15, 20, 30, 40 and 50 years) dentitions.

Age	Nd	Np	dmft	DMFT	$A-DMFT$
2	20	0	4	0	2.8
3	20	0	4	0	2.3
4	20	0	4	0	2.0
5	20	0	4	0	1.8
6	18	2	4	0	1.5
6	18	2	2	2	0.8
7	16	6	4	0	1.1
7	16	6	2	2	0.8
7	16	6	0	4	0.4
8	14	10	4	0	0.8
8	14	10	2	2	0.7
8	14	10	0	4	0.6
9	12	14	4	0	0.6
9	12	14	2	2	0.7
9	12	14	0	4	0.7
10	8	18	4	0	0.2
10	8	18	2	2	0.6
10	8	18	0	4	1.0
11	4	22	4	0	0.2
11	4	22	2	2	0.6

Nd = Number of primary teeth in the mouth or that should be present in the mouth at this age.

Np = Number of permanent teeth in the mouth or that should be present in the mouth at this age.

dmft = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old.

DMFT = Numbers of permanent teeth that are decayed, missing due to caries or filled.

A-DMFT = The Ageless DMFT Index.

Age	Nd	Np	dmft	DMFT	$A-DMFT$
11	4	22	0	4	1.0
12	0	28	0	4	1.2
13	0	28	0	4	1.1
14	0	28	0	4	1.1
15	0	28	0	4	1.0
20	0	28	0	4	0.9
30	0	28	0	4	0.7
40	0	28	0	4	0.6
50	0	28	0	4	0.6
Highest possible DMFT e dmft					
2	20	0	20	0	14.1
5	20	0	20	0	8.9
12	0	28	0	28	8.1
15	0	28	0	28	7.2
20	0	28	0	28	6.3
40	0	28	0	28	4.4
50	0	28	0	28	4.0
80	0	28	0	28	3.1
Nd = Number of primary teeth in the mouth or that should be present in the mouth at this age.					
Np = Number of permanent teeth in the mouth or that should be present in the mouth at this age.					
dmft = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old.					
DMFT = Numbers of permanent teeth that are decayed, missing due to caries or filled.					
A-DMFT = The Ageless DMFT Index.					

In mixed dentition, as age increases, the weight of the DMFT increases in relation to the dmft, in the A-DMFT score. For example, at seven years of age, dmft = 4 and DMFT = 0 yield A-DMFT = 1.1, while dmft = 0 and DMFT = 4 yield A-DMFT = 0.4. In turn, at ten years of age, dmft = 4 and DMFT = 0 yield A-DMFT = 0.2, while dmft = 0 and DMFT = 4 yield A-DMFT = 1.0 (Table 1).

A two-year-old individual with dmft = 2 presents A-DMFT = 1.4, and with dmft = 8 presents A-DMFT = 5.7. Five-year-old individuals with the same dmft values present A-DMFT = 0.9 and 3.6, respectively. Therefore, the difference in dmft of six units is the same (8 – 2) at both ages, but in A-DMFT the difference is 4.3 (5.7–1.4) for the two-year-old, and 2.7 (3.6–0.9) for the five-year-old (Table 2). This same logic is applied to individuals with mixed dentition (Table 3). In other words, individuals of the same age, with different dmft or DMFT values, present more attenuated differences in the A-DMFT index than in the dmft and DMFT indices, either in primary and permanent dentition (Table 2) or in mixed dentition (Table 3).

Table 2

Individuals with **same age**, but different dmft + DMFT. **Primary** (2 and 5 years) and **permanent** (12, 15, 20, 40 and 50 years) dentitions.

Age	Nd	Np	dmft	DMFT	$A-DMFT$
2	20	0	2	0	1.4
2	20	0	4	0	2.8
2	20	0	6	0	4.2
2	20	0	8	0	5.7
2	20	0	20	0	14.1
5	20	0	2	0	0.9
5	20	0	4	0	1.8
5	20	0	6	0	2.7
5	20	0	8	0	3.6
5	20	0	20	0	8.9
12	0	28	0	2	0.6
12	0	28	0	4	1.2
12	0	28	0	6	1.7
12	0	28	0	8	2.3
12	0	28	0	28	8.1
15	0	28	0	2	0.5
15	0	28	0	4	1.0
15	0	28	0	6	1.5
15	0	28	0	8	2.1
15	0	28	0	28	7.2

Nd = Number of primary teeth in the mouth or that should be present in the mouth at this age.

Np = Number of permanent teeth in the mouth or that should be present in the mouth at this age.

dmft = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old.

DMFT = Numbers of permanent teeth that are decayed, missing due to caries or filled.

A-DMFT = The Ageless DMFT Index.

Age	Nd	Np	dmft	DMFT	$A-DMFT$
20	0	28	0	2	0.4
20	0	28	0	4	0.9
20	0	28	0	6	1.3
20	0	28	0	8	1.8
20	0	28	0	28	6.3
40	0	28	0	2	0.3
40	0	28	0	4	0.6
40	0	28	0	6	0.9
40	0	28	0	8	1.3
40	0	28	0	28	4.4
50	0	28	0	2	0.3
50	0	28	0	4	0.6
50	0	28	0	6	0.8
50	0	28	0	8	1.1
50	0	28	0	28	4.0
80	0	28	0	28	3.1
Nd = Number of primary teeth in the mouth or that should be present in the mouth at this age.					
Np = Number of permanent teeth in the mouth or that should be present in the mouth at this age.					
dmft = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old.					
DMFT = Numbers of permanent teeth that are decayed, missing due to caries or filled.					
A-DMFT = The Ageless DMFT Index.					

Table 3
Individuals with **same age**, but different dmft + DMFT. **Mixed** dentition (7, 9 and 11 years).

Age	Nd	Np	dmft	DMFT	$A-DMFT$
7	16	6	1	1	0.4
7	16	6	2	2	0.8
7	16	6	3	3	1.1
7	16	6	4	4	1.5
7	16	6	16	6	5.0
9	12	14	1	1	0.3
9	12	14	2	2	0.7
9	12	14	3	3	1.0
9	12	14	4	4	1.3
9	12	14	12	14	4.4
11	4	22	1	1	0.3
11	4	22	2	2	0.6
11	4	22	3	3	0.9
11	4	22	4	4	1.2
11	4	22	4	22	5.8
Nd = Number of primary teeth in the mouth or that should be present in the mouth at this age.					
Np = Number of permanent teeth in the mouth or that should be present in the mouth at this age.					
dmft = Numbers of primary teeth that are decayed, missing due to caries or filled, in children who are at least two years old.					
DMFT = Numbers of permanent teeth that are decayed, missing due to caries or filled.					
A-DMFT = The Ageless DMFT Index.					

The results from the simulations reported in Tables 1, 2 and 3 can be further illustrated by the following examples. A two-year-old child with dmft = 4 presents A-DMFT = 2.8; a five-year-old with the same dmft = 4 presents A-DMFT = 1.8. This difference in A-DMFT of one unit (2.8–1.8 = 1) reflects a higher caries severity in the two-year-old child than in the five-year-old. This difference is not detected through the dmft index (4–4 = 0). Alternatively, two four-year-old children, one with dmft = 4 and another with dmft = 2, will present A-DMFT = 2 and A-DMFT = 1, respectively. If they were younger, for example, two years of age and had same dmft values, i.e. 4 and 2, the A-DMFT values will be 2.8 and 1.4. It is noteworthy that the two-

unit difference in dmft for the older age (four years old) is attenuated to a single-unit difference in A-DMFT, while the same difference in dmft in the younger age (two years old) is less attenuated, i.e. to a difference of 1.4 in A-DMFT (2.8–1.4 = 1.4).

Discussion

We have shown here that, in theory, a new dental caries index, the Ageless DMFT index (A-DMFT), can better reflect caries severity at various ages than can the DMFT and the dmft indices, because the A-DMFT index considers the length of time for which teeth are exposed to the risk of caries. In addition to this theoretical advantage, the A-DMFT brings together, in a single index, individuals of all ages with all dentitions (primary, mixed and permanent), which provides it with practical advantages.

Usually, the DMFT or dmft index for one or two specific ages, or a maximum of three ages, is used to make inferences regarding caries severity in a population, in a general manner. It is common for researchers and professional organizations to choose to examine participants of a specific age, such as five-year-olds for primary dentition or 12-year-olds for permanent dentition. This practice especially limits the scope of the population studied and prevents safe conclusions regarding caries severity in a population as a whole. The caries index that we are proposing in the present study may lead to greater efficiency, because it would not be necessary to examine a representative population for each age or age group, when the objective was to describe the severity of caries in a population; a sample of people of any age (or of all ages) would be enough (or preferable) in many studies.

From the logistics point of view, there are also positive implications. Studies conducted in schools where children and teenagers of all ages are present together may become more efficient because there would not be the need to choose which ages should take part in the study, since all students could participate and the necessary sample size could be reached more quickly. In addition, including people of any age in samples and obtaining a single score for caries severity in a population can generate associations of greater robustness between caries and risk factors in studies investigating the causes of caries, especially those that seek to investigate whole population risk factors.

Age is an important factor inherent to the risk of caries. However, there are other factors, perhaps as important as or even more important than this factor that the A-DMFT index does not take into account. There is a hierarchy of susceptibility to caries according to type of tooth, type of surface and type of dentition (3, 4). The risk of caries in incisors is higher in the primary dentition than in the permanent dentition. Tooth susceptibility to caries also seems to be higher during the eruptive period because the enamel may be less resistant during eruption into the oral cavity. Regarding molars, during eruption, they stay below the occlusal plane and without contact with their antagonists, which favors accumulation of biofilm.

Consider, for example, a population in which individuals begin to present caries only at 20 years of age, in the first permanent molars. What does this mean? These individuals did not have caries when the first permanent molar broke through into their mouths, at the age of six, which is the most susceptible phase.

Is the new cavity at 20 years of age a result of a weak caries challenge for 14 years, or was this a sudden challenge over the last 2 or 3 years that was so strong that even a more mature tooth did not resist?

Another issue is that, after the more susceptible surfaces and teeth have already been affected (i.e. have already become D, M or F), the probability that this individual will have new cavities decreases. Therefore, is a population with DMFT = 4 (for example, with four first permanent molars affected) more susceptible to new cavities than a population with DMFT = 2 (for example, with two first permanent molars affected)? The answer is that it is probably not. Hence, might there be “critical” levels of DMFT that reflect caries risk on more susceptible surfaces and teeth? It seems that if the increase in DMFT is nonlinear (i.e. continuous homogeneous increase from one to 32), the A-DMFT index may theoretically not be very accurate for measuring caries severity. In other words, the A-DMFT index presumes (arguably wrongly) that the increase in DMFT as age increases is linear.

The index proposed in the present study seems to offer a theoretical improvement, compared with the DMFT index, because it incorporates the length of exposure of teeth (through the age of the individuals) as a factor inherent to the risk of caries. However, it is still limited because it does not incorporate other crucial factors, such as: type of teeth (primary versus permanent; incisor versus canine versus pre-molar versus molar); type of surface (occlusal versus proximal versus free smooth); post-eruptive age of teeth (first months after eruption versus over a year after eruption or already in occlusal contact with antagonists).

Another limitation of our proposed A-DMFT is that it loses an important feature of the DMF, i.e., the information provided by the D, M and F components. For example, an A-DMFT score does not give any hint regarding the level of restorative care in the population, while a DMF score with a high F to DMF ratio reflects a high level of restorative care in the population. Also, knowing the DMF score at differing ages is valuable in order to assess age and cohort effects. Aggregating the scores of different ages loses these analytical possibilities of the DMF.

The relativization of age in the A-DMFT index is useful for considering the length of time for which teeth have been exposed to caries in the oral cavity. However, simply dividing DMFT + dmft by age would “overweaken” the index score for older ages, while dividing it by the square root of the age attenuates this problem. This strategy of dividing by the square root rather than by the original value is often used in economic indices, and it more accurately reflects the intention of the index.

Conclusions

The A-DMFT index is particularly useful for describing the severity of caries in children with mixed dentition, and is advantageous in any situation in which a description of the severity of caries is desired in populations that include individuals of various ages; A-DMFT can be described for the entire study population, even if it consists of people of various ages and even if individuals with primary, mixed or permanent dentitions are combined. By using A-DMFT, rather than DMFT, it is not necessary to divide study populations into ages. This is more efficient and reflects the severity of caries in the population as

a whole, not only in one or two age groups in the population. In addition, including people of any age in samples and obtaining a single score for caries severity in a population can, arguably, generate associations of greater robustness between caries and risk factors in studies investigating the determinants of caries, especially those that seek to investigate whole population risk factors.

Declarations

Authorship

All authors contributed equally to conception and design of this article, they all drafted the article and revised it critically for important intellectual content and gave final approval of the version to be published.

Author contribution: All authors contributed to the conception and design of the study. The first draft of the manuscript was written by Luiz RR and Nadanovsky P. The critical review of the manuscript was performed by Santos APR and Gonçalves LS. All authors read and approved the defnitive manuscript.

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