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Literature Review Article

Comprehensive review of caries assessment systems developed over the last decade

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Abstract

Introduction: World Health Organization (WHO) in the year 2007 recognized the growing burden of oral diseases worldwide and emphasized the need to scale up action based on comprehensive data collection systems. In view of the global epidemic of untreated caries in children there is an urgent need to establish a scoring system that both assesses and quantifies various advanced stages of caries. Furthermore, the available data are not readily comparable due to the different scoring systems used. The DMF index despite having limitations has been widely utilized in oral epidemiological surveys. It is recommended by the WHO for measuring and comparing the experience of dental caries in populations. The path of future research in caries epidemiology will depend on finding an ideal caries index. **Objective:** This review is prepared to present and critically evaluate various new caries assessment systems that have been developed in the last decade. **Literature review:** A literature search was done to find out major caries assessment systems developed over last decade, it revealed there were five new indices developed to assess caries. These indices were critically evaluated to list their strengths and limitations. **Conclusion:** There are many promising new caries indices purposed, but still there is a need for further studies to evaluate their validity and reliability before they can replace DMFT index.

Introduction

Dental caries is a complex disease affecting the teeth, which is mainly caused by imbalance between demineralization and remineralization process around the tooth surface. It is a major cause of tooth loss and pain around the world. Caries incidence is witnessing a decline in developed countries due to proper availability of fluoride products, better oral health services and awareness regarding etiology of caries. At the same time incidence of caries is increasing in developing countries [13]. Research over the years has shown that caries is a preventable and controllable disease. To apply measures which can prevent or control caries, a reliable picture of it in a population is prerequisite; this can only be obtained if we have a reliable caries assessment system (index).

For several decades dental researchers are following and teaching DMF index developed by Klein, Palmer and Knutson in 1938 for assessing dental caries [11]. World health organization has adopted this index in its oral health assessment form for conducting national oral health surveys [16]. Various reasons can be stated for its continued use for assessing caries, foremost of them are: it is simple to use, valid and reliable, that is why it is still being used for assessment and comparison of caries status of the population groups around the world. However DMF index is facing criticism on various points (table I).

Table I – Major limitations of DMF index [3, 7]

1. DMF values are not related to the number of teeth at risk
2. It assesses only cavitated lesion extended into dentin
3. DMF index is invalid in elderly population, as teeth can be lost for reasons other than caries
4. Reaches saturation level at particular point of time when all teeth are involved and prevents registration of caries attack even when caries activity is continuing
5. Cannot be use to assess root caries
6. Rate of caries progression cannot be assessed
7. Does not give account for treatment needs
8. DMF index gives equal weight to missing, untreated decayed and well restored teeth
9. Assigning the maximum possible value for the 'M' component of DMFS (Surfaces) leads to overestimation of an individual's caries experience, and in any associated comparisons of in-caries experience, whereas assigning the minimum possible value for the 'M' component has the opposite effect (there is no such problem with the DMFT index)

From the public health viewpoint, major disadvantage of using DMF index is that it records only cavitated lesions and ignore incipient carious lesions. These lesions can be reversed by application of various preventive measures like fluorides if detected at earlier stages. So an index should be able to record these lesions to apply primary preventive measures in a population. The objective of this literature review is to critically evaluate major caries assessment systems purposed in last one decade and try to build up requisites for an ideal caries index.

Significant Caries (SiC) Index

Brathall [2] introduced this index in order to bring attention to the individuals with the highest caries values in each population under investigation. It tries to overcome limitation of the mean DMFT value in accurately assessing the skewed distribution of dental caries in a population especially in developed countries leading to incorrect conclusion that the caries situation for the whole population is controlled, while in reality, several individuals still have caries. This problem was analysed in detail in a study conducted in Nevada which confirmed that dental caries remains a common chronic disease among Nevada youth, and the mean SiC score was significantly higher than DMFT scores within each survey year across comparison groups ($p < 0.001$). The authors concluded that using both caries indices (DMF and SiC) together may help to highlight oral health inequalities more accurately among different population groups within the community in order to identify the need for special preventive oral health interventions [5].

SiC is calculated by sorting individuals according to their DMFT values, than one third of the population with the highest caries scores is selected and the mean DMFT for this subgroup is calculated. This value is the SiC Index. In this way investigators can bring to attention of authorities the need of preventive measures required for prevention/control of caries in this subgroup. Main disadvantage of SiC index is that this index is just an extension of DMF index as it follows same criteria for assessing dental caries and will have same limitations in assessing caries in a population as DMF index. Also this index is more of significance in population where caries prevalence is low and has a skewed distribution.

International Caries Detection and Assessment System (ICDAS) – I and II

ICDAS was developed in the year 2001 by the effort of large group of researchers, epidemiologists and restorative dentists [10]. It is an attempt to find a common caries assessment system based on many available such systems. ICDAS was developed on the basis of insights gained from a systematic review of the literature on clinical caries detection systems [9]. Use of the ICDAS was intended to make subsequent studies more useful for comparison, reviews or meta-analyses and thus fulfill the requirements of evidence-based dentistry [10, 15]. ICDAS-I was meant to include detection (D) of caries by stage of carious process, topography and anatomy, assessment (A) of caries process (whether cavitated or non-cavitated and active or arrested caries). But the ultimate index included detection of coronal caries and the assessment of lesion activity and root caries were not included due to lack of consensus and need for further discussions.

ICDAS coordinating committee came up with ICDAS-II in the year 2009 [8] which describes both coronal caries and caries associated with restorations and sealants (CARS) (table II). Its codes for coronal caries ranges from 0 to 6, indicating the severity of the carious lesions involving pulp are not being scored. Details of scoring criteria can be accessed from the website of ICDAS (www.icdas.org). The advantages of the ICDAS-II are that it includes stages of carious lesion progression in the enamel and it has found to be a valid and reliable caries assessment system especially for clinical trials assessing effectiveness of caries preventive/control agents [14]. Shortcomings of ICDAS-II include: it is a complicated index due to the recording of non-primary caries lesion related conditions, does not correlate well with the detection and assessment of the conditions and various type of restorations and may lead to an overestimation of seriousness of dental caries experience [4].

Table II – Scoring criteria for ICDAS-II

Code	Criteria
0	Sound tooth surface: no evidence of caries after prolonged air drying (5 s)
1	First visual change in enamel: opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure after prolonged air drying, which is not or hardly seen on a wet surface
2	Distinct visual change in enamel: opacity or discoloration distinctly visible at the entrance to the pit and fissure when wet, lesion must still be visible when dry
3	Localized enamel breakdown due to caries with no visible dentine or underlying shadow: opacity or discoloration wider than the natural fissure/fossa when wet and after prolonged air drying
4	Underlying dark shadow from dentine +/– localized enamel breakdown
5	Distinct cavity with visible dentine: visual evidence of demineralization and dentine exposed
6	Extensive distinct cavity with visible dentine and more than half of the surface involved
	CARIES ASSOCIATED WITH RESTORATION AND SEALANTS
0	Sound tooth surface with restoration and sealant
1	First visual change in enamel
2	Distinct visual change in enamel/dentin adjacent to restoration/sealant margin
3	Carious defect of > 0.5mm, with signs of code-2
4	Marginal caries in enamel/dentin/cementum adjacent to restoration/sealant, with underlying dark shadow from dentin
5	Distinct cavity adjacent to enamel/dentin
6	Extensive distinct cavity with visible dentin

Specific caries index

This index was purposed by Acharya [1] with the objective to develop a reproducible, surface specific caries index that would provide qualitative and quantitative information about untreated dental caries in an individual based on clinical

examination and would provide, if used with DMFS index, useful data for planning oral health care for a target population. The scoring criteria of the index are shown in table below.

Table III – The specific caries index

Score	Criteria
0	No carious lesion detected.
1	Carious lesion occurring on the occlusal, buccal pits and fissures of molars and premolars and the lingual pits of the anterior teeth.
2	Proximal caries affecting the molars and premolars.
3	Carious lesion situated on the proximal surface of the anterior teeth and not involving the incisal angle.
4	Carious lesion situated on the proximal surface of the anterior teeth, involving the incisal angle.
5	Carious lesion situated on the cervical region of the tooth
6	Carious lesion situated on the occlusal cusp tips of molars and premolars and on the incisal edges of incisors;
6A	Grossly decayed tooth/ root stumps indicated for extraction

The index has shown good reliability and validity in the study conducted by original author but further search on various databases did not reveal any other study using this index [1]. Some *drawbacks* of this index were - it employs same caries detection criteria as DMF or DMFS; in cases of large lesions, which cover more than one surface, only an assumption can be made regarding the originating lesion; the inability of this index, if used alone, to capture information useful for treatment planning; and the lack of provision for assessing root caries.

PUFA (pulp-ulcer-fistula-abscess) index

The failure of DMF index to provide information on the clinical consequences of untreated dental caries, such as pulpal abscess, which may be more serious than the carious lesions themselves, is the basis for the development of PUFA index [12]. This index records the advanced stages of untreated caries lesions so that caries data collected should have impact on health decision makers, which is not possible with DMF index. Scoring method of PUFA index is described in table IV.

Table IV – PUFA index scoring system

Code	Criteria
P/p	Pulpal involvement is recorded when the opening of the pulp chamber is visible or when the coronal tooth structure have been destroyed, the carious process and only roots or root fragments are left. No probing is performed to diagnose pulpal involvement
U/u	Ulceration due to trauma from sharp pieces of tooth is recorded when sharp edges of a dislocated tooth with pulpal involvement or root fragments have caused traumatic ulceration of the surrounding soft tissues e.g. tongue or buccal mucosa
F/f	Fistula is scored when pus releasing sinus tract related to a tooth with pulpal involvement is present
A/a	Abscess is scored when a pus containing swelling related to a tooth with pulpal involvement is present.

In many developing countries, access to oral health services is limited and teeth are often left untreated or are extracted because of pain or discomfort, such an index can provide useful information for researches and authorities. Strong points of this index can be simple to record, can be used for primary and permanent teeth and results can be presented alongside with DMF index. There are certain limitations appearing after a recent study [6] suggesting that there are few subjects with score “u” (ulcer) and assessment of abscess and fistula can be combined into one code. Hence reliability and validity of this index requires further discussion and research.

Caries assessment spectrum and treatment (CAST) index

This index was developed because of the need to find a reliable, pragmatic cohesive and easy to read reporting system which is based on the strengths of PUFA and ICDAS-II indices and

provide a link to the widely used DMF index (M and F component). It covers the total dental caries spectrum – from no carious lesion, through caries protection (sealant) and caries cure (restoration) to carious lesions in enamel and dentine, and the advanced stages of caries lesion progression in pulpal and tooth surrounding tissue (table V) [6]. It does not record active and inactive carious lesions. The CAST index has not been validated, nor has its reliability been tested. It is also not suggested for use in clinical trials. Other limitation can be that it does not provide data on treatment or preventive measures required for each code.

Table V – CAST index codes and criteria

Characteristic	Code	Description
	0	Sound – no visible evidence of a distinct carious lesion is present
Sealed	1	Sealed – pits and fissures have been at least partially sealed with a sealant material
Restored	2	A cavity has been restored with an (in) direct restorative material currently without a dentine carious lesion and no fistula/ abscess present
Enamel	3	Distinct visual change in enamel – a clear carious related discoloration (white or brown color) is visible, including localized enamel breakdown without clinical visual signs of dentine involvement
Dentine	4	Internal caries related discoloration in dentine – the lesion appears as shadows of discolored dentine visible through enamel which may or may not exhibit a visible localized breakdown
	5	Distinct cavitation into dentine – no (expected) pulpal involvement is present
Pulp	6	Involvement of pulp chamber – distinct cavitation reaching the pulp chamber or only root fragments are present
	7	Abscess/fistula – a pus containing swelling or a pus releasing sinus tract related to a tooth with pulpal involvement due to dental caries is present
Lost	8	The tooth has been removed because of dental caries
Other	9	Does not match with any of the other categories

Conclusion

This review found that while new caries detection criteria measured different stages of the caries process, there were inconsistencies on how the caries process was measured. The future of research, practice, and education in cariology requires the development of an integrated definition of dental caries and uniform systems for measuring the caries process. Many new indices have been developed to assess caries but we are far away from finding an ideal caries index which can replace or overcome limitations of DMF index. Some questions which remain unanswered in caries epidemiology are:

1. Is there a need to replace WHO recommended DMFT index especially for assessing caries in developing countries?
2. Should an ideal caries index suggest treatment needs of different caries stages?
3. What stage of the caries process should be measured; what are the definitions for each selected stage?
4. What is the best clinical approach to detect each caries stage on different tooth surfaces?
5. Should the research be separated with regard to find out an ideal coronal and root caries index?
6. Should separate indices be developed for assessing caries in oral health surveys and clinical trials?

At last it is better to say in current scenario it will not be easy to replace DMF index as epidemiologists had collected or still collecting lot of data based upon this index.

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