

## NEW CARIES ASSESSMENT SYSTEMS – A REVIEW

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### ABSTRACT

Dental caries is an extensive disease of the tooth that leads to destruction of calcified tissues. In order to improve Dental public health, measurement of diseases in quantitative terms is very important and essential. Hence World Health Organization established various scoring systems that both quantifies and assesses advanced stages of caries. Despite limitations of WHO criteria or diagnosing dental caries, it has been the most common index to be widely used in oral epidemiological surveys. The need for a more reliable caries assessment system (index) is needed in order to quantify the prevalence of dental caries. The aim of this review is to present various caries assessment systems developed over the past two decades with their strengths and limitations. Every index holds its limitations, hence further research in developing a relent indices is recommended before it could replace DMF index which is being widely used till date.

**KEYWORDS:** Dental caries assessment, ICDAS index, specific caries index, PUFA, CAST, significant caries index, Nyvad's criteria.

## INTRODUCTION

Dental caries is a multifactorial microbial infectious disease characterized by demineralization of the inorganic and destruction of organic substances of the tooth. It is a major cause of tooth loss and pain around the world (Landenbach et al, 2014). Research (Hakamcolak et al, 2013) over the years has shown that caries is a preventable and controllable. In order to prevent or control caries a reliable caries assessment system (index) is needed. For several decades, various indexes have been proposed for the assessment of dental caries. The DMF index developed by Henry Klein, Carol E Palmer and Knutson JW in 1938 have been followed by researchers for almost 50 years for assessing dental caries (Broadbent and Thomson, 2005). This index had limitations with recording cavitated and non cavitated initial lesions, and excluding third molar which have been to have an increased caries attack. In order to overcome this limitation World health organization came out with a modification in 1987 and 1997. This modified WHO criteria for dental caries is still being used for Oral Health Surveys (Anu et al, 2011).

This drawback has led to the introduction of new dental caries assessment indices that connects both cavitated and non cavitated dental carious lesion during oral health surveys. The main objective of this review article is to reveal various carious assessment systems proposed recently in last one decade and try to build a better caries assessment system that would meet the specifications of an ideal caries index.

**Significant caries index:** The significant caries index was proposed by Bratthal in the year 2000 to measure dental caries. The World Health Assembly of the WHO declared that by the year 2000 the oral health of the 12 year old in all the countries should not exceed 3 DMFT (Bratthal, 2000). Since, there is still a considerable amount of people in a population who exceed the WHO target, this index makes it easy to calculate.

In order to calculate the Sic index the people in a population are separated and sorted out according to their dmft score, then one third of the individual with the highest carries value is selected and then the mean value of this subgroup is calculated which constitutes the Sic index.

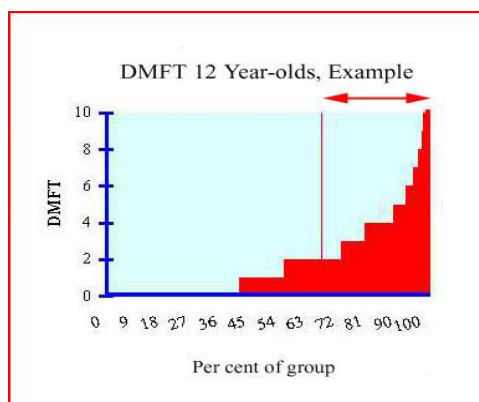


Fig 1: DMFS of 12year old in a population.

Figure 1 shows caries data for a population, expressed as frequency distribution. In this example, about 45 % are caries free (DMFT=0). The mean DMFT is 1.91, and the Significant Caries Index is 4.61. The arrow and vertical line indicate the individuals that are included in the calculation of the index. However, there will be few countries who might not achieve the goal of WHO by the year 2000. Accordingly, it has been proposed that Sic index for these countries should be achieved latest by 2015 (Bratthal, 2000). The advantage of SIC over DMFT is that it brings attention to the individual with highest caries values in each population. It also tries to overcome the limitations of mean DMFT values inaccurately accessing the skewed distribution of dental caries in a population. The main drawbacks of SIC index is that it is just an extension of the DMFT index as it follows the Same criteria for assessing dental caries and will have the same limitations.

### **ICDAS (International caries detection and assessment system)**

ICDAS was developed in the year 2001 by an international team of researchers. It is a clinical scoring system for use in research, dental practice and epidemiology. Later it was modified to ICDAS II in the year 2005. The need for an evidence-based system which would authorize standardized diagnosis and caries detection in various environmental conditions lead to the development of ICDAS (Neeraj et al, 2011). The ICDAS 1 and 2 criteria constitutes the concepts from the research conducted by Ekstrand et al in 1995 and 1997 (Ekstrand, 1995; Ekstrand, 1997) and Ismail et al 2004 (Ismail, 2004) who described the other

caries assessment system in a systematic review.

The ICDAS I system Includes: (D) Component for detection and (A) Component for assessment of caries. The major drawback of this system is that it only included detection of coronal caries and root caries were not included due to lack of information and needs for further discussion. Hence later ICDAS Committee came up with ICDAS II, which describes both coronal caries and caries associated with restoration and sealants (CARS) and root caries.

### **Detection of coronal caries:**

For detection of coronal caries by ICDAS system the surface of the teeth must be potentially clean and dry. Drying of the tooth surface prior to the examination is the key for detecting noncavitated lesion. A ball end explorer is used for surface examination to check for contour, minor cavitation or sealants. Cleaning of the tooth with a toothbrush or prophylaxis head / cup before clinical examination is advisable (Ekstrand, 1987).

Since there were minor variations with each code depending on the surface characteristic, number of factors, if the caries is associated with restoration or sealant, a detailed description of each code is given (CARS) which describes both coronal caries and caries associated with restoration and sealants (Workshop Maryland, 2005). The codes for coronal caries is given in Table.1. The codes for caries associated for restoration and sealants is given in Table.2.

## ICDAS two digit coding method

A two-number coding system is suggested to identify restorations / sealants with the first digit, followed by the appropriate caries code

0 = Sound, that is, surface not restored or sealed (use with the codes for primary caries)

1 = Sealant, partial

2 = Sealant, full

3 = Tooth colored restoration

4 = Amalgam restoration

5 = Stainless steel crown

6 = Porcelain or gold or PFM crown or veneer

7 = Lost or broken restoration

8 = Temporary restoration

9 = Used for the following conditions

96 = Tooth surface cannot be examined: surface excluded

97 = Tooth missing because of caries (tooth surfaces will be coded 97)

98 = Tooth missing for reasons other than caries (all tooth surfaces will be coded 98)

99 = Unerupted (tooth surfaces coded 99)

## Detection of Root caries:

According to the National Institutes of Health (NIH) Development there was not clear evidence on the validity of clinical diagnostic systems for root caries. Root caries are frequently observed near the (CEJ). The color of the root lesions has

been used as an indication of lesion activity. However, color has been shown not to be a reliable indicator of caries activity (Lynch and Beighton, 1994). One score will be assigned per root surface. The facial, mesial, distal, and lingual root surfaces of each tooth should be classified as follows:

**Code E:** If the root surface cannot be visualized directly as a result of gingival recession or by gentle air-drying, then it is excluded. Surfaces covered entirely by calculus can be excluded or, preferably, the calculus can be removed prior to determining the status of the surface.

**Code 0:** The root surface does not exhibit any unusual discoloration that distinguishes it from the surrounding or adjacent root areas, nor does it exhibit a surface defect either at the CEJ or wholly on the root surface. The root surface may have a natural anatomical contour or the root surface may exhibit a definite loss of surface continuity or an anatomical contour that is not consistent with the dental caries process.

**Code 1:** There is a clearly demarcated area on the root surface or at the CEJ that is discolored (light / dark brown, black) but there is no cavitation (loss of anatomical contour < 0.5 mm) present.

**Code 2:** There is a clearly demarcated area on the root surface or at the CEJ that is discolored (light / dark brown, black) and there is cavitation (loss of anatomical contour  $\geq$  0.5mm present).

A study was conducted by Diniz MB in 2009 on the reproducibility and accuracy of the

ICDAS II for occlusal caries detection based on Ekstrand histological classification and Lussie et al assessment of caries extension. The intra-examiner kappa values were 0.51 and 0.58 respectively, which concluded that ICDAS II offered good reproducibility and accuracy in detecting occlusal caries especially the caries lesion on the outer surface of enamel (Diniz et al, 2009).

Shoaib et al 2009 conducted an in vitro study on the validity and reproducibility of ICDASII criteria in primary teeth. 112 extracted primary molars were taken and the most infected caries on the proximal and occlusal surfaces were noted, followed by sectioning and validation using Downer and Ekstrand – Rickets - Kidd (ERK) scoring system. The mean intraexaminer reproducibility (Cohens kappa) ranged from 0.78 to 0.81 while the interexaminer reproducibility ranged lower from 0.68 to 0.70 thus concluding that ICDAS II criteria validity and reproducibility were acceptable when applied to primary molar teeth (Shoaib et al, 2009).

The advantages of ICDAS are that it is clinically reliable in permanent teeth and acceptable in primary teeth. It is designed to detect 6 stages of carious severity and it is also very suitable for use in clinical trials assessing the effectiveness of carious control agents.

The drawbacks of ICDAS are

- Root caries assessment criteria have not been tested in any studies
- The data obtained are non cohesive and difficult to read

- Data collected over estimate the seriousness of dental caries
- Results are difficult to compare against widely used DMF indices

### **SPECIFIC CARIES INDEX:**

It is a new system for describing untreated dental caries experience in developing countries. It was proposed by Shashidhar Acharya in 2006 (Acharya, 2006) with the objective to develop a reproducible surface specific caries index that would provide qualitative and quantitative information about untreated dental caries that would provide information on not only the caries prevalence but also the location and type of caries lesion in an individual based on clinical examination. This index is based on GV Black classification of cavity preparation. Codes for specific caries index is given in Table 3.

The study conducted by Acharya in 2006 (Acharya, 2006) on 339 rural children in the age group of 12-15years using the specific caries index in conjunction with DMFS index concluded that Type1 and Type 2 were found to be the most common carious lesion and the reproducibility of the specific caries index was also found to be good.

Some drawbacks of this index are it gives the same criteria caries detection as that of DMF or DMFS, the inability of this index when used alone to get information useful for treatment planning in cases of large lesions covering more than one surface and the lack of provision for assessing root caries.

**PUFA (pulp-ulcer-fistula-abscess) index:**

This index was developed by Monse et al in 2010 (Monse et al, 2010) to overcome DMF failure to provide information on the untreated dental caries such as pulp abscess which may be more serious than the carious lesion themselves. This index records the advanced stages of untreated carious lesion. The index is expressed in uppercase letters (PUFA) when used for permanent dentition and lowercase letters (pufa) when used for primary dentition. The codes for PUFA index given in Table 4.

A study was conducted by the original author Monse B et al in 2010 to validate the index within the Philippines National Oral health survey 2006. The resultsshowed that the prevalence of PUFA / pufa > 0 was 85% and 56% for the 6 and 12year old respectively. These results made It evident that PUFA index provides relevant information for epidemiologists by complimenting the other classic caries indices (Monse et al, 2010).

Calculation and Interpretation:

PUFA / pufa = ( filled + sound ) \* 100 / D + d

(High scores indicates dental treatment neglected due to lack of knowledge, facility, cost and importance of dentition)

**Strength of PUFA:**

Simple to record; Can be used for primary and permanent teeth along with DMF index; Can provide useful information for researchers and authorities in developing countries where the access to oral health services is limited and teeth are often left

untreated.; The index is easy and safe to perform, even for nondentists it takes little time to perform and does not require any additional equipment

The drawbacks of PUFA:

Stages of carious lesion progression in enamel are not being assessed; Few subjects with score "u" (ulcer); Assessment of abscess and fistula can be combined into one code; The reliability of this index needs further research and discussions

**CARIES ASSESSMENT SPECTRUM AND TREATMENT (CAST) INDEX:**

This index was developed by Frencken et al for full assessment of dental caries in the year 2011. "SPECTRUM" is considered as the backbone of this index as it covers from no lesion to the advanced stage of progression of caries. The application of CAST covers the total dental caries spectrum where the three stages of enamel lesions are distinguished (Frencken et al, 2011).

CAST instrument was created only for the purpose of epidemiological study. A study was conducted by De Souza Al in 2014 to investigate CAST instruments validity. Validation was determined through sensitivity, specificity and Youden index (100%, 92.9% and 93%) examined visually and through micro -CT (96%, 86% and 83%) respectively. The interexaminer consistency was 0.76%. Construct validation was obtained for the CAST instrument (De Souza et al, 2014 a).

The reproducibility of this instrument in the year 2014 which was calculated and expressed as kappa coefficient value (k)

and percentage of agreement (Po). For the 2-6year childrens the  $k=0.74$ ,  $Po=98.3\%$ . For the 6-9years  $k=0.68$  to  $0.86$ ,  $Po> 93.7\%$ . For the 19-30year population  $k=0.87$  and  $Po=94.1\%$ , thus concluding that the cast instrument can be reliably used in epidemiological studies since the reproducibility was "almost perfect" in primary and permanent dentition (De Souza et al, 2014 b).The codes for CAST index given in Table 5.

Advantages of CAST index:

- A dmf score can be easily calculated from the CAST score
- Used only for epidemiological surveys
- Visual / tactile hierarchical one digit coding system
- Includes total spectrum of stages of caries lesion.
- Is built on the strength of the ICDAS, DMF and PUFA indices

Limitations:

- It does not record active and inactive carious lesion
- It has not been validated nor has its reliability been tested
- It is not suggested for use in clinical trials
- It does not provide data on treatment

#### **NYVAD'S CARIES DIAGNOSTIC CRITERIA:**

Nyvad's criteria was developed in the year 1999 by BenteNyvad (Nyvad et al, 1999). This criteria was the first classification system for the assessment of both cavitated and non cavitated lesions at active and inactive levels. Includes

manifestation of dental caries in the initial stage, even before a cavity exists. The Nyvad's classification is based on visual and tactile examination. A special feature of Nyvad's classification in addition to assessing the severity of the lesions is that each score shows an assessment of lesion activity. Hence the criteria are designed in such a way that it reproduces all the transitions of a caries lesion that occurs over time in a patient either naturally or due to caries control procedures. For clinical examination a sharp end explorer is used to get the tactile feel of the lesion surface. An active lesion in the enamel is said to be matte and rough on probing gently, on the other hand the inactive lesion appears shiny and smooth on gentle probing (Thylsstrup et al, 1994). This surface phenomena may also be visually observed. The criteria are easy to adapt and are used for statistical analysis.

The reliability of this criteria was determined through a study in 2011 in primary teeth and the mean examination time was calculated. Eighty children were examined by calibrated examiners under standardized conditions. At the tooth surface level the inter and intra examiner values were 0.82/0.86, 0.80/0.86 and 0.90/0.94 respectively. At the individual level the inter and intra-examiner values were 0.84/0.94, 0.69/0.74 and 0.95/0.97. The mean examination time was 226.5s. Hence the use of Nyvad's criteria showed reliable results when used in primary teeth and the examination time was also acceptable (Sellos and Soveiro, 2011).The codes for Nyvad's criteria given in Table 6.

Advantages:

The criteria can identify incipient caries lesion. Def index can be omitted as it measure only cavitated lesion. Diagnosis of initial lesion can stop the progression of lesion hence long term treatment is not

needed. Limitations: Physiological wear of the occlusal surface due to mastication can lead to the disappearance of the lesion. Difficult to make an exact diagnosis of precavitated active lesions on the occlusal surface than facial surface.





**Table 1: The codes for coronal caries**

CODE	CRITERIA
0	Sound tooth surface: No evidence of caries after 5 seconds of air drying
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
2	Distinct visual change in enamel: opacity or discoloration distinctly visible at the entrance to the pit and fissure when wet, the lesion must still be visible when dry
3	Localized enamel breakdown (with no visible dentine or underlying shadow): opacity or discoloration wider than the natural fissure / face when wet and after prolonged air drying
4	Underlying dark shadow from dentine
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

**Table 2: Caries associated with restoration and sealant (CARS)**

CODE	CRITERIA
0	Sound tooth surface with restorations and sealants
1	First visual change in enamel
2	Distinct visual change in enamel / dentin adjacent to restoration / sealant margin
3	Cariou 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

**Table 3: The Specific caries index and criteria**

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

**Table 4 : PUFA criteria**

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 pulp 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 Eg: tongue, or buccal mucosa
F/f	Fistula is scored when the 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

**Table 5 : Cast index score and criteria**

Characteristic	Code	Description	Concept of health
Sound	0	No visible evidence of a distinct carious lesion	Healthy
Sealed	1	Pit and / or fissures are at least partially sealed with a sealant material	Healthy
Restored	2	A cavity is restored with a (in) direct restorative material	Healthy
Enamel	3	Distinct visual change in enamel only. A clear caries is visible with or without localized enamel breakdown	Reversible premorbidity
Dentin	4	Internal caries related discoloration in dentin	Morbidity
	5	Distinct cavitation into dentin. The pulp chamber is intact	Morbidity
Pulp	6	Involvement of pulp chamber	Serious morbidity
Abscess/fistula	7	A pus containing swelling or a pus releasing sinus tract related to a tooth with pulpal involvement	Serious morbidity
Lost	8	The tooth has been removed due to dental caries	Mortality
Other	9	Does not correspond to any of the other categories	Mortality

**Table 6 :Nyvad's scoring criteria**

Score	Category	Criteria
0	Sound	Normal enamel translucency and texture (slight staining allowed in the otherwise sound fissure)
1	Active caries (intact surface)	Surface of enamel is whitish/yellowish, opaque with loss of luster; feels rough when the tip of the probe is moved gently across the surface; generally covered with plaque. No clinically detectable loss of substance. Intact fissure morphology; lesion extending along the walls of the fissure.
2	Active caries (surface discontinuity)	Same criteria as score 1. Localized surface defect (microcavity) in enamel only. No undermined enamel or softened floor detectable with the explorer.
3	Active caries (cavity)	Enamel/dentin cavity easily visible with the naked eye; surface of the cavity feels soft or leathery on gentle probing. There may or

		may not be pulpal involvement.
4	Inactive caries (intact surface)	Surface of enamel is whitish, brownish or black. Enamel may be shiny and feel hard and smooth when the tip of the probe is moved gently across the surface. No clinically detectable loss of substance. Intact fissure morphology; lesion extending along the walls of the fissure.
5	Inactive caries (surface discontinuity)	Same criteria as score 4. Localized surface defect (microcavity) in enamel only. No undermined enamel or softened floor detectable with the explorer.
6	Inactive caries (cavity)	Enamel/dentin cavity easily visible with the naked eye; surface of the cavity feels shiny and feels hard on gentle probing. No pulpal involvement
7	Filling (sound surface)	
8	Filling + active caries	The caries lesion may be cavitated or noncavitated
9	Filling + inactive caries	The caries lesion may be cavitated or noncavitated

### CONCLUSION

Today various caries indices will describe the entire spectrum of disease from demineralization of enamel to extensive caries involving the pulp. The index is considered to be an ideal method to quantify the disease. Several new indices have been developed to assess dental caries, however every index has its own disadvantages, advantages, uses and limitations, hence further research is needed. The future of research and education in cariology requires an integrated system for measuring the caries process. It can be concluded that in the

current scenario, it will not be easy for other indices to replace the DMF index as the epidemiologists are still collecting data based upon this index and the newly developed tools of epidemiological caries assessment is yet to evolve further, so further research in developing a relent indices is recommended.

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