

# Caries Detection with ICDAS and the WHO Criteria: A Comparative Study

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## ABSTRACT

**Introduction:** Dental caries is the most prevalent chronic disease affecting mankind and is the primary reason for tooth pain and edentulism. The presence or absence of caries depends on the diagnostic cut-off points selected.

**Aim:** This study evaluated the comparability of two systems i.e., the International Caries Detection and Assessment system (ICDAS II) and the World Health Organization (WHO) criteria for detection of carious lesions among a set of outpatient subjects and was assessed for an equivalency point between the systems.

**Materials and Methods:** A total of 242 subjects were independently inspected by two examiners who were trained

and calibrated accordingly for detecting a carious lesion using the WHO and the ICDAS II criteria. Caries prevalence and the mean decayed teeth were calculated using both the systems. Wilcoxon test was employed to compare the mean caries score obtained with the WHO criteria and the ICDAS. Caries prevalence, according to the WHO criteria and ICDAS II criteria was compared using McNemar's test.

**Results:** The equivalency point between these two systems was at score four of the ICDAS II in this particular study.

**Conclusion:** In addition to unearthing a significant number of non-cavitated carious lesions, the ICDAS II can be equated to the WHO criteria at score four of the ICDAS II.

**Keywords:** Dental Caries, Dental public health, Diagnosis, Epidemiology, Visual inspection

## INTRODUCTION

Dental caries is the localised destruction of the susceptible dental hard tissues by acidic by-products from bacterial fermentation of the dietary carbohydrates [1]. It is the most prevalent chronic disease of the communities worldwide and is the primary reason for tooth pain and edentulism [2,3,4].

The term dental caries can be used for the carious lesion and the carious process as well. This condition refers to a continuum of disease states of increasing severity and tooth destruction that ranges from subsurface clinical changes to lesions with dentin involvement either with an intact surface or cavitation [5-7]. The presence or absence of decayed teeth primarily depends on the diagnostic cut-off points selected.

In this regard, epidemiological surveys based on the World Health Organization (WHO) caries detection methods play an eminent role in monitoring the trends with respect to dental caries [8,9]. The WHO criteria [10] which is widely used by the (Decayed-Missing-Filled) DMFT/ (Decayed-Missing-Filled-Surface) DMFS index to identify decayed teeth states that such teeth should be identified with the presence of cavitation. This criterion has been incorporated to increase the reliability factor in community based surveys.

There is a school of thought which states that a carious lesion should be detected at an early stage which precedes a cavity so that preventive measures can be employed to halt the process of cavitation, thereby reducing the overall cost of the curative services [11-14].

The impetus for developing a new system which detects early stages of a carious lesion started during the International Consensus Workshop on Caries Clinical Trials (ICW-CCT) [15] held in Scotland in the year 2002, which finally culminated in the birth of the International Caries Detection and Assessment

System (ICDAS).

The ICDAS which was developed for use in clinical research, clinical practice, dental education and surveys was revised and extended in the year 2005, later called the ICDAS II [16]. This system had been fabricated in such a way that both the cavitated and the non-cavitated carious lesions could be assessed with acceptable reliability. There have been few studies which have proved the validity and the reliability of this index [17].

However, the data generated from the ICDAS should be carefully analysed to determine its comparability with the WHO caries detection method as most of the earlier caries prevalence studies have been performed by employing the WHO criteria.

There have been few studies in the past which compared the WHO criteria to the ICDAS among the preschool, 12-year-old and 15-year-old children [18-21] and the score 3 of the ICDAS has been the point where these two systems match. However, this is a subject of debate and information regarding the equivalency point in an adult population is unavailable. Considering the above data, the main objective of this study was to compare these systems and to assess the equivalency point among a representative adult population.

## MATERIALS AND METHODS

This cross-sectional study was approved by the Institutional Ethical committee of Kamineni Institute of Dental Sciences, Nalgonda district, Telangana, India (IEC/143/KIDS). The study population consisted of the residents of Nalgonda district who attended the dental outpatient of dental institute. Verbal informed consent was taken from every subject and the ethical principles were followed in accordance with the World Medical Association (WMA) and the Helsinki declaration. This scientific study was carried out for a period of three months (Feb-April 2014).

## Caries Detection Criteria for the WHO, ICDAS II WHO System [Table/Fig-1,2]

For the WHO caries assessment system [10], the examiner recorded a surface as decayed only if it presented with detectably softened floor, undermined enamel or a softened wall. According to this criterion, all the stages that precede cavitation as well as other conditions similar to the early stages of a carious lesion were considered sound.

Code	Description
Sound tooth	A crown is recorded as sound if it shows no evidence of treated or untreated dental caries. The stages of caries that precede cavitation as well as other conditions similar to the early stages of caries are considered sound because they cannot be reliably diagnosed.
Decayed crown	Caries is recorded as present when a lesion in the pit and fissure or on a smooth tooth surface has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall. Where any doubt exists, caries should not be recorded as present

**[Table/Fig-1]:** WHO criteria for a carious lesion [10].

Code	Description
0	There should be no evidence of caries after prolonged air drying (5 seconds). Surfaces with developmental defects (enamel hypoplasia, fluorosis, attrition, abrasion and erosion) and intrinsic and extrinsic stains will be considered as sound.
1 - First visual change in enamel	When seen wet, there is no evidence of any change in color attributable to the carious activity, but after prolonged air drying a carious opacity or discoloration (White or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel.
2 - Distinct visual change in enamel	The tooth must be viewed wet. When wet there is a (a) carious opacity (white spot lesion) and / or (b) brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel.
3 - Localised enamel breakdown due to caries with no visible dentin or underlying shadow	The tooth viewed wet may have a clear carious opacity (white spot lesion) and / or brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel. Once dried for approximately 5 seconds there is carious loss of tooth structure at the entrance to, or within, the pit or fissure/fossa. If in doubt, or to confirm the visual assessment, the CPI probe was used gently across a tooth surface to confirm the presence of a cavity apparently confined to the enamel.
4 - Underlying dark shadow from dentin with or without localised enamel breakdown	This lesion appears as a shadow of discolored dentin visible through an apparently intact enamel surface which may or may not show signs of localized breakdown (loss of continuity of the surface that is not showing the dentin).
5 - Distinct cavity with visible dentin	Cavitation in opaque or discoloured enamel exposing the dentin beneath.
6 - Extensive distinct cavity with visible dentin	Obvious loss of tooth structure, the cavity is both deep and wide and dentin is clearly visible on the walls and at the base. An extensive cavity involves at least half of a tooth surface or possibly reaching the pulp.

**[Table/Fig-2]:** ICDAS II criteria for caries detection on the pit and fissures [16].

The detection of dental caries is a two stage process represented by a two digit code for each tooth surface. The first digit refers to classification of the tooth surface whether it is sound, sealed, restored, crowned or missing. The second digit refers to the carious stage of the tooth surface in an ordinal scale and is mentioned below.

For the ICDAS system, the D stands for detection of dental caries by (i) stage of the carious process; (ii) topography (pit and fissure or smooth surfaces); (iii) anatomy (crown vs roots); and (iv) restoration or sealant status. The A in the ICDAS stands for assessment of the carious process by the stage (non-cavitated or cavitated) and activity (active or arrested) [16]. This study does not include an assessment of the lesion activity or root caries.

Based on the prevalence of dental caries among the 35-44 year old

adults in a survey conducted earlier [22], which is 50%, the expected prevalence of ICDAS to be around 65%, alpha at 2.5% and the power of the study at 85%, the final sample size was calculated to 242.

A non-probability convenience sampling method was employed to carry out this study. The patients attending the dental clinics of the institute were initially interviewed and only those who gave their consent to be a part of the study were examined. Subjects suffering from any serious systemic diseases, completely edentulous individuals and those who opted not to be a part of the study were excluded.

Two recently graduated examiners were selected to carry out the clinical aspects of the study. The examiner allocated for the ICDAS II recording was meticulously trained through a series of stations. In a station, a tooth with a particular code of ICDAS was displayed so as to visualise the meaning of the particular code.

An experienced epidemiologist taught a full course of the theoretical aspects of the ICDAS II with the help of a power point presentation (www.icdas.org) and displayed all the photographs of the various codes as described by the ICDAS II. Following this, the examiner was shown a set of 20 extracted teeth which corresponded to the various stages of the ICDAS II scores and was asked to grade the teeth. Any errors made were immediately discussed and resolved.

The second examiner, similarly, was put through a theoretical and a practical session for detecting carious lesions according to the WHO caries assessment system.

Prior to the start of the actual study, both the examiners were put through an assessment of 20 subjects which were not a part of the main study. Each subject was assessed twice with respect to the WHO system and the ICDAS II separately. Provision was then made to reassess these subjects at a later date. The intra-examiner variability was then analysed.

After the training and the calibration sessions, the examination of the subjects were commenced. Each subject was put through both the assessment systems in separate cabins and the examiners were unaware of each other's results. The examinations for both the systems were conducted at the surface level of the teeth. The surfaces chosen for scoring were identical for both the systems in accordance to the ICDAS wardrobe concept. The same procedures of illumination, cleaning and drying were done to avoid any discrepancies in the recording pattern. The instruments used were the WHO periodontal probe and a plane mouth mirror. Strict infection control measures were employed during the examination of every subject. Trained dental assistants were part of the examination pattern among both the systems.

## STATISTICAL ANALYSIS

The data analysis was carried out with the SPSS software version 18. The mean caries scores were calculated at each ICDAS cut-off and were compared with the mean caries score obtained by the WHO criteria using the Wilcoxon test. Caries prevalence, according to the WHO criteria and ICDAS II criteria was compared using McNemar test. A p-value of <0.05 was considered statistically significant.

## RESULTS

A total of 242 subjects consisting of 141 females and 101 males, in the age group of 19-54 years, were a part of this cross-sectional study. The intra-examiner variability of the two examiners during the calibration exercise was 0.62-0.70 for the ICDAS criteria and 0.80-0.85 for the WHO system.

At the subject level, as expected, ICDAS II had a higher sensitivity for detecting lesions (98.7% of the study subjects were identified as decayed) compared to the WHO caries detection methods (69.8% of the study subjects were identified as decayed) as seen in the [Table/Fig-3].

On analyzing the diagnostic performance of the two systems at the

tooth surface level, it depicts that with increasing ICDAS scores, the agreement between these systems have fared much better than with the lower ICDAS scores [Table/Fig-4].

The caries prevalence and the mean decayed teeth of the WHO system correlated well with the score 4 cut-off of the ICDAS II, indicating that the equivalency point between these systems is at score 4 of the ICDAS II [Table/Fig-5,6]. The cut-off values for score 5 and 6 of the ICDAS II criteria were not significant.

	At the subject level		Total
	Caries free	With caries	
ICDAS	3	239	242
WHO	73	169	242
$\chi^2=76.483, df=1, p<0.05^*$			
Odds ratio (95%CI) = 0.03 (0.009-0.09)			

**[Table/Fig-3]:** Caries prevalence of the WHO and the ICDAS II at the subject level.

Chi-square test

\*p<0.05 statistically significant

CI- Confidence Interval

WHO	ICDAS 0	ICDAS 1	ICDAS 2	ICDAS 3	ICDAS 4	ICDAS 5	ICDAS 6	Total
Sound	5674	170	273	227	2	26	12	6384
Decayed	26	2	5	12	19	197	75	336
Total	5700 (84.8%)	172 (2.6%)	278 (4.1%)	239 (3.6%)	21 (0.3%)	223 (3.3%)	87 (1.3%)	6720 (100.0%)

**[Table/Fig-4]:** Relationship between the scores for the decayed component obtained using ICDAS II and WHO criteria at the tooth surface level (single examiner per system).

	No. of teeth decayed (WHO)	Score 1 cut-off	Score 2 cut-off	Score 3 cut-off	Score 4 cut-off
Prevalence (95%CI)	70.25 (64.21-75.66)	98.76 (96.42-99.58)	94.21 (90.52-96.52)	84.3 (79.18-88.34)	69.42 (63.35-74.88)
p-value		<0.001*	<0.001*	<0.001*	0.5 (NS)

**[Table/Fig-5]:** Comparison of caries prevalence obtained through WHO and ICDAS II using score 1, score 2, score 3 and score 4 cut-off.

Mc Nemar test

\*p<0.001 statistically significant

	No. of teeth decayed (WHO)	Score 1 cut-off	Score 2 cut-off	Score 3 cut-off	Score 4 cut-off
Mean(SD)	1.38 (1.44)	4.30 (1.96)	3.55 (1.94)	2.36 (1.77)	1.35 (1.42)
p-value		<0.001*	<0.001*	<0.001*	0.058 (NS)

**[Table/Fig-6]:** Mean decayed teeth according to WHO and different cut-off points of the ICDAS criteria.

Wilcoxon test \*p<0.001 statistically significant

## DISCUSSION

The need for ICDAS was to put a reliable system in place for detection of early stages of a carious lesion to shift the focus back on prevention. Subsequently, the validity and reliability of this instrument had been proved in a number of studies [17,20,23]. India does not have a national oral health policy and thereby the dental services are mostly in private hands with major emphasis on the curative services. From an Indian perspective, the ICDAS system is a must as it helps the physician to focus on preventive strategies rather than curative tertiary level services. Recent surveys have indicated an increasing prevalence of dental caries and the dental establishment would do a lot of good to the masses if this system is implemented at all levels [24-26].

A striking difference in the approach of this present study is that the dental caries experience of the study subjects was not calculated due to the difficulties posed by the complex nature of presenting the ICDAS results and the emphasis was placed on the comparability of

the two systems with respect to detection of caries.

In accordance with the earlier study carried out by Braga MM et al., [18], two inexperienced examiners were chosen to handle these two systems. They were methodologically trained and calibrated on a group of 20 subjects who were not a part of the main study sample. The kappa values for the intra examiner variability was 0.75- 0.80 for the WHO and 0.62- 0.70 for the ICDAS II. Expectedly, the values for the WHO were better than the ICDAS system. The kappa values for the ICDAS scores in this study are lower than that of the earlier studies carried out by Mendes FM et al., [21] Ismail AI et al., [16] and Braga MM et al., [18]. However, studies carried out by Stoleriu S et al., [27] and Bottenberg P et al., [28], the kappa values for the ICDAS II were much higher than the present study. One reason that can be attributed to this is that the study subjects were from an endemic fluoride belt and thereby fluoride opacities could have confused the inexperienced examiner in spite of the training imparted on the differential diagnostic aspects of dental fluorosis.

The use of the ICDAS II unearthed a significant amount of non cavitated lesions in comparison with the WHO caries detection methods and is evident at the subject level of the study. 98.7% of the subjects were caries positive with the ICDAS II in contrast to 69.8% of the subjects with the WHO system and this difference was statistically significant. Assessing the results at the surface level, the caries prevalence of the ICDAS at score 1 cut-off (98.76%), score 2 cut-off (94.21%) and score 3 cut-off (84.3%) was much higher than the caries prevalence of the WHO system (70.25%) and these results were statistically significant. Similar results are seen in studies conducted by Iranzo- cortes JE et al., [19] and Braga MM et al., [18].

Discussing the contentious issue of the equivalency point between these systems, score 4 of the ICDAS was seen to be matching with the WHO scores in this study, as evident from the similar mean decayed teeth at score 4 cut-off of the ICDAS system. Other studies carried out by Mendes FM et al., [21], Braga MM et al., [18] and Iranzo- cortes JE et al., [19] have found the equivalency point at three. The equivalency point obtained in this study is consistent with the one that is recommended by the ICDAS coordinating committee [29]. These variations in the equivalency point could be attributed to the fact that caries detection criteria of the WHO does say that caries is recorded as present, if there is an unmistakable cavity, but whether the cavitation is into the enamel or the dentin has not been clearly mentioned and the other criteria i.e. the undermined enamel or a detectably softened floor or wall is self-explanatory. The aspects that are highlighted here need further discussion.

On the other side, at the tooth surface level [Table/Fig-4], the data depicts an increasing trend in agreement between the two systems, with an increasing ICDAS code. However, the subject of contention is that out of 5700 tooth surfaces scored by ICDAS as 0, the WHO criteria had identified 26 tooth surfaces as decayed. The same pattern repeats with the ICDAS score 5. Out of 223 surfaces scored by ICDAS as score 5, the WHO criteria had identified 26 tooth surfaces to be sound. Similar results have also been displayed in the study carried out by Braga MM et al., [18] and no explanation had been given for such a peculiar finding and it has repeated in the present study as well. This highlights the existence of human error in spite of the meticulous training exercises and there can be no justification for such an error.

There is a general perception among the examiners that the ICDAS method of examination was far more cumbersome and the method of detecting carious lesions is not ideally suited in an epidemiological setting. This is because it entails the drying of a particular tooth surface for about five seconds, thereby severely hampering the use of this system in large scale epidemiological surveys. Portable air compressors can be used to dry the tooth surfaces, but in a country like India, cost-effective options are always preferred. A viable alternative could be the usage of chip blower instead of the portable

air compressors but as of now, we do not have any scientific data to substantiate the effectiveness or efficacy of this technique. This could therefore be one of the future areas of research to make ICDAS more viable in an epidemiological setting.

Discussing the limitations of the study is that the intra-examiner variability could not be assessed as it was not feasible to re-examine the study subjects at a later date. Nonetheless, the main objective of this study has not been on the reproducibility of the ICDAS or the WHO criteria.

## CONCLUSION

The use of ICDAS in this study has unearthed a significant amount of non-cavitated lesions in comparison to the gold standard. In conclusion, the equivalency point between these two systems is at the score 4 of ICDAS in this particular study.

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